Exploring and Applying Physics

[Facebook group]

Posts by Eugenia Etkina from 2023

Eugenia Etkina
January 1 ·

Hi all, happy New Year and we are beginning to prepare for our Energy meeting on January 7th. There are several thinks that the participants need to do before the meeting. First, please make sure that you signed up to attend on the EVENTS page.
Then, find a brick and a few (3-5) pieces of chalk, and prepare a few pieces of white paper. Second, you need to find a house with a few flights of stairs and shoes with hard soles. Running or walking shoes will not do (or not be very helpful). First run/walk up the stairs as fast as you can and watch how you feel and most importantly listen to the sound that your shoes make. Next run/walk downstairs as fast as you can (be careful) and watch how you feel and listen to the sound that you make. It is better if you have a few friends or a few students to do the same at once (up and down). Repeat both experiments a few times, rest after climbing the stairs. Record your observations.
Finally, go through your children's/siblings/friends/your own toy collection and find the toys that have springs that shoot something or jump, pull back cars, or anything that moves or jumps but not batteries. Put those toys in a box for the meeting.
If you finished reading the post, please like it or comment to make it more visible for other group members. Thank you!

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Eugenia Etkina
January 2
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Hi all, thank you for signing up for the Energy meeting on Jan 7th. If you have not done it yet, please do! And if you did sign up, please make sure that you do all the prep work that I listed yesterday - bricks, chalk, toys and running up and down stairs.

Today I want to talk about the questions that we habitually ask our students and how these questions help them become critically thinking citizens. Specifically the words: Describe and Explain.

Some even use them together, asking a student to describe and explain something simultaneously. For example: describe and explain what happens to a thrown upward ball. Here, the describe is relatively simple - as the word DESCRIBE means to say what you OBSERVE. We all observe the same thing here - the ball goes up and then comes down. This is all that we observe, right?

But to EXPLAIN means to say HOW it happened and sometimes (although rarely in physics), WHY it happened. While the OBSERVE is something that is relatively objective (not entirely as it depends on the tools that we use, and using different tools we would observe different things, but for simplicity I would say that we all can agree on what we observed), the EXPLAIN part is totally subjective. For example, some could EXPLAIN what they observed saying that the ball went up because when it went through air, it created vacuum behind itself and nature "abhors vacuum", so it pushed the ball up. Then at some point the ball started coming down because it is the natural tendency of all objects to fall back to Earth (this is more or less what Aristotle would say). While both parts of this explanation sound totally ridiculous, the good thing about them is that both are experimentally testable and falsifiable! And this is the main difference between the scientific EXPLAIN and the religious explain. How can we test those two explanations? If the abhorring vacuum is the cause, and we do the experiment in a vacuum, then the objects should not go up in at all. This is a possible experiment to perform if you have a vacuum jar. If the natural place of object is on Earth, then there should be no objects flying up by themselves (think of helium balloons).

While these explanations might seem silly, in fact, discussing these issues with the students is extremely important. They are bombarded with a ton of information every day. Do they habitually ask themselves whether what they are reading/hearing is an observation or an explanation? And if it is

an explanation, then is it falsifiable? And if it is falsifiable, then how can we run an experiment to test it?
There is a great movie "Fair Game" https://en.wikipedia.org/wiki/Fair_Game_(2010_film) about the failure of our politicians to recognize these elements of reasoning and understand that the the claim that Saddam Hussein was making weapons of mass destruction was an explanation not an observation and it was falsifiable. If you have not watched it, do - it is a good lesson in hypothetico-deductive reasoning.
Bottom line, habitually asking your students to differentiate between observations and explanation and focus on experimental testing of the explanations for possible rejection is at the heart of science and the hear of the ISLE approach to learning it. If you finished reading the post, you know what to do next, thank you!

EN.WIKIPEDIA.ORG
Fair Game (2010 film) - Wikipedia
Fair Game is a 2010 biographical political drama film directed by Doug Liman and starring Naomi Watts and Sean Penn.[4] It is based on Valerie Plame's 2007 memoir Fair Game[4] and Joseph C. Wilson's 2004 memoir The Politics of Truth.[5]

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Eugenia Etkina
January 3

Hi all! Yesterday I wrote a post about the difference between DESCRIBE and EXPLAIN. I also wrote about the testability of scientific explanations (one of the important elements of the ISLE approach). Testability means that we can think of an experiment that will rule out the explanation. If we wish that our students develop this important habit of mind, we need to be ready to help them test their explanations. It is not an easy thing to do, but it is an important habit to develop - thinking of ALL students' ideas as experimentally testable. Let me share an example from my teaching to show how we develop these skills and habits.

A long time ago (in 1998) I was teaching a science methods course for future elementary teachers in a masters program at Rutgers. I put a streak of rubbing alcohol on the chalkboard and asked my students to observe it. Then I asked the students to tell me what happened to the streak. They all agreed that the streak disappeared slowly. They explained the "slow" disappearance by saying that alcohol might be made of smaller parts, they called them "things". After that I asked them to explain how the "things/parts" disappeared. I expected them to say that the parts of alcohol left the streak as they were moving randomly and some were moving fast enough that they could leave. But instead, I heard two completely different ideas: Idea 1: alcohol parts were “sucked into the board” and “air absorbed alcohol parts”.

I was surprised that a question that I thought to be very easy for the students turned out to be so difficult. I did not know how to respond to those ideas. I put students in groups and asked them to think of possible experiments whose outcomes they could predict using those two ideas. The students came up with the following experiments: (A) take a piece of paper, weigh it and then wet it in alcohol, weight it again and wait for it to dry and (B) wet a piece of paper in alcohol and put it in a vacuum. Their reasoning for these experiments was the following:

(A) Take a piece of paper, weigh it and then wet it in rubbing alcohol. Weigh the paper. Then wait for it to dry and then weight is again. Prediction based on Idea 1: The weight of the paper after alcohol dried should be the same as the weight when it was wet because the alcohol parts are still in the paper.

Prediction based on Idea 2: The weight of the paper after alcohol dried should be the same as the weight of the paper before it was wetted with alcohol because air would take all alcohol parts from the paper.

(B) Take a piece of paper and put it in a vacuum. Prediction based on Idea 1: Vacuum should make no difference assuming that it does not change paper's ability to dry.
Prediction based on Idea 2: The paper should not dry as there is no air to absorb alcohol parts.
The first experiment is easy to conduct and Eugenia could do it right away as she had a sensitive scale and plenty of rubbing alcohol. See the experiment here: https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...
The second experiment, while theoretically possible, is not feasible in the classroom as there is no way to create good vacuum there. What to do? How to test the second idea that most of the students seemed to hold? We could use a vacuum jar which produces relatively low pressure. But it is still not vacuum. After several discussions with David Brookes we came up with the experiment that uses student ideas but allows for the regular classroom experiments. Watch the video and think why we needed two pieces of paper and not one
https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...
Bottom line, testing student ideas is not only important for "correct" physics but also for helping the students develop the habits of mind needed to question claims that bombard them all the time. Even if those testing experiments are hypothetical. Over the years we accumulated a huge library of testing experiments for different ideas and we videoed many of them - the links are in the textbook, ALG and OALG. Do not skip those!
If you finished reading this post, please like it or comment on it to make it more visible. Thank you!

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Eugenia Etkina
January 4
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Hi all, I continue today with how we approach student ideas for testing experiments. Before you proceed reading this post, please read yesterday's post as this post is a continuation.
The example I used yesterday shows how sometimes student ideas for testing experiments, while technically correct, cannot be implemented in the classroom, and need to be modified using the knowledge of the teacher (unless the students come up with the control idea for the twi strips in yesterday's post themselves). Such thinking is the habit of mind that we need to strive to develop. We should habitually think not only which students' ideas are testable and how to test them, but also, how to modify students' ideas that seem impossible to implement into something that we can do.
In addition, you might be asking a question – what should I do if I do not have a vacuum jar and a pump at my disposal? This is where our developed materials come in handy. Over the years we listened to students' explanations and their proposed experiments and videoed those. The videos are available for free at https://media.pearsoncmg.com/aw/aw_etkina_cp_2/videos/, http://islevideos.net/ , ISLE youtube channel at https://www.youtube.com/@ISLEPhysics, and Gorazd Planinsic youtube channel at https://www.youtube.com/@gorazdplaninsicfmful3516. If your students propose something and you do not have equipment, check out these resources and you might find something that fits.
There are two more alternatives here. The first one is to ask your students to come up with a substitution or a different experiment that you can do and the second is to discuss the issue with the physics teachers or physics researchers in the community. That is why we have this community!
Back to the former - asking your students to come up with a different experiment. Here is the story (this is the story from the class of Gorazd Planinsic)
When the students study wave optics, they learn that light can be modeled as a wave. When they study electromagnetic waves, they learn that those light "waves" can be modeled as waves of changing E and B fields. The next step is to help students learn that light can be modeled as

a stream of quanta. One of the first observational experiments that students observe in this unit (see chapter 27 in the textbook) is a negatively charged electroscope being illuminated by regular and UV light sources. In the second case, the electroscope discharges. The students need to use the electromagnetic wave model of light to explain this observation. One of their explanations sometimes is that the UV light ionizes the surrounding air and ionized air discharges the electroscope. How can we test this idea? The students immediately suggest to put electroscope in a vacuum – to get rid of air. But this is not a possible experiment. In this case we ask students to come up with a “doable” experiment whose outcome they can predict using their explanation. After group discussions they come up with a “doable” experiment whose outcome they can predict using their explanation. They suggest charging the electroscope positively. If it is the air that discharges the electroscope, then there should be no difference in the behavior of the electroscope. To their surprise, the outcome of the experiment does not match their prediction and they need to come up with a new explanation.

I am also reminding you about our first meeting this year - Saturday, Jan 7 at 10 am PST, 1 pm EDT and 7 pm CET.

If you finished reading the post, please like it or comment to make it more visible for other group members and to make sure that the next post comes to your Facebook feed. And you visit any of the two youtube channels that I wrote about, please subscribe!

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Eugenia Etkina
January 5
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Hi all, as always before our meetings, I will not post new content in the last couple of days, only announcements about the meeting to help people find the link and information easily. The meeting is on Saturday, Jan 7 at 10 am US Pacific time, 1 pm US Eastern time and 7 pm Central European time (Italy, Slovenia, Croatia, etc.). Please know your time zone to make sure you do not miss the meeting.
The meeting is dedicated to energy (it will be the first energy meeting, we will need 2 at least). Our approach to energy is VERY DIFFERENT from

traditional, as we use the TOTAL energy and system's approach as opposed to just mechanical energy. Total energy is a conserved quantity, while mechanical is not. The different between conserved and constant is important, therefore I would like those who attend the meeting to review the notes from our Momentum meeting in December. If you cannot find them, please comment here and I will post the link.
The zoom link for the meeting is https://rutgers.zoom.us/my/etkina..., the password is 164680. It is always the same link to all meetings, so if you attended a meeting before and saved the link, use it. Please do not click on the link now, do it only 10 min prior to the start of the meeting. 10 min are important as zoom might ask you to update. I posted a few days ago the materials needed for the meeting and the experiments you need to do. If you cannot find those directions, please comment here and I will repeat them. If you have not registered for the meeting, please do it today. Thank you.

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Eugenia Etkina
January 6

Hi all, this is my second reminder of the meeting tomorrow. 10 am US Pacific time, 1 pm US Eastern Time and 7 pm Central European time. zoom link is https://rutgers.zoom.us/my/etkina... password 164680.
The most important step in preparation is to run up and downstairs in shoes with hard soles and record how you feel and what you hear. If you do not have time to get a brick, chalk and toys, it's ok, we have videos. But for the stairs experiment there is no substitution, you need to do it yourself or observe others doing it. Having more people do it together will help a

lot. Please like or comment on this post to make it more visible. Not enough people saw my yesterday's post with the announcement. We have 30 people who plan to come and 6 more maybe - I hope that all of them see my posts. Thank you!

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Eugenia Etkina
January 8

Hi all, we had a great meeting yesterday (it was the first part of Energy, the second meeting will be in a couple of weeks). Thank you all those who came and stayed for almost 2.5 hours! Here are the link to the zoom recording and to the folder with all of the meeting materials including the slide deck.
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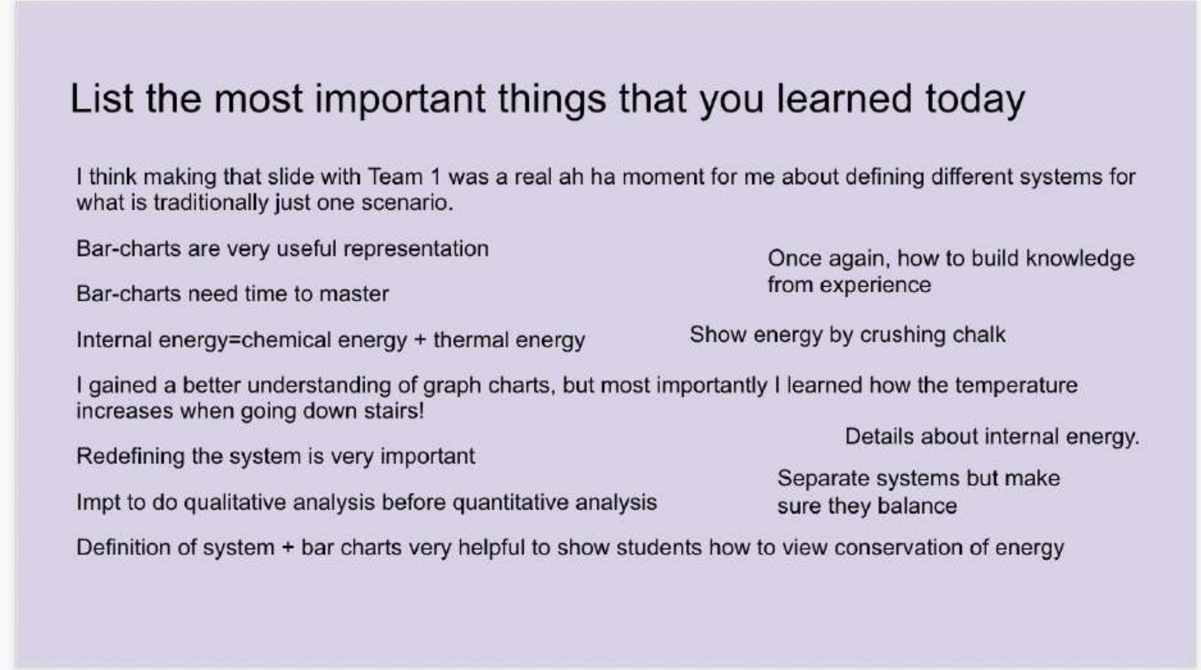
password 3!Him.q!
Meeting folder: https://drive.google.com/.../1SuyazPT_viM-x9Mx...
Screen shot of what people learned
If you plan to attend the second meeting, make sure that you do all of the activities that we did in the OALG Chapter 7. You can see how far we went looking at the slides. If you read the post to the end, please respond to it or like it to make it more visible for other members.



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Eugenia Etkina
January 9
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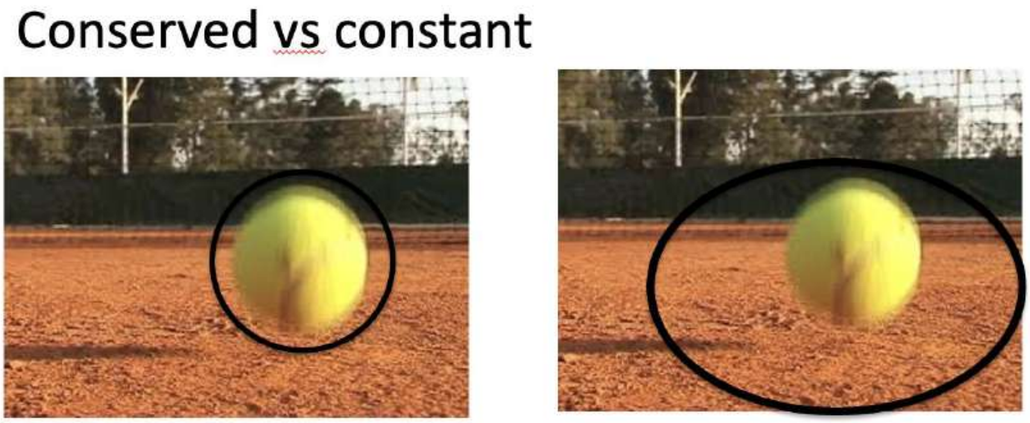
Hi all, as always, after our meeting for a specific topic, I continue discussing it to remind people of the important things that we learned. Today it is the idea of a system. In physics a system is an object or a group of objects that we decide to include. Everything else is the environment. To analyze any process involving energy you first need to decide what is in your system and what is in the environment. Forces internal to the system cannot change the total energy of the system but their work is the mechanism for converting one form of energy in the system into another. Imagine a falling object. When we include Earth in the system, the system possesses gravitational potential energy, but Earth does not do any work

changing the total energy of the system. However, it still exerts a force on a falling object and this force, by doing "internal" work, converts the gravitational potential energy of the system into kinetic. But it does not add to the total energy of the system. It remains constant (disregard the air for simplicity).
If we do not include Earth in the system, the system does not have any gravitational potential energy (RIGHT! A single object does not have the GPE), but Earth does work when the object is falling. This work goes into the increase of the kinetic energy of the system.
In the first case, when an object and Earth are in the system and the object is falling (and we disregard air for simplicity), the total energy of the system is constant. In the second case, when Earth is not in the system, the total energy of the system is changing, so it is not constant, but it is still CONSERVED, as by redefining the system we can find one where the total energy is constant. The confusion between the terms conserved and constant is one of the major obstacles in understanding conserved quantities.
Please post your questions about this issue. Thank you.



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Eugenia Etkina
Admin
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January 11 at 10:11 AM
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Hi all, today I continue posts about the choice of a system. But before we start with the system, I would like to say a few words about work.
We all remember that work is a scalar product of force and displacement. But the displacement of what? An important point is that the displacement refers to the displacement of the point of application of the force. This means that when a ball (the system) lands on the floor and stops, the floor cannot do negative work on it as the floor does not move. It does exert an impulse though - as for the impulse the time is important, not the displacement. So, how can we explain what the floor does using the language of work? We invent a new idea - of pseudo work and the movement of the ball's center of mass instead of the floor. Which makes the problem more complicated.
But even in this case, there is a problem as the ball warms up as it stops and the floor does too. Do we ignore these effects? How do we account for them? To simplify the analysis, we can include the ball, Earth, and the floor in the system. Then the gravitational potential energy of the falling ball-Earth converts into kinetic energy of the ball as the ball falls down and then this kinetic energy right before the ball hits the floor eventually converts into internal energy of the ball and the floor (most of it is thermal, as the ball and floor warm up). Watch the video in infrared of this process and the result in the screen shot of the last moment. The activity involving the process is in the OALG Activity 7.5.4. In the experiment the ball is made of steel. If you finished reading to the end, please do not forget to like or comment on the post to make it more visible for other members of the group. Thank you.
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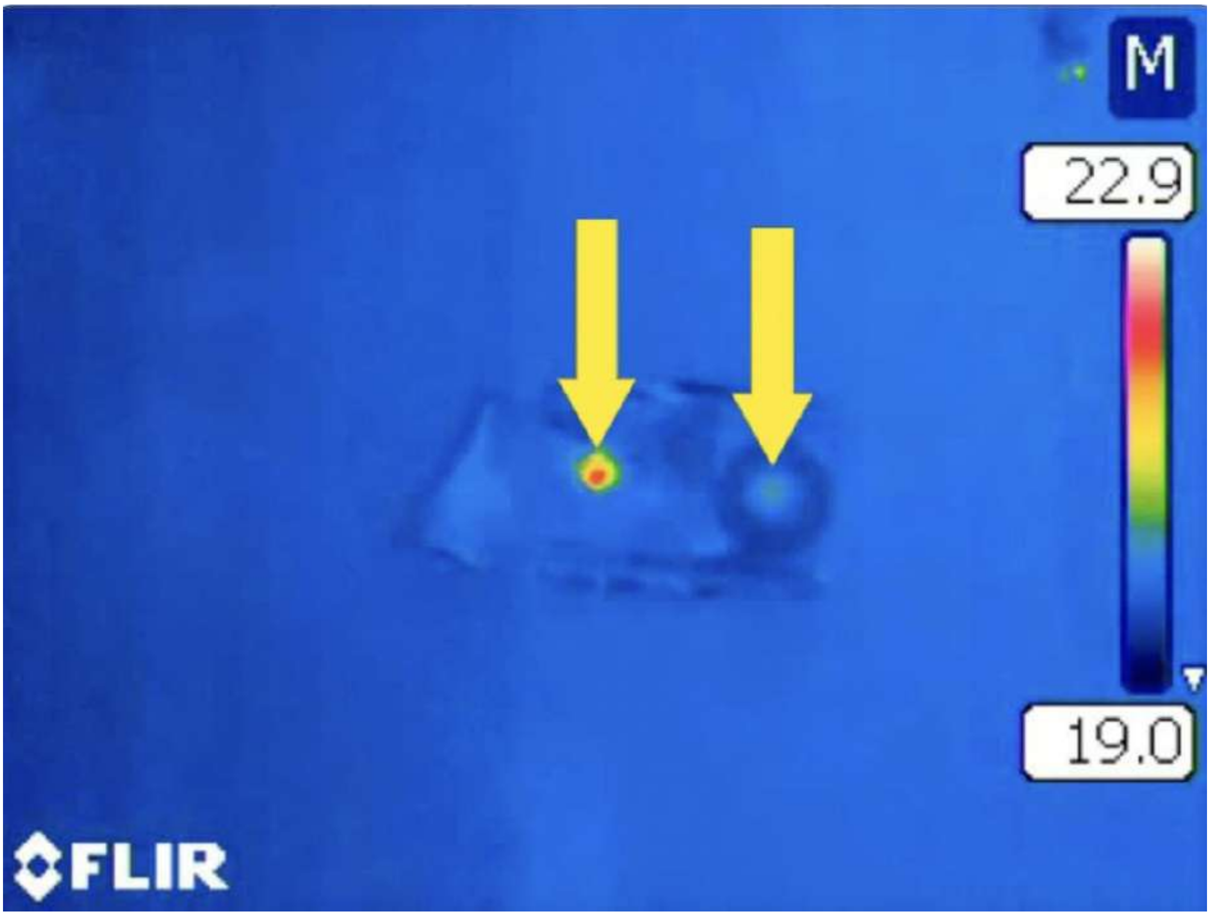

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Eugenia Etkina
Admin
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Hi all, a few things today. First, please see yesterday's poll and vote for the date for the second energy meeting. So far the first date is winning, but only 9 people have voted. Please vote!!

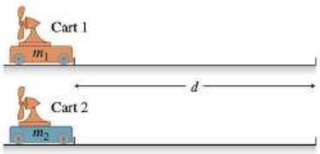
Second, I will continue with the discussion of energy today. Today the post is the difference between energy and momentum. Remember, that energy of a system is changed when an external to the system object does work on it. The work is done when the point where the external force is exerted moves over some distance. So, when we walk on a hard surface without slipping, the friction force component of the force exerted on us by the surface does NO work on our foot (unless we bring it pseudo work that we talked about before). But this force exerts an impulse that changes our momentum! The impulse is equal to the force times the time interval over which it is exerted, therefore no displacement is needed. The same is true when we walk upstairs. The stairs exert an impulse on is but DO NO WORK.

To explain the change in our kinetic energy during walking we need to consider our own internal energy that gets converted into mechanical energy. This is where the change of kinetic energy comes from, not from the work of the surface on us.

I am attaching the screen shot of a table that summarizes other differences between work, impulse, energy and momentum. The research that we did together with Lane Seeley and Stamatis Vokos found that physics teachers have tremendous difficulties when they encounter the problems that involve the comparisons in the table. So, please work through it and include it as an exercise for your students (without the answers, of course). We will discuss all these issues and MORE! at our second meeting on energy that you need to vote for (see the beginning of my post).

If you finish reading the post, please comment or like it to make it more visible for other group members.

FIGURE 7.5 Two fan carts of different masses with identical fans.



It is important to understand the differences between force, acceleration, work, impulse, momentum, and kinetic energy. To illustrate this, we will perform the following thought experiment. Imagine two carts on a smooth surface that have identical fans attached but different masses. The fans rotate and push away the air around the carts; according to Newton's third law, the air pushes on the carts in the opposite direction, making them accelerate. Both carts start from rest, and we let them move the *same distance* on the floor (see Figure 7.5). Table 7.5 compares the above physical quantities for the two carts. Notice that some quantities are the same for both carts, some are larger for cart 1, and some are larger for cart 2. Your task is to think about the explanations for the statements in the table.

TABLE 7.5 Physical quantities describing the motion of two fan carts

Quantity	Cart 1 (mass m_1)	Cart 2 (mass $m_2 = 2m_1$)
Force exerted by the air on the fan cart	$\vec{F}_{\text{A on 1}} = \vec{F}$	$\vec{F}_{\text{A on 2}} = \vec{F}_{\text{A on 1}} = \vec{F}$ Same as cart 1
Acceleration of the cart	$\vec{a}_1 = \dfrac{\vec{F}}{m_1}$	$\vec{a}_2 = \dfrac{\vec{F}}{m_2} = \dfrac{\vec{F}}{2m_1} = \frac{1}{2}\vec{a}_1$ Less than cart 1
Time interval to travel distance d	$\Delta t_1 = \sqrt{\dfrac{2d}{a_1}}$	$\Delta t_2 = \sqrt{\dfrac{2d}{a_2}} = \sqrt{\dfrac{4d}{a_1}} = \sqrt{2}\Delta t_1 > \Delta t_1$ Greater than cart 1
Work done by the fan on the cart	$W_{\text{A on 1}} = Fd\cos 0°$	$W_{\text{A on 2}} = Fd\cos 0° = W_{\text{A on 1}}$ Same as cart 1
Change of kinetic energy of the cart after moving distance d	$\Delta K_1 = \dfrac{m_1 v_{1f}^2}{2} = Fd$	$\Delta K_2 = \dfrac{m_2 v_{2f}^2}{2} = Fd = \Delta K_1$ Same as cart 1
Speed of the cart after moving distance d	$v_{1f} = \sqrt{\dfrac{2Fd}{m_1}}$	$v_{2f} = \dfrac{v_{1f}}{\sqrt{2}}$ Less than cart 1
Change of momentum of the cart after moving distance d	$m_1 v_{1f}$	$m_2 v_{2f} = 2m_1 \dfrac{v_{1f}}{\sqrt{2}} = \sqrt{2} m_1 v_{1f}$ Greater than cart 1
Impulse exerted on the cart after moving distance d	$\vec{J} = \vec{F}\Delta t_1 = m_1 \vec{v}_{1f}$	$\vec{J} = \vec{F}\Delta t_2 = m_2 \vec{v}_{2f}$ Greater than cart 1

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Eugenia Etkina
Admin
January 18

Hi all, yesterday I received a message from a physics teacher from Nigeria. He asked me: How do you motivate students to learn physics? This is what I answered.

"There are several ways to do it.

1 Let them explore something that they are interested in. Maybe sports they play or a vocation they plan to choose, or something that their parents do.
2 Let them observe some cool experiment and use this experiment as the "need to know" to learn more before they can explain it. There are lots of cool videos on youtube that they can explain after they learn some physics.
3 Let them know that they are getting better at something in learning physics. If they do not see that they are getting better, they are not motivated to struggle.
4 Let them resubmit their work for improvement and give them grades for the improved version without taking any points for multiple tries.
5 Let them explain things to others, let them work in groups.
6 Give them simple materials for experiments and let them explore under your guidance.
7 Be "cool". Your coolness and creativity motivates them. Make them feel that learning is "cool".
8 Make work a reward, not punishment. If somebody did not do their work, say: "Sorry, you did not do your homework, and that is why you cannot work on this problem. Next time do your homework and you will be rewarded". When reward our students by decreasing their work, this sends a message that work is punishment and no work is a reward. Turn this around!
9 Stop lecturing. This kills all motivation. Always. "

We have discussed many of the ideas before here. What do you think? Can you add more? Do you agree with my ideas? Please add more!
If you read the post to the end, please respond or like it to make more visible.

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Eugenia Etkina
Admin
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January 20 at 3:44 PM
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Hi all, a few things today. First, please sign up for the second energy meeting if you plan to attend. EVERYONE is welcome! If you missed the first energy meeting, review the slides and other materials that I mentioned in my post yesterday. We will be discussing the issues that are not present in any other textbooks or teaching approaches.
Second, please if you view a post, spend a second clicking "like". It takes literally a second but it makes the post more visible for other members and makes Facebook inform you when the next post is up. The record number of viewers of a single post is 1100 (post by Christine Russell) but is has fewer than a 100 likes and comments.
The third is about the recommendations of a brain researcher about learning. So far I found two books that are accessible to non-biologists and help apply the findings of brain research immediately. The first one is "The art of changing the brain" by James Zull (2002). Reading this book in 2003 (first time I read it) I was amazed how ISLE naturally aligns with the recommendations of brain science (if you read the book you will see, it is absolutely crazy). I have been using this book in my classes for the past 20 years and it never gets old. Every time I reread it, I find new ideas. I strongly recommend. But this year, I learned about another book which is as illuminating as Zull's book only more contemporary and has a lot of connections to the AI. Now, that we are all concerned about the role of the AI in student learning, this book is even more timely. The title is "How we learn" and the author is Stanislas Dehaene (2022). It took me a long time to finish it and after that I took notes about his final recommendations for helping people learn based on all of the science that he describes in the book. For the next few days I will be posting parts of those recommendations (they are in quotation marks below and then I add my thoughts about those). Please comment!
Here is the first ideas: (pages 275-277

"Do not underestimate children. At birth infant possesses a core set of skills and knowledge. Object concepts, number sense, a knack for languages, knowledge of people and their intentions… so many brain modules are already present in young children, and these foundational skills will later be recycled in physics, mathematics, history and philosophy classes. Let's take advantage of children's early intuitions: each word and symbol, however abstract, must connect to prior knowledge. This connection is what gives them meaning."

This is the idea that connects to our long discussion of building of student ideas instead of trying to get rid of them thinking of them as misconceptions.

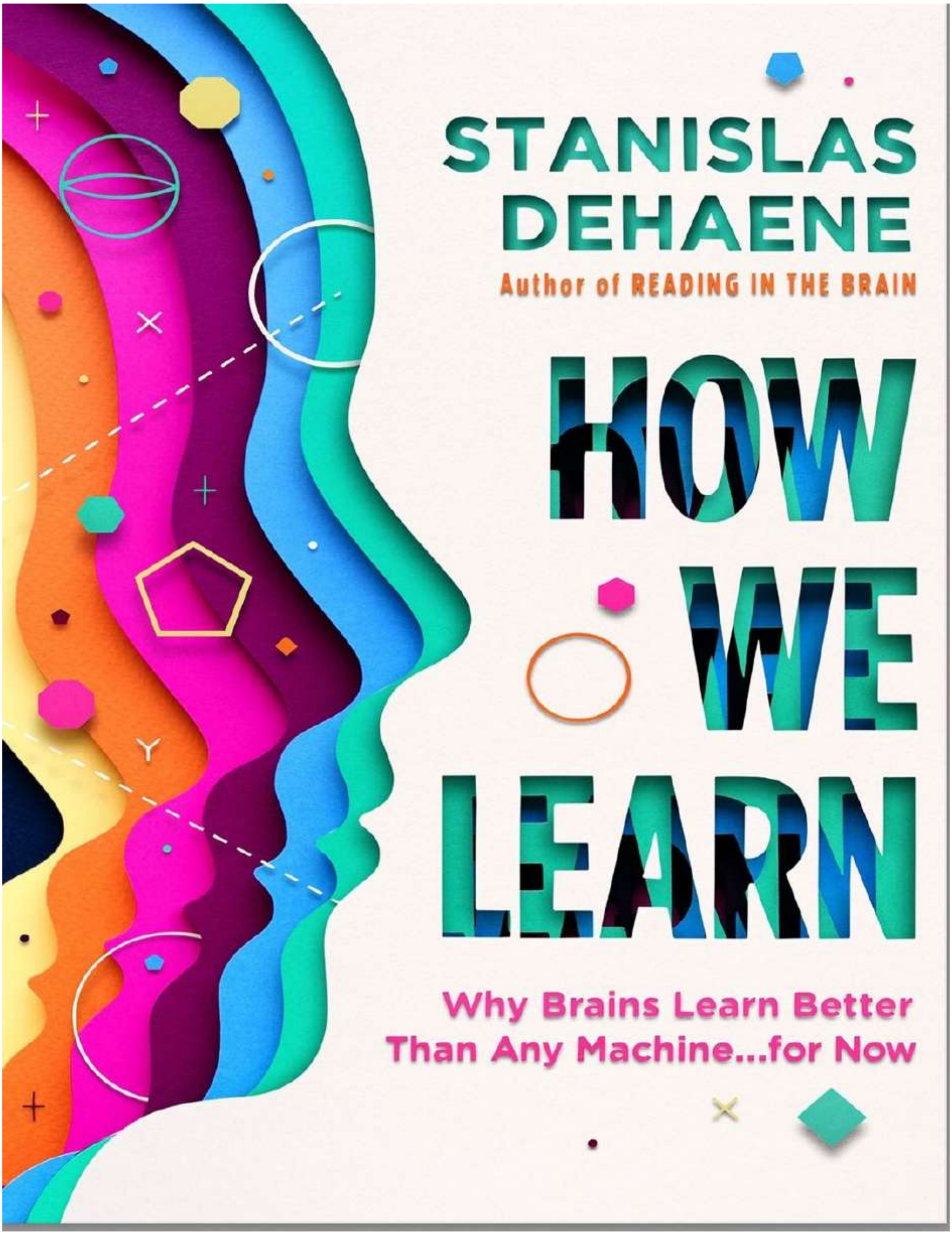
"Enrich the environment. Construction games, puzzles, rich vocabulary, serious explanations."

This message connects to what we do in the ISLE approach - observational experiments, multiple explanations, testing experiments, applications experiments, the array of multiple representations, reflections, specific attention to language - all these elements of the ISLE approach are enriching the learning environment of our students as opposed to traditional words and mathematics and demos.

"Rescind the idea that children are different – there are no different learning styles! People learn in the same way but differences learn in the extant knowledge, initial motivation, and pace of learning. Meet them where they are!"

For years I taught my students that the idea of different learning styles is bogus, not supported by any evidence. All people need concrete experience before abstract ideas, all need multiple representations, all need to be able ot test their ideas, etc. The differences mentioned by Dehaene are the exactly the things that we address in ISLE every day! (if you have questions about this aspect, please post them here, we had lots of meetings dedicated to them last year).

This is it for today. I will continue tomorrow. I am pasting the cover of the book to make it easier for yo to find it. PLEASE sign up for the meeting and do not leave this post uncommented! Thank you!



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Eugenia Etkina shared a post.
Admin
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January 20 at 9:35 PM
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This is an amazing story. When she proposed in her dissertation that the sun is made mostly of hydrogen (based on her observations and reasoning), Henry Russel (a famous astronomer and one of the creators of the famous Hertzsprung-Russel diagram) told her that it was a ridiculous idea and she should not make this claim in her dissertation as it would never be allowed to defend. 4 years later he claimed credit for this idea. Luckily, now the history has been straightened out and if you google who discovered that Universe is made mostly of hydrogen and helium, the name of Cecilia Payne comes up first. I am sharing the post by Jane Jackson today but I encourage you to listed to a podcast about Cecilia Payne on the "Stuff you missed in history class' poscast. It is facinating. Of course there are books written about her, but the podcast is short and very focused.

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Eugenia Etkina

Admin

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January 21 at 4:28 PM

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Hi all, today is the second installment of the summary of the Dehaene's book. Again, it is the connection between these recommendations and the ISLE approach that is important. I will comment on those connections.
From Dehaene (but paraphrased a little)
Dehaene: Pay attention to attention! And get rid of distractions.
Attention is a gateway to learning: virtually no information will be remembered if it has not been previously amplified by attention and awareness. Teachers should be masters of capturing students' attention and directing it to what matters. This implies carefully getting rid of all distractions: overly illustrated textbooks and excessively decorated classrooms.
Eugenia: Indeed, focusing student attention on what is important is important! In the ISLE approach we do it first by selecting very simple experiments for observational experiments with no extra bells and whistles and also telling students what to focus on. This is essential for them to come up with the patterns we want them to see. The next step is the Reflections at the end and the "Time for Telling" - this is when we again focus on the main ideas from the lesson. Paying attention to small details like two subscripts for forces, correct language for energy (NO gravitational potential energy of a single object elevated above Earth, for example) is also crucial. The students need to learn from us what is important and why.
Dehaene: Keep children active, curious, engaged and autonomous. Passive children do not learn much. Make them more active. Engage their intelligence, so that their minds sparkly with curiosity and generate new hypotheses. But do not expect them to discover everything on their own: guide them through a structured curriculum.
Eugenia: This is what ISLE is about - engaging the students in developing their own patterns, explanations, hypotheses and actively testing them. The fact that they are developing their own ideas is key! And while they are engaged in these activities, they are autonomous! Especially when they design testing experiments for their own hypotheses. But it is not an open inquiry approach. Their mental work is carefully scaffolded by our

materials. That is why using the ALG/OALE activities and asking them to read the textbook AFTER is so important. We are different form most reformed approaches that we DO NOT ask the students to read the textbook before class. They need to engage in activities first and then, only then read the book where the same activities that they just did are described. And of course, remember our kinestetic activities? We had a whole meeting on them. Review if you forgot.

If you finished reading the post, please like or comment on it. And please sign up for second energy meeting. We still have rather few people who signed up. Is the date inconvenient? Only one person commented on it so far. Thank you all!

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Eugenia Etkina shared a post.

Admin

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January 23 at 6:01 PM

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Marie Curie, Emmy Noether, Lise Meitner - these women changed our understanding of the world and the laws of physics and yet, only one of them received a Nobel Prize only because her co-author (her husband) refused to receive his if Maria was not on the team. And the names of the other two (Noether and Meitner) are not known to most physics students. This post is for your library.

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Eugenia Etkina
Admin
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January 24 at 3:38 PM

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My yesterday's post about Marie Curie, Emmy Noether and Lise Meitner was seen and commented by lots of people. Anne Ann-Marie Pendrill commented that textbooks usually do not mention their names. I am attaching a screenshot of a description of Lise Meitner's work in our textbook (Chapter 29). If this text interests you, read the book by Ruth Lewin Sime "Lise Meitner: A life in Physics". Lise Meitner and her nephew Otto Frisch explained experiments performed by many people including Enrico Fermi and Irene and Frederic Joliot Curies and, Lise Meitner, Otto Hahn and Fritz Strassman, who shot neutrons into uranium to produce heavier elements. But what they found that the elements that appeared as the result of reactions had properties similar to barium, and not at all of transuranic elements. Nobody could solve the puzzle, except Meitner and Frisch. But as history shows, long before their quantitative solution, another woman, Ida Noddack proposed this possibility. She was also never recognized for her contributions. Needless to say that neither was Lise Meitner...

Lise Meitner.

Bohr's liquid drop model of the nucleus

Quantitative Exercise 29.6 represents an experiment performed by German scientists Lise Meitner, Otto Hahn, and Fritz Strassmann in the 1930s. Their goal was not to split uranium, but instead to produce elements heavier than uranium. They thought that bombarding uranium with neutrons would lead to neutron capture and subsequent beta decay that in turn would increase the number of protons in the nucleus, thus creating heavier elements. (You will find the explanation of how neutron capture leads to the production of heavier elements in Section 29.6.) To their surprise, the nuclei produced in the reaction behaved like isotopes of barium and other nuclei with about half the mass of uranium. They were at a complete loss to explain this result. At this point, Meitner, who was Jewish, had to flee Germany under Adolf Hitler's regime. She immigrated to Sweden. There, she asked her nephew Otto Robert Frisch (who was working in Denmark with Niels Bohr) to help interpret these results.

Meitner and Frisch decided that Bohr's **liquid drop model** of a nucleus could explain the strange experimental results (see Figure 29.10). In this model, the nucleus was compared to a drop of water: just as surface tension holds the water drop together, nuclear forces hold the nucleons together. However, in heavy nuclei, such as uranium, there are too many electrically charged protons present. The protons repel each other and can overwhelm the effect of the "surface tension," especially if the nucleus is not spherical. The model suggested that such a nucleus could stretch and divide into two smaller pieces. This meant that the uranium nucleus is very unstable, ready to split with the slightest provocation—such as being hit by a neutron. Meitner and Frisch had come

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29.6 Mechanisms of radioactive decay 939

up with a model for fission. Unfortunately, the Nobel Prize committee did not think that the work of Lise Meitner contributed enough to the discovery of fission, and so she did not share the Nobel Prize given to Otto Hahn in 1944.

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Eugenia Etkina
Admin
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January 25 at 3:46 PM
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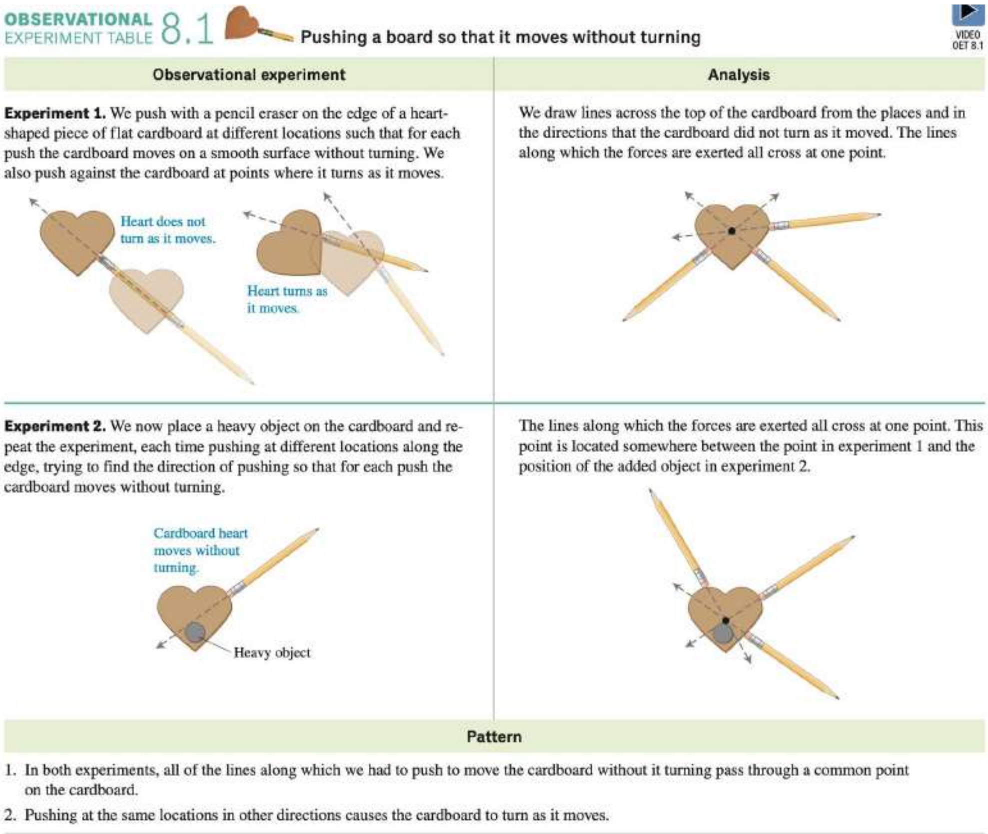
Hi all, a few things today. First, I am reminding you about our second meeting on energy this coming Saturday. So far only a few people signed up, please do! The sing up place is in the EVENTS.
Second, I am thinking of not having meetings for Statics and Rotational motion (Chapters 8 and 9) and moving to Vibrations and Waves in February. That is why I will start posting important ideas about these chapters here for those who teach this material to follow. If you feel that we need meetings for those topics, please comment.
The Chapter 8 on Static Equilibrium starts with the students developing the concept of the center of mass. We approach the center of mass differently from other books, that is why I wanted to attract your attention to the very first activity that students do do come up with this idea. The center of mass of a rigid body is a very special point. How special? If the object does not have any fixed axis of rotation, then NO force whose line passes through this point can cause the rotation of the object. The students figure out the location of this point in a very quick and yet powerful experiment. I am attaching the screenshot and the link to the video in the textbook. https://mediaplayer.pearsoncmg.com/.../secs-experiment...
Remember, ALL OUR VIDEOS ARE FREE on Pearson website. The link to those videos is on islephysics.net and I am posting it here. The OALG videos are in the OALG files on Mastering Physics or in the FILES posted

here. We have over 300 videoed experiments for you! https://media.pearsoncmg.com/aw/aw_etkina_cp_2/videos/
If you finished reading the post, please comment on it or like it. Thank you!


OBSERVATIONAL EXPERIMENT TABLE 8.1 Pushing a board so that it moves without turning

VIDEO OET 8.1

Observational experiment	Analysis
Experiment 1. We push with a pencil eraser on the edge of a heart-shaped piece of flat cardboard at different locations such that for each push the cardboard moves on a smooth surface without turning. We also push against the cardboard at points where it turns as it moves.	We draw lines across the top of the cardboard from the places and in the directions that the cardboard did not turn as it moved. The lines along which the forces are exerted all cross at one point.
Experiment 2. We now place a heavy object on the cardboard and repeat the experiment, each time pushing at different locations along the edge, trying to find the direction of pushing so that for each push the cardboard moves without turning.	The lines along which the forces are exerted all cross at one point. This point is located somewhere between the point in experiment 1 and the position of the added object in experiment 2.

Pattern

1. In both experiments, all of the lines along which we had to push to move the cardboard without it turning pass through a common point on the cardboard.
2. Pushing at the same locations in other directions causes the cardboard to turn as it moves.

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Eugenia Etkina
Admin
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January 31 at 3:31 PM
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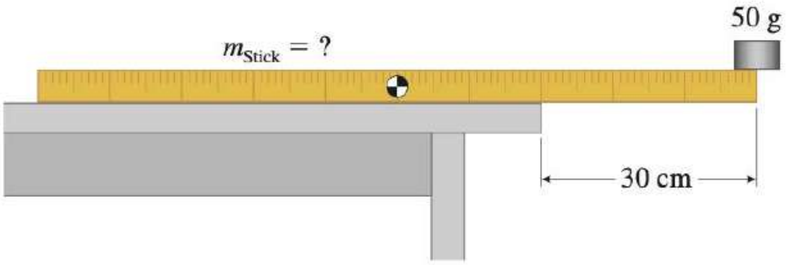
Hi all, two things today. First: Please vote for the meeting date for vibrations. So far very few people voted. If you are interested in learning how to teach vibrations through the ISLE approach, please choose the date that is good for you or vote for both.
Second: I continue our discussions related to static equilibrium. Note for those who use PUM materials - we do not have statics module, if you plan to teach torque and equilibrium, use the ALG or the OALG. I will not go through the ISLE progression of how to help students construct the physical quantity of torque and equilibrium conditions as this progression is described in the textbook and in the ALG/OALG through activities.
I will focus on a quick but efficient lab to help students apply this knowledge. All you need to this lab is a meter stick, a small object of a known mass and a scale. The students need to design an experiment to determine the mass of the meter stick only using this small object of a known mass and then compare what they find using a scale. This is an application experiment and thus, the students need to use uncertainties and assumptions to explain the difference in the results. I love this experiment, it was one of the first application experiments that I developed when I was a high school physics teacher. So, it is over 35 years old
Here is the text in the ALG:
8.4.1 DESIGN AN APPLICATION EXPERIMENT
PIVOTAL Lab: Equipment per group: whiteboard and markers, meter stick, 100-g object.
You have a meter stick of unknown mass and a small 100-g object. Design an experiment to determine the mass of the meter stick using your knowledge of static equilibrium.
a. Draw a picture of the experimental set-up.
b. Describe the procedure in words.
c. Apply the concepts of equilibrium to develop equations that can be used to predict the mass of the meter stick. Then predict the mass.
d. Use a scale to measure the mass and compare the result to the predicted value.
e. How can you explain the difference between the predicted and the measured value?
As always, there is a solution to the problem in the textbook, disguised as Try it Yourself after one of the worked examples - see the a.ttached screenshot

If you read the post to the end, you know what to do. Thank you!

Try it yourself A uniform meter stick with a 50-g object on it is positioned as shown below. The stick extends 30 cm over the edge of the table. If you push the stick so that it extends slightly farther over the edge, it tips over. Use this result to determine the mass of the meter stick.



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Eugenia Etkina
Admin
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February 2 at 3:45 PM
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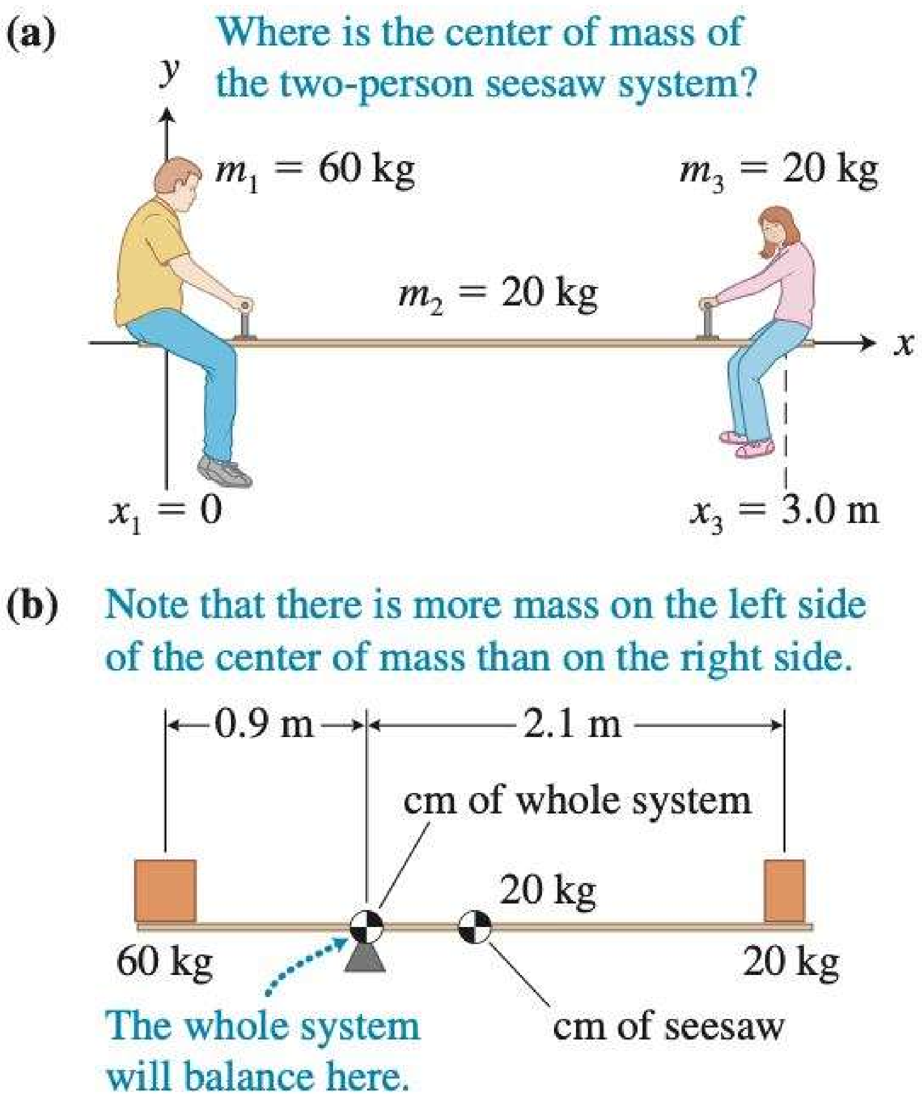
Hi all, thank you for responding yesterday. It means that some posts reach you. I am not sure what to do to help you see the posts every day. One way to do it is to check the posts as often as you can (once a day is good) to see what new stuff came. It comes every day. I post professional development ideas and the members share their ideas, post questions, etc. If we wish to have a community, we should try to participate. Liking and commenting on the posts also helps Facebook notify you about the next post. I thank you all for doing just that.

Today two things: please scroll down and find the poll for the Vibrations workshop. So far February 18th wins, but maybe if more people reply, the date will be the 25th. PLEASE vote!
Second, I wanted to continue with the center of mass. Please check my previous post on this (Jan 31). The term center of mass is very confusing. This point is not the point around which the mass of an object is distributed evenly. IT IS NOT!
The center of mass is always closer to the part of the object that has more mass. This is because the lighter parts that are farther away produce a larger torque due to the larger lever arm. The example showing it is attached. So, what is it the center of? What do you think?
The example is my previous post of January 31 is a great experiment for the students to figure it out. Let them tape a small (100 g) object of a known mass to the end of a meter stick and then ask them to find the center of mass by balancing the contraption and figure out the masses on two sides. They will see that the masses on two sides of the point are unequal.
WHY?? It is an amazing activity and I encourage you to do it with your students. There is another very interesting aspect of the center of mass which I will discuss tomorrow. If you finish reading, please lie the post or comment on it. Liking it does not really mean that you have this feeling, it is just a way to make it more visible for other group members.

FIGURE 8.17 The masses on each side of a system's center of mass are unequal.



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Eugenia Etkina
Admin
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February 3 at 3:27 PM
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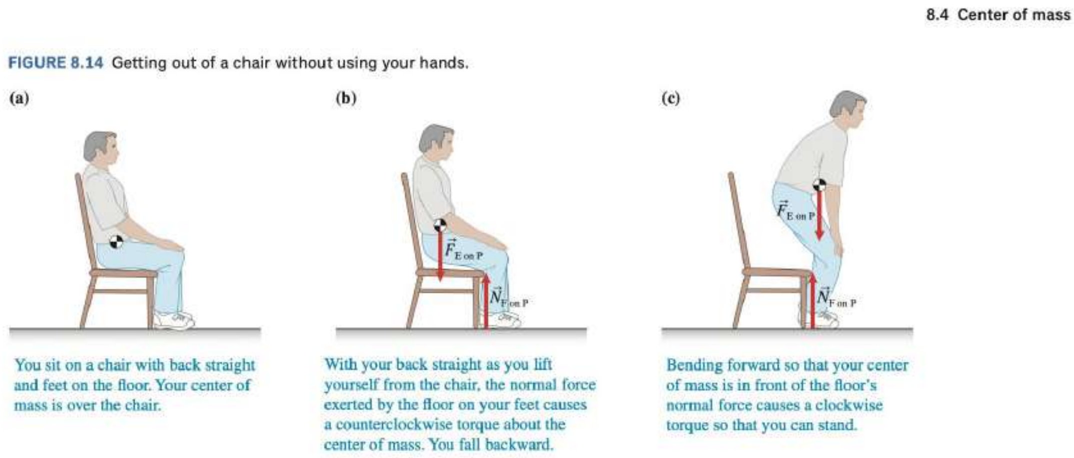
Hi all, thank you for your incredible and caring response to my plea to "like" the posts to make them more visible. THANK YOU! Please keep doing it! Two things today.
It looks like Feb 18 is a better day for the workshop on Vibrations. I am calling our meetings Workshop now as this is what Anne L. Caraley called them, and I think it is an accurate name. I will create the EVENT for the workshop tomorrow.
Second, I will continue with the center of mass. One of the best experiments to see the role of the center of mass in our lives is the following. I make all my students do it and it serves as a great "need to know" for static equilibrium and later as an application experiment that they can explain themselves. Here it goes.
Sit on a chair with your back firmly to the back of the chair and feet in front of the chair, not under. In this position try to stand up. Do not bend forward, keep your back strictly vertical. You will never be able to do it, as the torque due to the force that Earth exerts on you (the force passing through the center of mass of your body) and the force exerted on your feet by the floor will rotate you back to the sitting position. You can only get up if you tilt forward or put your feet under the chair. You need to make sure that the torques due to the force exerted on you by Earth and by the floor rotate you forward. Drawing force diagrams and analyzing torques helps explain this unsuccessful attempts. Try it yourself, then with your students and you will be amazed how great it works! Here are the pictures from the textbook describing and explaining the experiment.
If you finished reading the post, please comment or like it! Thank you!



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Eugenia Etkina
Admin
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February 5 at 4:26 PM
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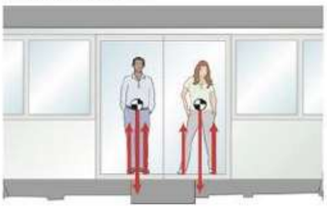
Hi all, my post from yesterday is again, invisible. I posted about the meeting on Vibrational Motion and people are not seeing it. I am not sure what is happening to Facebook. Please, if you are reading this post, check out my post from yesterday, it is very important.
Today I will continue with static equilibrium, specifically, about how stable is the equilibrium. I do not think any other textbooks discuss the issue of stability of equilibrium: when is the equilibrium stable? What does it mean the equilibrium is stable? Those who rock sitting on a chair know what it means. You rock and then the chair comes back to the vertical position. Until it does not.... You probably all saw people riding a bicycle on a rope. How do they do it? We discuss it all in the book following the ISLE approach - observe, think, explain, design an experiment to test your

explanation, predict the outcome of this experiment using the explanation, run the experiment, and compare outcome to the prediction, revise and repeat if the outcome and the prediction do not match. Here is the beginning of this conversation in the textbook. The video is at https://mediaplayer.pearsoncmg.com/.../secs-egv2e-testing...
Check out Chapter 8 to continue and if you do not have the textbook, get an examination copy from Pearson. The instructions how to do it are on islephysics.net or just email me at eugenia.etkina@gse.rutgers.edu
If you read the post, you know what to do next. PLEASE comment or like it. Thank you.

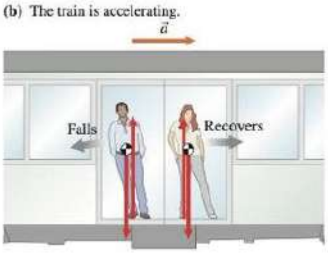
238 CHAPTER 8 Extended Bodies at Rest

FIGURE 8.21 Balancing on the subway.

(a) The train is at rest.



(b) The train is accelerating.



Equilibrium and tipping objects

You have probably observed that it is easier to balance and avoid falling while standing in a moving bus or subway train if you spread your feet apart in the direction of motion. By doing this you are increasing the **area of support**, the area of contact between an object and the surface it is supported by. To understand area of support, consider two people riding the subway (see **Figure 8.21**).

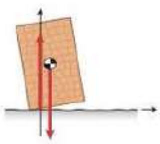
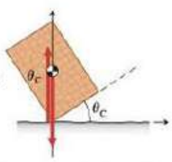
In Figure 8.21a, the man's feet are close together, whereas the woman's feet are farther apart. When the train accelerates toward the right, as shown in Figure 8.21b, the two people tilt to the left. The man falls over because the gravitational force exerted by Earth on his body is outside the area of support provided by his feet. The woman recovers because the gravitational force still points between her feet. These patterns lead us to a tentative rule about tipping:

> For an object in static equilibrium, if a vertical line passing through the object's center of mass is within the object's area of support, the object does not tip. If the line is not within the area of support, the object tips.

If this is a general rule, then we can use it to predict the angle at which an object with a known center of mass will tip over (see Testing Experiment **Table 8.4**).

TESTING EXPERIMENT TABLE 8.4 Testing our tentative rule about tipping

VIDEO TET 8.4

Testing experiment	Prediction	Outcome
Experiment 1. Place a full box of crackers on a flat but rough surface. Its center of mass is at its geometric center. The box's height is 20 cm and the bottom surface is 13 cm × 6.5 cm.	1. The center of mass of a full box of crackers is at its geometric center. 	
Tilt the box along the 13-cm side a little and release it.	2. When you release the slightly tilted box, it returns to the vertical position because of the torque due to the gravitational force exerted by Earth. 	The box returns to the vertical position.
Tilt the box at larger and larger angles. Predict the angle at which the box will tip.	3. When you tilt the box more and more, eventually the line defined by the gravitational force passes over the support point for the box at its bottom edge. Tilting the box more than this critical angle causes it to tip over. 	
	4. For a box with a side of 13 cm and a height of 20 cm, this angle will be $\theta_C = \tan^{-1}(13\text{ cm}/20\text{ cm}) = 33°$.	The outcome matches the prediction.

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Eugenia Etkina
Admin
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February 7 at 3:52 PM
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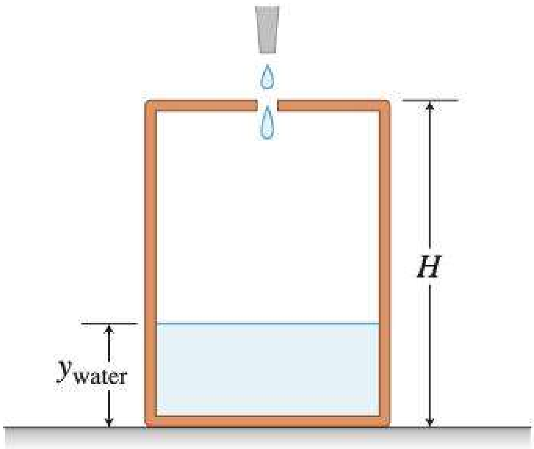
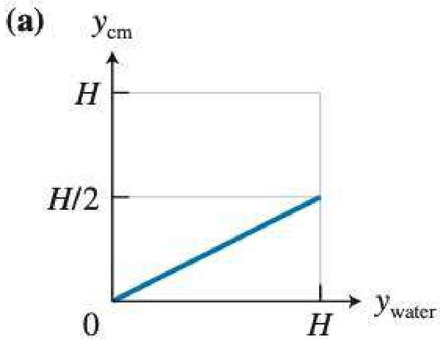
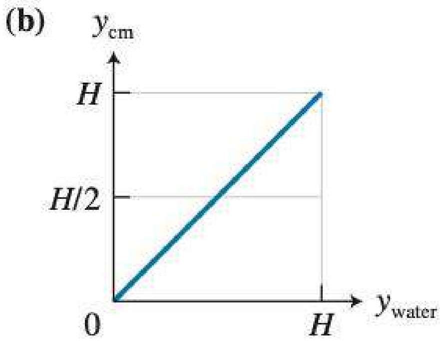
Hi al, first thank you for responding to my pleas to like or comment on the posts - the numbers of views is climbing up to the numbers that we had prior to when the posts became invisible. Please continue!
Second, I wanted to remind you of one of the important features of the ISLE approach - Using multiple representations as reasoning tools. While many curricula approaches use MRs, we use them often in non-traditional ways and we have our specific ones that nobody else has. This non-traditional ways of using a familiar representation is one of the features of AP problems too. Today I am posting an example from Chapter 8 (as we have been working on it for a while). Please post your answer choices and explanations in the comments. And also, please comment on what reasoning skills a students should use to be successful on this problem. The problem uses graphical representations but not the functions of time. If you have our textbook, you will find examples of such non-traditional use of graphs in almost every chapter. Enjoy!
And if you read the post, PLEASE do not forget to comment on it or like it. THANK YOU!!!

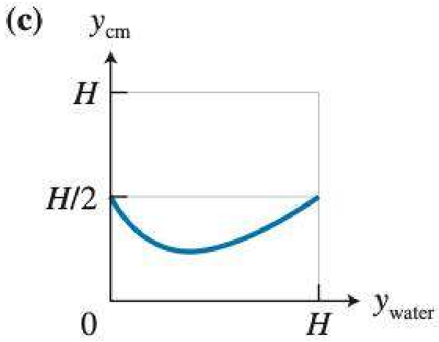
11. Water starts dripping at a constant rate into an empty plastic can through a small opening at the top, as shown in **Figure Q8.11**. Which graph shows the correct qualitative dependence of the vertical position of the center of mass of the water-can system (y_{cm}) on the height of the water level in the can (y_{water})?

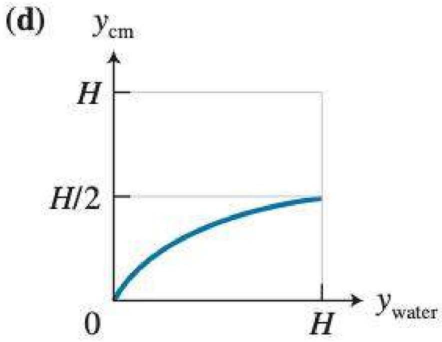
FIGURE Q8.11

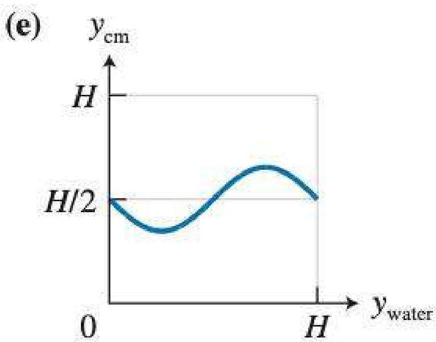












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Eugenia Etkina
Admin
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February 8 at 4:10 PM
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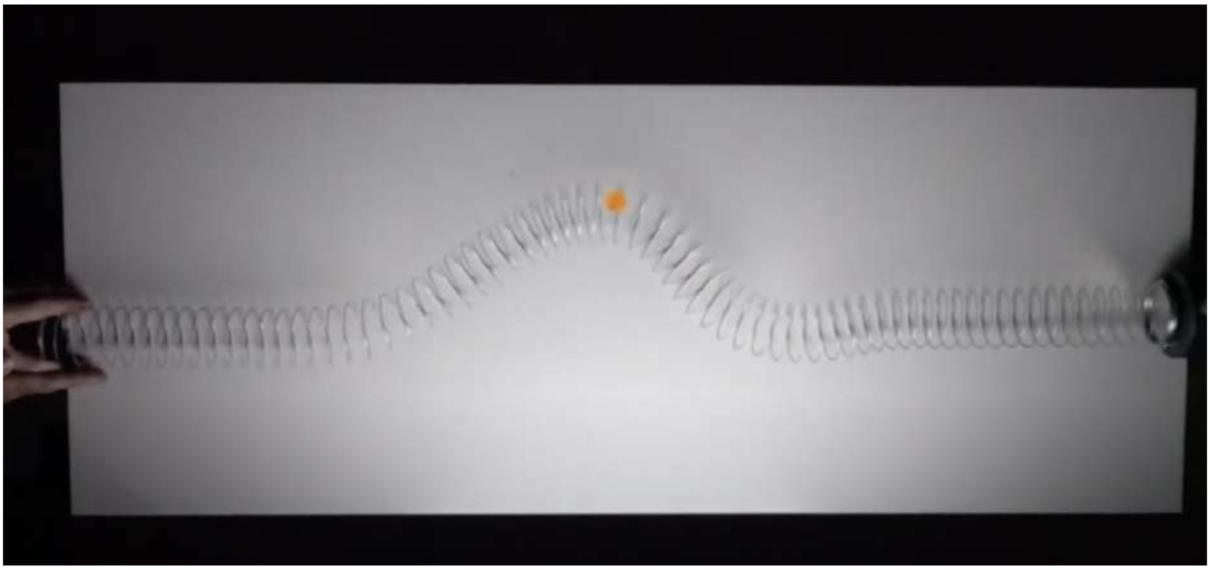
Hi all, I already wrote that Gorazd Planinsic and I are working on a new book dedicated to educating teachers who wish to implement the ISLE approach. One of the elements of such education is the development of productive habits. Habits of mind, habits of practice, and improvement.
Today I am starting a set of posts dedicated to the development of physics habits of mind. Such habits are crucial for implementing the ISLE approach.
Here is the first installment:
In order to implement the ISLE approach, a teacher needs to think like a physicist habitually. One of the most important habits of such thinking is treating physics as a process not as a set of rules. This habit relates to the physics epistemology. If we think about epistemology as the field of knowledge that investigates the elements of knowledge and how the knowledge is constructed, then the above habit is an epistemological habit. What does it mean to have physics epistemology?
First, let’s consider the elements of physics knowledge. We could group the normative knowledge (the knowledge that our students need to develop independently of the level of a physics course that they are taking) into the following categories: physical phenomena and physical objects,
models of phenomena (objects, systems, etc.),
physical quantities and their relationships,
measuring instruments,
physics devices,

testing experiments,
predictions of the outcomes of testing experiments,
application experiments,
assumptions.
If you think of ANYTHING that you know in physics, your knowledge would fall into one of those categories. We will analyze each of them separately and give examples of how to help teachers and students think about each as a physicist.
1. Physical phenomena and physical objects(things that happen and can be observed directly or indirectly).
Examples are mechanical motion of discrete objects, wave motion on a disturbed string, fluid flow in a river, light shining on a surface, clothes sticking to each other after being pulled from a dryer. When we observe physical phenomena, we conduct observational experiments with no expectation of the outcome. The goal of doing such experiments is to identify some pattern with later we model or explain. When students observe phenomena, it is important to ask the following questions:
· What did you observe?
· What data can you collect?
· How can you represent the data to find patterns?
· What are the important patterns?
· What patterns can we explain?
Here is an example of a physical phenomenon: Use a slinky and have the students take a slo mo movie of a pulse propagating through it. https://www.youtube.com/watch?v=gT5_KYmOgKs The students observe the disturbance that they created travel along the slinky. They also observed each coil moving up and down while the disturbance propagated to the right.
· They can collect data concerning the speed of the propagation of the disturbance, they can change how the slinky is taut and measure the speeds, they can also change the amplitude of the disturbance and measure the speed and so forth.
· There are many patterns that they can find varying different parameters.
· They can explain the propagation by the interactions of the coils and use this explanation to account for different speeds for different conditions.

To help students conduct observational experiments in the ISLE approach, we have developed relevant self-assessment rubrics. They can be found at https://drive.google.com/.../0By53x8SYAF1IR1plbFV.../view... Please like or comment on the post to make it more visible. Thank you.



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Eugenia Etkina
Admin
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February 8 at 11:18 PM
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Hi all, this is my second post today at the request of Hrvoje Mililoža. Hrvoje Miloloža and Eugenio Tufino are working together to solve the problem of deleted zoom recodings of our workshops. They only last on the cloud for about 10 months and then they get deleted. Hrvoje and Eugenio will save them as audio files (the videos themselves are huge) and post them in our archive google folder. They asked me to make a post and ask people if anyone saved the videos on their hard drive. They are asking if anyone saved the following recordings:

2. How to save time when helping students learn physics?
4. Kinestetic activities
5. The ISLE approach: Essential elements that cannot be omitted
Please let us know if you have those video recordings saved, thank you!

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Eugenia Etkina
Admin
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February 9 at 3:43 PM
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Hi all, today is the second post about elements of physics. Yesterday, the first element was physical phenomena and objects. today the post is about the models of physical phenomena, objects, interactions, etc. Read on. Please do not forget to like or comment after you are done reading. Thank you. Warning: long post.
1. Models of phenomena, objects, systems, processes and interactions
While the word model is ubiquitous in educational vernacular, the definitions of models vary in textbooks and science education literature. In the ISLE approach we adopt the definition of a model as a simplified version of a phenomenon, object, a system, or a process (Etkina, Gentile and Warren, 2005). Examples of models are free fall (model of a phenomenon when you consider objects falling in the absence of air - simplification) and point-like objects (model of an object when you disregard the object's size – simplification).
Etkina and colleagues discuss different types of models including models of systems (ideal gas), models of processes (constant motion model, isobaric process, isothermal process), or models of interactions (field model). It is possible to think of what we call hypotheses or explanations

of phenomena as models, because those are simplifications in some way too.
Explanations can be causal or mechanistic. A causal explanation (a causal model) shows how one physical quantity depends on another quantity but does not have a mechanism (for example F= G m1m2/r^2, see cause-effect relationships below). A mechanistic explanation involves a mechanism explaining the relationship (for example, the liquids cool during evaporation as the fastest molecules leave and the average kinetic energy of the remaining molecules decreases). When students develop models, it is important to ask the following questions:
· What phenomenon, or object, or system are you trying to simplify?
· What are your simplifications?
· How can you justify these simplifying assumptions? or When is the model applicable?
· Is the model qualitative (if yes, is it causal or mechanistic) or quantitative?
· What experiments can you conduct to rule out the model?
· What predictions can you make about the outcomes of these experiments using the model?
· What are the limitations of the model?
Here is an example of analysis of an ideal gas model using the above questions:
· We are trying to simplify real gases.
· The simplifications are that the particles are identical point-like objects that have mass but no size, they interact with each other only during collisions but not at a distance, and their motion obeys Newton's laws.
· As the interactions of microscopic particles decrease dramatically is the distance between them is larger than their sizes, we can estimate that in air for example, the average distance between the particles in air at normal conditions is about 30 times larger than their diameter, therefore their size is negligible and there is no interaction at a distance.
· The model is both qualitative and mechanistic and quantitative. The mechanistic aspect relates to how the model explains why the gas exerts pressure on the walls of the container. We can quantify the model and use it to describe the pressure that ideal gas should exert on the walls of a container (p=1/2 m0nV^2).

· We can test this model to predict how the pressure of the same gas should depend on the volume or temperature. See relevant experiments in Chapter 15 of College Physics: Explore and Apply.
· The model is limited to rarefied gases.
There is another important point that we need to consider. It is the relationship between the models and multiple representations. We can think of a force diagram or an energy bar chart, for example, as an abstract model of a phenomenon of interaction of an object with other objects. If the students view a force diagram or a bar chart in this way, they can answer the same questions about the diagram as listed above.
Let's say the students need to model the phenomenon of dribbling a basketball in place using a bar chart (to learn how to draw bar charts, use Chapter 7 in College Physics: Explore and Apply)
· First, they need to observe the phenomenon of dribbling in place. They can choose the ball, Earth, and the floor as a system and the hand that touches the ball as an external object. The initial state is right after the hand pushed the ball and it is going down with some kinetic energy and the final state when the ball comes up to the hand.
· We simplify the situation by ignoring surrounding air and the motion of Earth. The simplification of Earth as stationary is easily validated, as its mass is infinitely larger than the ball's. How can we validate the air assumption?
· The model is quantitative. According to it, some of the ball's kinetic energy is converted to the internal energy of the ball and the floor during their interactions, the ball does not shoot over the height from which it was dropped which should have happened if no mechanical energy was lost. The ball comes back to the same height not higher.
· This analysis also leads to predictions of multiple testing experiments: what will happen if a person merely drops the basketball, what will happen if a person pushes harder on the ball at the beginning, etc. We can see how an abstract model of an energy bar chart allows us to explain phenomena and predict new phenomena.
· The model is limited to dribbling in air when the distance of the dribble is much less that Earth's radius.
Reference to the paper about the models: Etkina, E., Warren, A., & Gentile, M. (2006). The role of models in physics instruction. The Physics Teacher, 43(1), 15-20. The figure attached is from the paper.

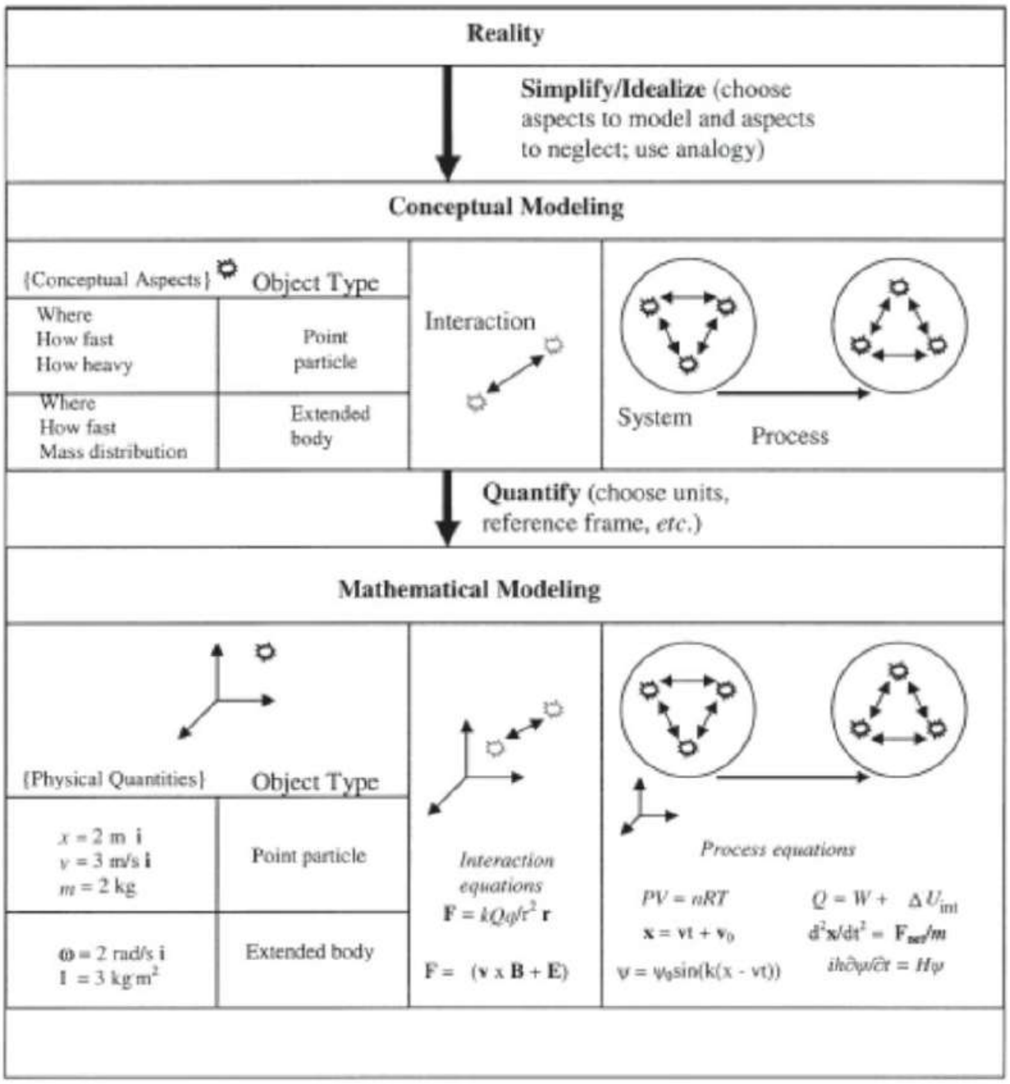

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Fig. 1. We can model nature by focusing on an object, an interaction, a system, or a process. Quantifiable models include mathematical expressions such as interaction equations, state equations, and causal equations.

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Eugenia Etkina shared a link.
Admin
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Hi all, today is my third post about the habits of mind of physicists. We started with the elements of physics knowledge and went over phenomena and models (see my mosts in two previous days). Today my post is about physical quantities.
Please do not forget to like it or comment on it to make it more visible. Thank you.
Physical quantities and their relationships characterize models quantitatively (these are velocity, acceleration, force, electric charge, etc.).
A physical quantity is a feature or a characteristic of a physical phenomenon that can be measured in some unit. A measuring instrument (next post) is used to make a quantitative comparison of this characteristic with a unit of measure. Examples of physical quantities are your height, your body temperature, the speed of your car, or the temperature of air or water.
Physical quantities that contain information about the direction of some quantity are called vector quantities and are written using symbols with an arrow on top (F, v). Force and velocity are vector quantities. Physical quantities that do not contain information about direction are called scalar quantities and are written using italic symbols (m, T, and l). Mass is a scalar quantity, as is temperature.
It is important to recognize the difference between operational definitions of the quantities (a= delta v / delta t) and the cause effect relationship (a = sum of forces/mass) – see causal explanations that I posted about yesterday.
An operational definition tells us how to determine a specific quantity but does not tell us why it has a specific value as the variables in the definition cannot be changed independently (when we double time interval, the change in velocity doubles). A cause effect relationship tells us what the quantity depends on as we can change the variables in dependently (the

mass of an object can be doubled without changing the net force exerted on it).
One of the important features of physical quantities is that they are not exact numbers with units (or points on a number line), they are intervals. The value of the interval within which we know the quantity is predicated on the method that we used to determine it. An excellent document describing how to help students learn about experimental uncertainties in the ISLE approach was created by M. Gentile and A. Karelina and can be found at https://drive.google.com/.../1bYPf4GzCTtETFT7C9tz4g791MQp... .
When the students are developing a new physical quantity, it is important to ask them the following questions:
· What phenomenon or a model does this quantity describe?
· How do you define the quantity operationally?
· What are the units of the quantity?
· How does this quantity depend on other known quantities? How do you know it?
· How can we test this relation experimentally?
· How do we determine the quantity: can we measure it directly or we need to calculate it using other measurable quantity?
Here is an example of analyzing the physical quantity of acceleration:
· The quantity describes the changes in motion of an object. Operationally acceleration is defined as as lim of delta v/delta t where delta v is the change of velocity vector and delta t is the time interval during which this change occurred. Based on the definition depending the delta t we can talk about instantaneous acceleration or average acceleration.
· The units of acceleration are m/s^2
· For an inertial reference frame observer, the acceleration of an object (or system) depends on its mass and the sum of forces exerted on it [insert equation here]. We can test this cause-effect relationship using an Atwood machine setup for example.
· We can “measure” the quantity using an accelerometer.
To help student answer the above questions we have developed self-assessment rubrics. They are at https://drive.google.com/.../0By53x8SYAF1IT3lwa3o.../view...
Please comment on your thoughts about physical quantities! Thank you!

RUBRIC G: Ability to collect and analyze experimental data					
	Scientific Ability	Missing	Inadequate	Needs improvement	Adequate
G1	**Is able to identify sources of experimental uncertainty**	No attempt is made to identify experimental uncertainties.	An attempt is made to identify experimental uncertainties, but most are missing, described vaguely, or incorrect.	Most experimental uncertainties are correctly identified. But there is no distinction between random and experimental uncertainty.	All experimental uncertainties are correctly identified. There is a distinction between experimental uncertainty and random uncertainty.
G2	**Is able to evaluate specifically how identified experimental uncertainties may affect the data**	No attempt is made to evaluate experimental uncertainties.	An attempt is made to evaluate experimental uncertainties, but most are missing, described vaguely, or incorrect. Or only absolute uncertainties are mentioned. Or the final result does not take the uncertainty into the account.	The final result does take the identified uncertainties into account but is not correctly evaluated. The weakest link rule is not used or is used incorrectly.	The experimental uncertainty of the final result is correctly evaluated. The weakest link rule is used appropriately and the choice of the biggest source of uncertainty is justified.
G3	**Is able to describe how to minimize experimental uncertainty and actually do it**	No attempt is made to describe how to minimize experimental uncertainty and no attempt to minimize is present.	A description of how to minimize experimental uncertainty is present, but there is no attempt to actually minimize it.	An attempt is made to minimize the uncertainty in the final result is made but the method is not the most effective.	The uncertainty is minimized in an effective way.
G4	**Is able to record and represent data in a meaningful way**	Data are either absent or incomprehensible.	Some important data are absent or incomprehensible. They are not organized in tables or the tables are not labeled properly.	All important data are present, but recorded in a way that requires some effort to comprehend. The tables are labeled but labels are confusing.	All important data are present, organized, and recorded clearly. The tables are labeled and placed in a logical order.
G5	**Is able to analyze data appropriately**	No attempt is made to analyze the data.	An attempt is made to analyze the data, but it is either seriously flawed or inappropriate.	The analysis is appropriate but it contains minor errors or omissions.	The analysis is appropriate, complete, and correct.

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Eugenia Etkina
Admin
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Hi all, I continue today the series of posts related to the epistemology of physics. Remember that epistemology is the study of knowledge: what elements constitute knowledge and how it is constructed. We continue the conversation about elements. In my previous posts I wrote about phenomena, models, and physical quantities. Today is measuring instruments and physics devices.

1. Measuring instruments help us measure physical quantities (such as a meter stick, a clock, am ammeter, etc.) Some quantities can be measured

directly using an appropriate device (time, length, electric current) and some can only be calculated (kinetic energy, entropy). Here is the list of questions that the students should be able to answer about any measuring instrument.

· What physical quantity does this instrument allows us to determine?

· What are the physics principles behind the operation of the instrument?

· What are the rules of the operation of the instrument.

· What are safety procedures (if applicable)?

Below is an example of the analysis of such measuring instrument as a spring scale to determine unknown forces. (see the example from the textbook College Physics: Explore and Apply.

· A spring scale allows us to determine an unknown force.

· The principles of operation of a spring scale are Newton’s second law and superposition of forces. The scale shows the stretch of a spring which is calibrated in newtons using Hooke’s law. The scale us used to balance an unknown force. For example, when we use the scale to hang an object at rest (zero acceleration), the forces that the spring scale and Earth exerts on the object add to zero (superposition), or balance each other (Newton's second law, as acceleration is zero). Therefore, the magnitudes of these forces are the same and the reading of the scale is equal in magnitude of the force that Earth exerts on the object.

· To have an accurate measurement of an unknown force, the scale and the object have to have zero acceleration. To have an accurate reading of the scale, the person reading the scale needs to have their eyes at the level of the dial.

· What are safety procedures? Do not use the scale for the forces larger than the largest measurement it reads.

2. Physics devices (a motor, a generator, a mirror, a lens, a battery). When the students learn encounter a new measuring instrument, it is important to ask the following questions:

· What is the name of the device?

· What are the main parts of the device?

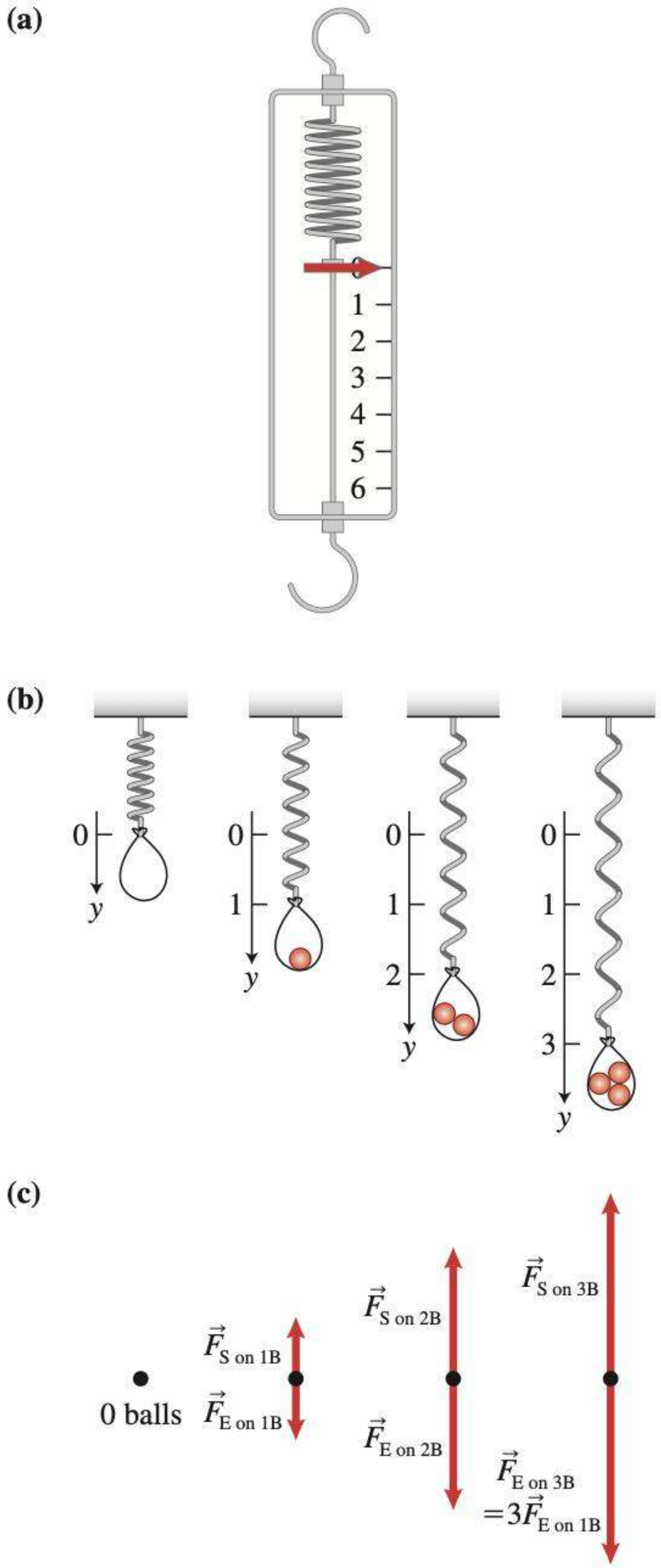
· What are physics principles/ relations that govern the operation of a device?

· What are the safety procedures?

We can take as an example an AC electric generator. Here are possible answers:

· The name is electric generator.
· The main parts are a rotating coil of wire and a stationary magnet or a rotating magnet and a stationary coil of wire (or a stationary coil and a rotating magnet).
· The principle of operation is electromagnetic induction: when magnetic flux through the coil is changing due to the relative motion of the coil and the magnet, electric current is generated through the coil.
· I did not come up with safety procedures yet. Any ideas?
If you finished the reading, please comment on the post or like it to make it more visible. Thank you.

FIGURE 3.5 Using a spring scale to measure forces.



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Eugenia Etkina shared a link.
Admin
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Hi all, late post today. I continue with the last several elements of physics. Tomorrow we will talk about how those elements are connected logically. Waring: long post. When you finish reading, please like it or comment on it. thank you.

1. Testing experiments. These are experiments specifically designed to test a model/hypothesis/explanation. They are different from the observational experiments, although they also involve physical phenomena as we predict their outcome using the idea under test before conducting those experiments. An example of such testing experiment can be the famous Galileo's inclined plane experiment when he was testing his hypothesis that all objects fall at constant acceleration without air resistance.

Here are the questions that will help our students design and conduct testing experiments:

· What is the hypothesis/model/relation to be tested?

· Brainstorm possible experiments whose outcome you can predict using the hypothesis/model/relation under test. What quantities can you measure and what quantities can you calculate?

· Make predictions about the outcomes of the experiments that you designed (before conducting them) as if the hypothesis that you invented is correct. How does the prediction follow from the hypothesis? Explain.

· What additional simplifying assumptions are you making in your predictions?
· How do these assumptions might affect the predicted outcome – do they make the result smaller or larger than actual?
· After you conducted the experiment, how do you know whether the prediction and outcome match or do not match?
· What is your judgment about the hypothesis/model/relation?
We will analyze Galileo's inclined plane experiment as an example.
Galileo was testing his hypothesis that when objects fall freely, their speed increases proportionally to time, in other words v is proportional to t.
As he could not measure the speed directly and the time of fall was always rather short for the times when people did not have hand held watches, Galileo decided to measure the distance instead. He designed an experiment where a small ball rolled down an inclined plane and he made a prediction of what he should observe if his hypothesis is correct (as well as assumptions that this motion is similar to the motion fo a falling object).
While he used graphical methods to make the prediction, we can use our modern mathematical methods to do it: If v = at(where a is the coefficient of proportionality) then the average speed is at/2. Therefore, the distance traveled during time t is (at^2)/2. From this reasoning follows that the distance increases as the square of the time for an object that starts from rest. Therefore, if the ball covers distance d during the first second, in two seconds it would cover distance of 4d, in 3 second, 9d and so forth.
Galileo could measure these distances and compare those to predicted.
He also assumed that the motion of a rolling ball down the inclined plane is similar to the motion of a falling object. It is not clear how Galileo validated his assumption, but today we can do multiple testing experiments for his hypothesis that for a falling object without air resistance v = at. We can use the motion detector to obtain position vs time graph or design an indirect experiment with a string and fishing weights. Gorazd Planinsic, did this experiment with his students took a video. I will ask him to post the video here.
To help students learn to design testing experiments, we have developed a set of rubrics that can be found at https://drive.google.com/.../0By53x8SYAF1lUWtJX1N.../view...
2. Predictions of the outcomes of the testing experiments (not to be confused with hypotheses or models).

A prediction is a statement of the outcome of a particular experiment (before you conduct it) based on the hypothesis being tested. It says what should happen in a particular experiment if the hypothesis under test is correct. Prediction is not a guess. Without knowing what the experiment is, one cannot make a prediction. A prediction is not equivalent to a hypothesis but should be based on the hypothesis being tested. In the above example of Galileo, the hypothesis was that velocity of the objects is proportional to the time of fall and the prediction was the when the objects roll down the ramp, the distance that they cover is proportional to the time squared. Rubrics for the development of the ability to make predictions are at https://drive.google.com/.../0By53x8SYAF1IUWtJX1N.../view...

3. Application experiments.

These experiments are different from observational or testing experiments as to design them one needs to put several tested models together to achieve a specific goal. They make a bridge between physics and engineering. The goal can be the measurement of a physical quantity (how many significant figures of g do we know? How much energy does a square meter of Earth receive from the Sun? What is the coefficient of static friction between your shoe and the carpet?) or to build a specific device (to power an LED without burning it, or to build an electric motor, a telescope, etc.). Here are the questions that help students design and analyze application experiments:

· What is the problem that you are trying to solve?

· What experiment can you design to solve the problem?

· What equipment will you use? What physical quantities will you measure and how will you measure them?

· What is the mathematical procedure that will allow you to use the measured quantities to solve the problem?

· What additional assumptions are you making? How can you validate them?

· How will you evaluate the results of your experiment?

· What independent experiment can you design to solve the same problem?

· After you compared the results of the two experiments, are they the same or different? How do you know?

An example of a good application experiment is at http://islevideos.net/experiment.php?topicid=13&exptid=120
4. Assumptions.
Assumptions, as they are understood by physicists, are the things that we choose to ignore (air resistance, roughness of surfaces, mass of pulleys, rotational and velocity of Earth, etc.). The ISLE approach activities encourage students to make the assumptions and evaluate their effect on the predicted outcome of a testing experiment. The prediction is made based on the hypothesis under test, but additional assumptions that the prediction does not take into account might make prediction larger or smaller that the experimental outcome. Evaluating the effects of additional assumptions is crucial for testing models/hypotheses. To learn more about assumptions, read the document written by D.T. Brookes at https://docs.google.com/.../0By53x8SYAF1lbVN5Sk9P.../edit...
Assumptions.docx

https://www.facebook.com/groups/320431092109343/posts/1361077701378005/?__cft__[0]=AZXdgHKQrelWJoyslc9DOTZoC-VU1CBk9av49OTjNCl9Hu0iICnZsINlyWi3C9B4ZJjWZ3eSLnX5WkgnwV4yuio5uaO_NyiVe55xT_OKFjv0vwQAio4sjYcq2BxYojPyugbUjX2dh6cBOXmz33wdlzp9vMDdhjKMQfaIJk8HywGQUNnUS38bWRZqFKCyRVnpcE&__tn__=%2CO%2CP-R

Eugenia Etkina shared a link.
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Hello @everyone and Exploring and Applying Physics members! (I am trying to use the words to make the posts more visible!) Two things today: A reminder about our Saturday workshop - 10 am Pacific US Time, 1 pm Eastern US Time and 7 pm Central European Time. Vibrations. Zoom link: https://rutgers.zoom.us/my/etkina... password 164680

Second I continue with the types of reasoning that physicists use to construct knowledge. If you missed my post from February 14th, please read it first before you read this one. That post seems to be invisible for many people no matter what I do. Here is the next type of reasoning - SPHERICAL COW REASONING:

Spherical cow reasoning

Wikipedia, defines spherical cow reasoning as “a humorous metaphor for highly simplified scientific models of complex phenomena. Originating in theoretical physics, the metaphor refers to physicists' tendency to reduce a problem to the simplest form imaginable in order to make calculations more feasible, even if the simplification hinders the model's application to reality.” (https://en.wikipedia.org/wiki/Spherical_cow...)

Although Wikipedia considers the spherical cow metaphor humorous, it lies at the heart of physics – simplifying an incredibly complicated world to be able to explain and predict it. While the language of spherical cows is not used in education, we engage our students in “spherical cow” reasoning every time we ask them to ignore friction, air resistance, curvature of Earth’s surface, dependance of g on the distance from the center of Earth and so forth. We teach them Newton’s laws that are only applicable in inertial reference frames while as observers we, being on a rotating and revolving Earth, are clearly non-inertial reference frame observers. We do it as the effects of the above factors are small compared to the main factors affecting the phenomena and, if ignored, still lead to the predictions supported by the experiments. The problem is that very often our students and even teachers are not aware that a particular approach ignores some factor. A great example is the formulation of Newton’s first law in most American introductory textbooks. Every object continues moving at constant velocity if there are no external forces exerted on it. This formulation (or anything similar) leads the students to believe that the above is always true. But if an observer is accelerating themselves, then this law does not work.

We teach our students Newton’s laws often forgetting their biggest limitation - the observer! The second and third laws do not work for most observers on Earth and our students experience this every day when they on a school bus or in a car going to school. They feel being pushed forward and backward without any extra objects interacting with them when the bus starts or stops. They see other objects accelerating without any extra

forces exerted on them. How often do we bring these experiences in class? The reason for them is that when you are an observer in an accelerating reference frame, Newton's second law does not work. And therefore, the role of the first law is to limit the observers to only those who do not accelerate themselves. This nuanced meaning of the law is often lost in a traditional statement about EVERY OBJECT CONTINUES BLAH BLAH BLAH. No, every object does not continue. It only does if the person observing this object does not accelerate themselves. We can see Newton's first law as the statement of the existence of the inertial reference frame observers. Sounds wild, right?
The above example of Newton's first law shows the importance of discussing with the students what simplifications they are making when developing explanations/models or solving problems. Helping physics teachers develop the awareness of the ever-present spherical cow reasoning in physics teachers is infinitely more important.

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Eugenia Etkina
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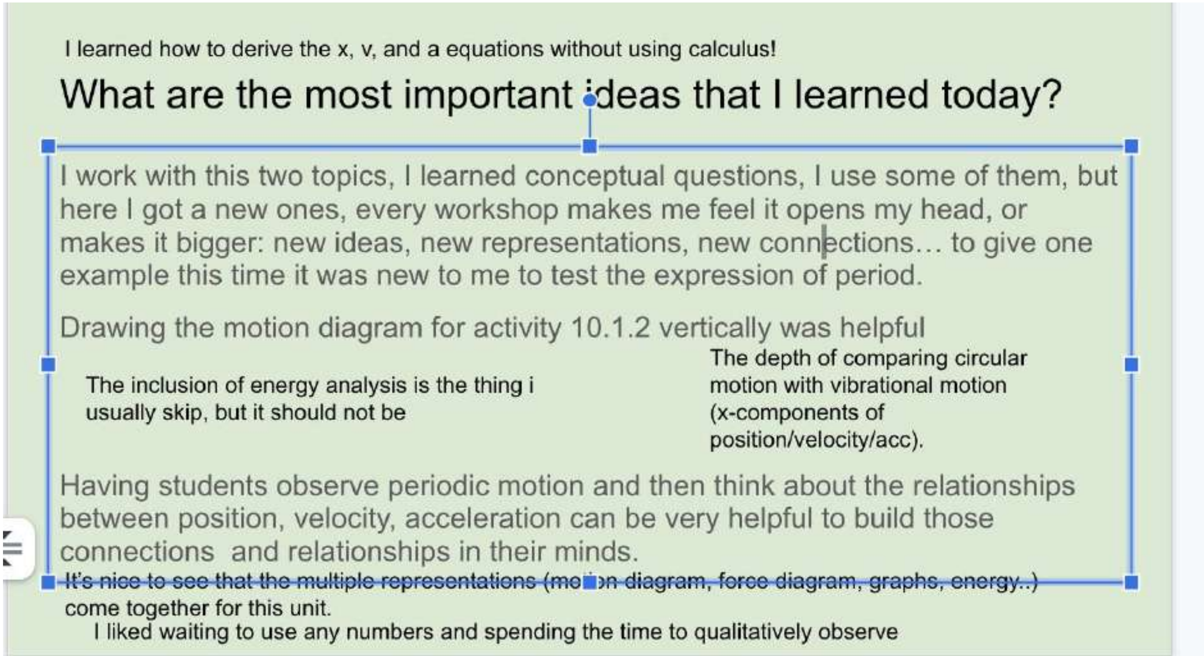
Hi Exploring and Applying Physics people! We had a really nice workshop for Vibrational motion. The link to the zoom recording is at https://rutgers.zoom.us/.../zb3K7aJwbTYmgRSVuPgNDLRi0Oble... the password is 5@4Ve^n+
The link to the slides with all other links in them is at https://docs.google.com/.../1BNeKfhG7fXQ9xZn1MDUT.../edit...

The summary slide of what people learned is pasted below. Participants, please comment!
Our next workshop in March will be for Static electricity. It was the choice of the participants of the Vibrations workshop. I will announce possible dates in a couple of days. Thank you, Exploring and Applying Physics group members!



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Eugenia Etkina shared a link.
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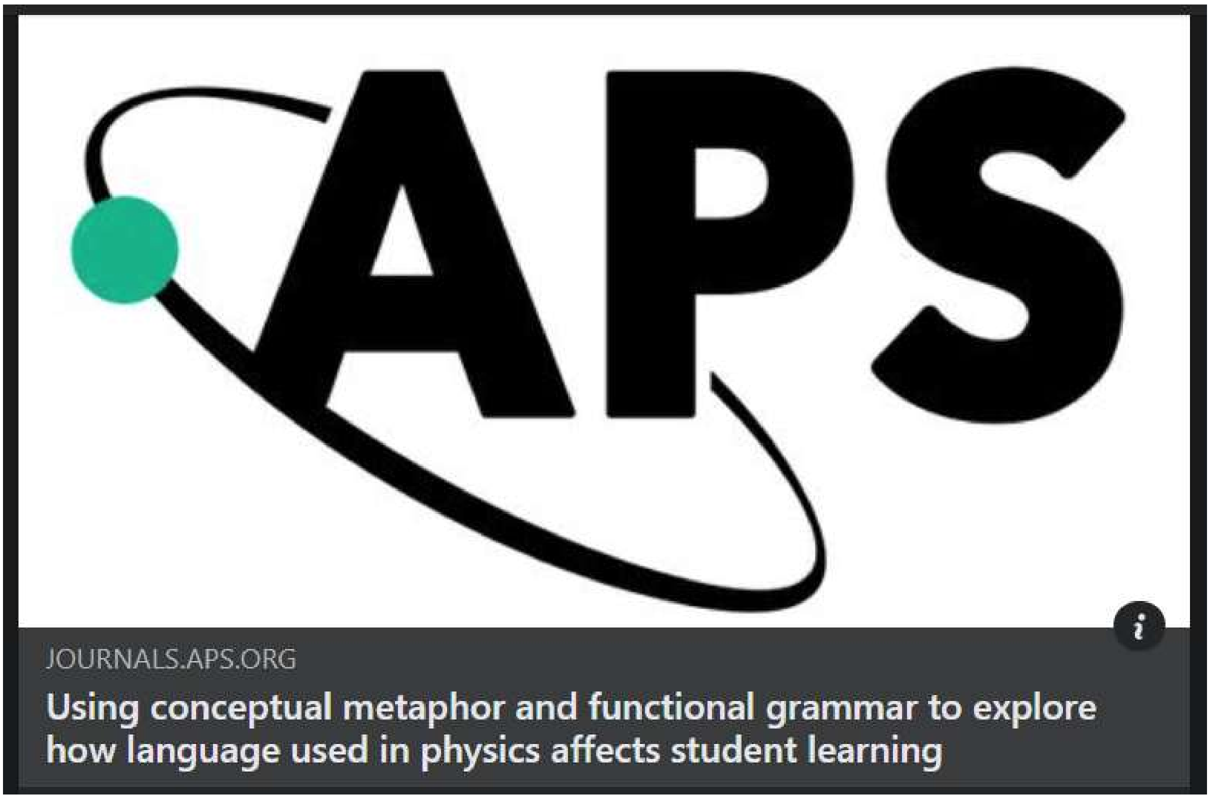
Hi all at Exploring and Applying Physics, three things today. First, as I said before, the posts are becoming invisible on Facebook. Probably some

algorithms changed. While before each post had 500-1000 views, the latest posts have 20-50 views. The only person who sees this number is me as the owner and it makes me sad. Please, if you want this group to continue, check the posts every day and comment. Thank you.
Second, I am thinking about the following possible dates for static electricity workshop: March 11 or March 18. Any preferences? I will post the poll tomorrow, but this is just heads up.
Finally, I continue with the types of reasoning that physicists use. We discussed inductive and spherical cow reasoning, the next one is analogical.
· Analogical reasoning
Analogical reasoning is often used when we wish to explain a new phenomenon using something that we know using the word “like”. Analogy is a cognitive device and should not be confused with metaphor, which is a figure of speech. When the word “like” is dropped an analogy becomes a metaphor. For example, we can say that time is precious like money is. In this case, money is an analogy for time. But when we say: “Don’t waste my time”, we do not refer to money as analogy but we speak about time as we would speak about money.
When we make analogies, we are trying to understand/explain some new phenomenon using our knowledge of a familiar phenomenon. The new phenomenon is called a “target” and the known phenomenon – a “base”. Making an analogy is in a way mapping the objects and their relationships in a target to the known objects and their relationships between objects in the base (Glynn, Duit & Thiele, 2012).
For example, a common analogy is to say that electric charge flows in a circuit (target) like water flows through a closed pipe system (base) (Gentner & Gentner, 2014) with the battery (object) being analogous to the pump (object). While a battery does not look like a pump, its relationship to other parts of the electric circuit is like the relationship of a pump to the parts of a closed water system. There are two important habits of mind when using analogical reasoning:
1. We should not forget that every analogy has limitations or situations when the analogy is no longer valid. For example, this analogy cannot explain the short circuit phenomenon in an electric circuit.
2. Research shows that it is much more effective when the students come up with analogies to help them understand something, instead of the

instructor providing them with analogies, as sometimes what is a base for the teacher is not familiar to the students (Gentner and Gentner, 2014).
Research also shows that in physics analogies with time become metaphors (Brookes & Etkina, 2006). For example, when physicists were first figuring out what electric current was, they had a model of a weightless fluid of positive electric charge moving through the circuit. Then, as water is also a fluid, it became an analogy for the movement of the electric charge. But now we simply say: “Current flows”, which is a metaphor based on the original analogy.
Analogical reasoning plays an important role in the ISLE process. When the students are developing a mechanistic explanation of a phenomenon, they almost always use analogical reasoning. Such reasoning allows them to relate the new explanation/mechanism to something that they already know.
For example, in the case of explaining how a disturbance can propagate along a string, they come up with an analogy of multiple springs strung together. When one spring is pulled, it pulls on the next one, and so forth. This is how the disturbance spreads along the string without carrying any material.
When preparing future physics teachers, it is important to encourage them to come up with their own analogies and when they do so, ask for the mapping of objects and relationships and, most importantly, the limitations. Habitual searching for analogies is a common habit of mind of physicists.
References:
Glynn, S. M., Duit, R., & Thiele, R. B. (2012). Teaching science with analogies: A strategy for constructing knowledge. In Learning science in the schools (pp. 259-286). Routledge.
Gentner, D., & Gentner, D. R. (2014). Flowing waters or teeming crowds: Mental models of electricity. In Mental models (pp. 107-138). Psychology Press.
Brookes, D. T. & Etkina, E. (2007). Using conceptual metaphor and functional grammar to explore how language used in physics affects student learning. Physical Review, Special Topics, Physics Education Research, 3, 010105 https://journals.aps.org/.../10.1103/PhysRevSTPER.3.010105



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Eugenia Etkina
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Hi all Exploring and Applying Physics people! Today is my next post related to the epistemology of physics. This time it is about hypothetico deductive reasoning, the key reasoning that distinguishes science from religion. The post is long. Please do not forget to like or comment when you finish reading it. Thank you.

· Hypothetico-deductive reasoning

We already touched up on this reasoning when we discussed testing experiments and predictions as elements of physics and elements of the ISLE process. According to Encyclopedia Britannica “hypothetico-deductive method, also called H-D method or H-D, procedure for the construction of a scientific theory that will account for results obtained through direct observation and experimentation and that will, through inference, predict further effects that can then be verified or disproved by empirical evidence derived from other experiments.”

Galileo used the H-D method when he made predictions of the outcome of his inclined plane experiment and then made a judgement about the motion of falling objects based on the outcomes of the experiment. Arthur Eddington used H-D reasoning when he predicted the deflection of the position of starts using newly proposed general relativity by Albert Einstein. H-D method used in science is crucial as is separates science from religion. When a scientist proposes a hypothesis, even if it explains all known phenomena, the hypothesis needs to be potentially falsifiable through some experiment. If there is no experiment that can potentially reject the hypothesis, the hypothesis is not scientific.

H-D methods is used in the ISLE process when we make predictions of the outcomes of the testing experiments using a hypothesis under test and then make judgement about the hypothesis based on the outcomes of the experiment.

This is how the logical progression works: If such and such [hypothesis] is true and I do such and such [testing experiment], then such and such should happen [prediction] because[explicit connection between the hypothesis and the prediction]. But, such and such [prediction]did not happen [outcome of the testing experiment], therefore such and such [hypothesis] is not true [judgement]. Or: And such and such [prediction] happened [outcome of the testing experiment], therefore such and such [hypothesis] has not been rejected yet.

The following prompts help students develop H-D reasoning:

· What is the phenomenon(a) that your hypothesis explains?

· What is the hypothesis? Can you come up with a different one?

· Can you design an experiment whose outcome you can predict using this hypothesis?

· What should be the outcome of the experiment if your hypothesis is true? How do you know? Explain.

· After you conduct the experiment, how would you know if the outcome matched or did not match the prediction, especially when the experiment is quantitative?
· What are experimental uncertainties in your testing experiment? How do they affect your prediction?
· What are additional assumptions (additional to the hypothesis under test) that you made in your prediction? Will the assumptions, if not validated, lead to the outcome larger or smaller than predicted?
· How can you validate your assumptions?
· After you conducted the experiment, what is your judgement about the hypothesis?
We have an example in Chapter 22 of the textbook where we use H-D reasoning when to test a hypothesis that each point of an extended source emits one ray of light. There the reasoning was as follows (see attached screen shot)):
If such and such [our hypothesis that each point of an extended light source sends one light ray] is true and I do such and such [cover the light bulb with aluminum foil with a tiny hole it in], then such and such should happen [we should see a tiny light spot on the wall] because [when that one light ray hits the wall, some of this light will reflect to our eyes]. But, such and such [the tiny light spot] did not happen [in fact the whole wall was brightly lit], therefore such and such [the hypothesis that each point of an extended source of light emits one ray] is [not true].
How can we help pre-and in-service physics teachers develop H-D reasoning? As every other scientific ability, they need to first learn the steps of the logical chain when testing simple hypotheses. After they design a first testing experiment and make a prediction about its outcome, they need to reflect on the steps and record those steps as shown in the example above. Then, when they test every new idea that they devise, they need to carefully word the prediction using the language shown above. Over the years we observed several difficulties with this process:
· Teachers confuse explanations/hypotheses with predictions.
· They wish to run testing experiments to “see what happens” without making predictions.
· They do not use hypotheses to make predictions.
· They do not follow the H-D progression in their reasoning putting the description of the experiment after if: “ifI do such and such, then such and

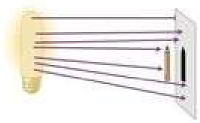
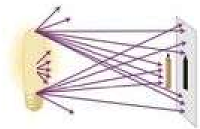
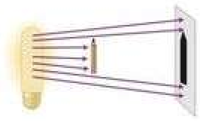
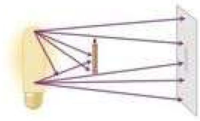
such will happen”. This logical chain does not follow hypothetico deductive reasoning logical flow as there is no hypothesis and no deduction based on the hypothesis.

In Chapter 1 of the College Physics: Explore and Apply textbook and of the ALG/OALG we have three activities that will help you practice such reasoning. In addition, we suggest reading activities that help students develop H-D reasoning skills. Such activities consist of the students reading a scientific text that describes a process of the development of a specific idea in physics and annotating it to note elements of physics (see ALG and OALG Chapter 1).

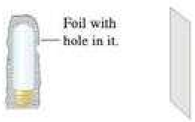
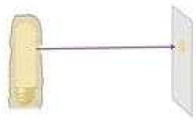
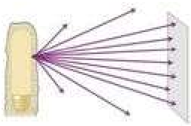
I will post tomorrow and example of such activity. If you read the post, you know what to do.

TESTING EXPERIMENT TABLE 22.2 **How many rays does each point on a light source emit?**

VIDEO TET 22.2

	Predictions		
Testing experiment	**Based on one-ray model**	**Based on multiple-ray model**	**Outcome**
Experiment 1. Turn on a lightbulb and place a pencil close to the wall between the bulb and the wall. 	We predict a dark, sharp shadow behind the pencil where the rays do not reach the wall. 	We predict a dark, sharp shadow behind the pencil where the rays do not reach the wall. 	We see a dark, sharp shadow on the wall.
Experiment 2. Turn on a lightbulb and place a pencil closer to the bulb between the bulb and the wall. 	We predict a dark, sharp shadow on the wall, as in Experiment 1. 	We predict an almost uniformly illuminated wall with a hint of a shadow. 	We see a light, fuzzy shadow (not as dark as in Experiment 1).

(CONTINUED)

	Predictions		
Testing experiment	**Based on one-ray model**	**Based on multiple-ray model**	**Outcome**
Experiment 3. Cover the bulb with aluminum foil and poke a hole in the foil in the middle of the bulb facing the wall. Turn the bulb on. 	We predict that we will see only a spot on the wall directly in front of the hole. 	We predict that the whole wall will be dimly lit. 	We observe that the wall is dimly lit. If we cover the first hole and poke a hole in a different place, the result remains the same.

Conclusions

Experiment 1. Both models gave predictions that matched the outcome of this experiment. Neither is disproved.

Experiments 2 and 3. The predictions based on the one-ray model did not match the outcomes of the experiments; thus, that model is disproved. The predictions based on the multiple-ray model matched the outcomes of both experiments; thus, the model is supported (not proved).

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Eugenia Etkina
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#theory
Hi all Exploring and Applying Physics, two things today. Yesterday I posted the poll for our next meeting on electric charge and force. While a 100% of those who voted are for March 11, only 5 people responded. Please cast your vote (see yesterday's post).
Today, I continue the habits of mind of physicists that we, as teachers, need ot develop. We talked about the elements of physics first and then the reasoning processes. One thing was left out. THEORY. It seems like it is an element of physics but without all the ways of reasoning that physicists use, one cannot understand what this word means (some US politicians definitely do not, as some of them proposed to remove theory for teaching science and leave only FACTS). So, the discussion of the term "theory" comes after the reasoning. It is below. Please like or comment on the post to make it more visible. Thank you.
Theory
The word “theory” is probably the most misunderstood and misused word in physics and in everyday language. Looking up the word “theory” in search engines we find the following definitions: “a supposition or a system of ideas intended to explain something, especially one based on general principles independent of the thing to be explained”, an “an idea used to account for a situation or justify a course of action” and the synonyms that are listed are hypothesis, conjecture, speculation, etc.
From these definitions and synonyms it looks like when we say “theory” we are speculating and there is no “proof”. However, if we look up the word “scientific theory”, the definition comes back completely different. From Wikipedia: “A scientific theory is an explanation of an aspect of the natural world and universe that has been repeatedly tested and corroborated using accepted protocols of observation (read observational experiments), measurement, and evaluation of results (read patterns). Where possible, theories are tested under controlled conditions in an

experiment (read testing experiments). In circumstances not amenable to experimental testing, theories are evaluated through principles of abductive reasoning (astronomy for example) that seeks the simplest and most likely conclusion from a set of observations (Occam's razor). Established scientific theories have withstood rigorous scrutiny and embody scientific knowledge." This is quite different from a speculation, right?

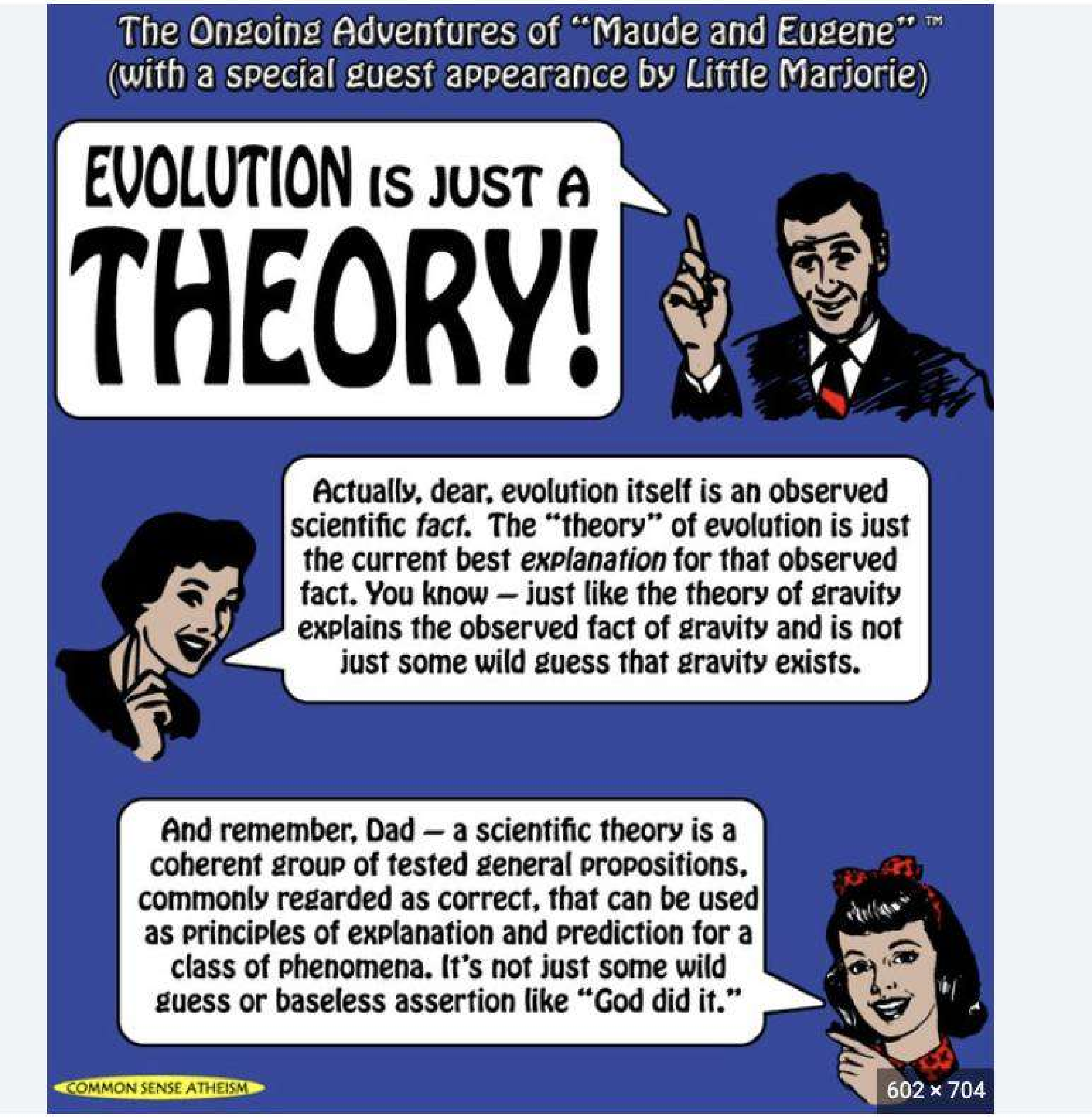
If we think of physics, then we have for example:

· Newtonian Theory which explains the wide range of mechanical phenomena involving macroscopic objects at the speeds much smaller that the speed of light; has its own set of physical quantities, conceptual and mathematical models which were tested in numerous experiments, measuring instruments and physics devices, and has its own limitations;

· Kinetic Molecular Theory which explains a wide range of mechanical and thermal phenomena involving microscopic objects, has its own set of physical quantities, conceptual and mathematical models which were tested in numerous experiments, measuring instruments and physics devices and has its own limitations;

· Special Relativity Theory which explains a wide range of mechanical phenomena involving macroscopic and microscopic objects moving at the speeds close to the speed of light, has its own set of physical quantities, conceptual and mathematical models which were tested in numerous experiments, measuring instruments and physics devices and has its own limitations.

From the examples below we see that the word theory in physics is much more specific than even the definition of a scientific theory in Wikipedia. To be called a "theory" in physics, a set of knowledge has to account for a wide variety of observational data, has its own set of physical quantities and mechanistic and causal explanations and mathematical models relating those quantities, has been tested in numerous testing experiments, and applied for practice. All kinds of reasoning, inductive, hypothetico-deductive, analogical and abductive are used to create the conceptual and mathematical structure of the "theory". The development and testing of these models is impossible without special measuring instruments and physics devices. Therefore, all of the elements of physics knowledge discussed above and all types of reasoning come together to form a "theory" in physics. And finally, each theory has its own very carefully defined set of limitations – statements when it can be applied to produce predictions that match the outcomes of the testing experiments. Thus, the word "theory" in physics and in science in general is as far from a "hypothesis" or a "speculation" as a finished house is far from individual bricks, doors, window frames, etc. Only a proper understanding of the word "theory" would allow teachers and students to argue against those who think that science education should only involve "facts".



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Eugenia Etkina shared a link.
Admin
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1d
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#speedoflight
Hi Exploring and Applying Physics people! I just watched this movie made by slo mo guys, it is incredible. Enjoy! You can use it in any light related unit. https://interestingengineering.com/.../youtubers-film-the...

https://www.facebook.com/groups/320431092109343/posts/1367747120711063/?__cft__[0]=AZUdbR9YSMyz0zvzFA-nMEC_e93OxDTIWKc6ROvEQmxz0jiHNWpJVOXIZkauQ9OGQMDy4BRVUeVFZoT97KXIqSBGKkSxrEYI7BfDtbo39UmMHdAoeueQFPRIt32SR8j7JHtCASEreuxrOdX8LVm6wHo&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin

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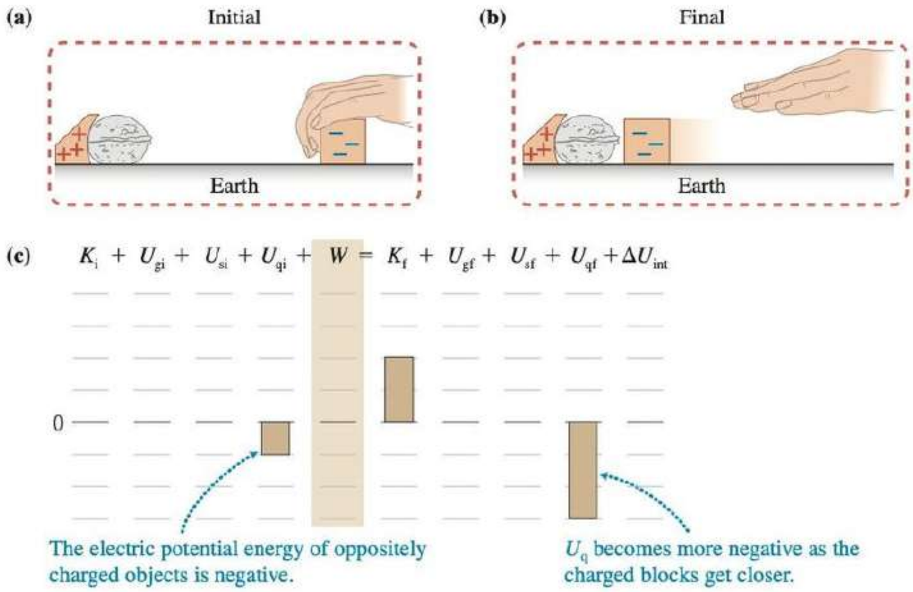
#electrostaticsworkshop
Hi all Exploring and Applying Physics people! I just created an event for our workshop on electrostatics. Please sign up there! March 11 as this is the day for which the majority voted. We have workshops about how to implement the ISLE approach in different physics topics every month. If you have not attended one, it is never late to start. People from all over the world get together to talk about teaching and learning physics, it is truly exciting.
This worksop, similar to the Vibrations will show how to use all of the multiple representations that we have learned so far to analyze complex physics phenomena. I am attaching the screen shot showing how we use energy bar charts to help students come up with the idea of negative electric energy for the interacting charges of the opposite sign. Research shows that it is a very difficult idea for the students.
Please sign up! And please like or comment on this message to make it more visible. Thank you!

FIGURE 17.16 The electric potential energy of two oppositely charged objects.



The bar chart in Figure 17.16c represents this process. The initial electric potential energy of the system is negative. As the objects come closer together, the kinetic energy of the system increases and its electric potential energy decreases, becoming even more negative. Our next step is to devise a mathematical expression for electric potential energy.

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Eugenia Etkina
Admin
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February 24 at 3:53 PM
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#waves
Hi all Exploring and Applying Physics people! Yesterday I posted about our next workshop for Static Electricity on March 11. The post is invisible for most of the group members. Only 57 people viewed it so far and regular numbers after 1 days are 400-500. Please check it out and go to your

EVENTS on Facebook and sign up for the workshop. As we skipped a large number of topics moving from Chapter 10 to Chapter 17, I will be commenting on those in my posts without the workshops. The next chapter after 10, is guess what? 11!!!! 11 is about Waves. It is a very long and rich chapter as it includes traveling waves, standing waves and sound. If you have the textbook College Physics: Explore and Apply and are using the ALG/OALG, please post your questions here.
I will start with how we help students learn what a wave is - the transfer of energy without the transfer of matter. We ask them to go to a nearest pond, river or even a big puddle and drop a small object into it (actually, spitting from a bridge works the best). And then observe and video what they see. They observe a series of circles spreading from the point where the object hits the surface. There are two explanations of these circles - the water is rushing out disturbed by the object or the water parts vibrate up and down pulling the nearby parts creating the spread. How can they test those two hypotheses? Here is the video for the observational experiment. What can be a testing experiment?
https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg…

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Eugenia Etkina

Admin

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February 25 at 7:55 PM

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#waves

Hi all people Exploring and Applying Physics! I continue about waves today. Before we get into how students in ISLE learn the mathematical description of waves, I would like to comment on the traditional mathematical description where the main relationship for waves is written as v=lambda X f. This is a very confusing way to write the relationship as it contradicts the main idea that for traveling waves speed does not depend on the wavelength (it sometimes depends on the frequency if we deal with dispersion, but for mechanical waves our students study this is not the case). It is the wavelength that depends on the frequency and speed. Therefore it is important that the students first investigate and find that the frequency - the number of full cycles for each point of a wave (or a period) only depends on the source - how it is vibrating and the speed - how far the disturbance travels in 1 second depends on the medium. The wavelength is the distance between two points in a wave the vibrate exactly the same way. This distance, as the students will find through the activities that I will describe tomorrow, depends both on the source of the wave motion and on the medium in which the wave propagates. The frequency and speed can be changed independently of each other, while as we will find out, the wavelength, as we will see, cannot be varied independently of one of them. It always surprises me when the textbooks introduce the relationship between those three as v=lambdaf or v= lambda/T. It should be lambda=v/f or lambda=vT.

Please do not forget to like the post or comment on it. Thank you.

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Eugenia Etkina
Admin
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February 27 at 3:19 PM
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#waves
Hi all at Exploring and Applying Physics! I am continuing with waves. In my previous post I discussed how frequency of the source and the properties of the medium affect the wavelength. Today, I will show how we derive the wave equation for a sinusoidal wave using the knowledge developed in Chapter 10 for the position-vs-time function for the harmonic motion and our understanding of wave motion.
The different between the mathematical description of vibrational motion and wave motion is that while position is a function of just one variable - TIME in vibrational motion, it is a function of TWO variables in wave motion. This is a HUGE difference, as the students have not experienced any functions of two variables before. I am attaching the screenshot of the reasoning process from the textbook, but the activities through which the students come up with the final function are in the OALG/ALG Chapter 11. The OALG file is posted here in the FILES. If you wish to learn how to help students do this, first work through OALG Chapter 10 (we did these activities during our workshop on vibrational motion, see the slides at https://docs.google.com/.../1BNeKfhG7fXQ9xZn1MDUT.../edit...
Activities 10.2.2 and 10.2.3. After that, work through activities 11.2.1 and 11.2.2 in the OALG File (also posted here). We write the weve equation differently from other sources, again for the reason of understanding. Here is the screenshot form the textbook. Please ask questions. And please do not forget ot like or comment on the post to make it more visible. Thank you.

Mathematical description of a one-dimensional traveling sinusoidal wave

Our goal is to construct a description of a traveling sinusoidal wave at different places along its path and at different times (clock readings). For simplicity, we only consider one-dimensional waves, such as waves on ropes or Slinkys, and we will assume that the mechanical energy of the source is not converted to the internal energy of the medium. In other words, no damping occurs—the amplitude of the vibration is the same at all points. We also assume that the speed of the wave propagation is constant throughout the medium. We choose the positive x-direction as the direction in which the disturbance travels at speed v. The left end of the rope at $x = 0$ is attached to the vibrating source. According to Eq. (11.1), the source oscillates up and down with a vertical displacement

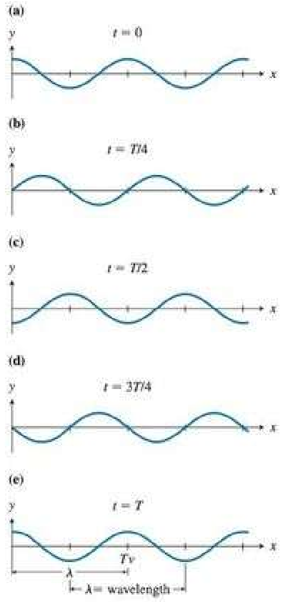
$$y(0, t) = A \cos\left(\frac{2\pi}{T}t\right)$$

The zero in the parentheses indicates that the function $y(0, t)$ describes the motion of the medium at the position $x = 0$ and clock reading t. The shape of the rope at five different times is shown in Figure 11.8. If you look at any other position along the x-axis, the rope vibrates in the same way as it does at $x = 0$ but at a different instant in the vibration cycle. For example, at the first tick mark to the right of $x = 0$, you see that at time zero, the rope displacement is $-A$; at time $t = T/4$, its y-displacement is zero, then $+A$, then 0, and finally back to $-A$.

We can mathematically describe the disturbance $y(x, t)$ of a point of the rope at some positive position x to the right of $x = 0$ at some arbitrary time t. Every point to the right of $x = 0$ vibrates with the same frequency, period, and amplitude as the rope at $x = 0$. But there is a time delay $\Delta t = x/v$ for the disturbance at $x = 0$ to reach the location x. The vibrational disturbance at position x at time t is the same as the disturbance at $x = 0$ was at the earlier time $t - x/v$. Thus, the vibration of the rope at position x can be described as

$$y(x, t) = A \cos\left[\frac{2\pi}{T}\left(t - \frac{x}{v}\right)\right] \qquad (11.2)$$

FIGURE 11.8 The shape of a transverse wave at five consecutive times.



The snapshot graph of the disturbance (Figure 11.8e) shows that the disturbance pattern repeats at a distance Tv (period multiplied by the wave speed). This distance separates neighboring locations on the rope that have the same displacement y and the same slope. This distance is called the **wavelength** of the wave and is represented by the Greek letter λ (lambda):

$$\lambda = Tv = \frac{v}{f}$$

where v is the speed of travel of the wave, T is the period of vibration of each part of the rope, and f is the frequency of vibration $(1/T)$.

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Eugenia Etkina

Admin

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March 1 at 3:03 PM

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#waves

Hi all Exploring and Applying Physics members! Two days ago I posted the textbook procedure for the development of the wave equation, today is the activity. It is in the OALG Chapter 11, you can download it now.

The difference in our approach is that we start with the position-vs-time sin function (y(t) for the source and then investigate how the function changes as the wave reaches the points farther away from the source. This means that the time of the start is later by x/v - the new time for an arbitrary point is (t-x/v). This also means that the points at the distance x=vT (T - is the period of vibrations of the source) will vibrate the same way as the source. Therefore we can give this distance a special name - wavelength.

The final function becomes y=Asin (2pit/T-2pix/lambda). This is the function of two variables - x and t and thus there are two graphs that we need to represent it - y(t) and y(x). This way we have a temporal period T and spatial period lambda. See the attached screen shot of the activity. Note that the first variable is t in the function, and not the traditional x. This underscores the building on the function that the students learned in the vibrational motion. This is a subtle but very important difference.

The link to the simulation is at https://phet.colorado.edu/.../wave-on-a-string_en.html

If you read to the end, you know what to do, thank you!

OALG 11.2.4 Represent and reason

The goal of this activity is to construct a mathematical representation that describes the motion of the wave on a string.

Open the PhET simulation at the following link:

https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html

Set damping to "none", set tension to "low", select "no end", and select "oscillate".

Now set the frequency to 0.5 Hz, check "rulers" and "timer". You're all set to go.

a. The motion of the green dot attached to the oscillator can be described by the function:

$$y_{\text{at } x=0} = A\cos\left(\frac{2\pi}{T}t\right)$$

The motion of another point on the string at a distance x from the starting point can be described as the same motion as the point at $x = 0$, but with a time delay t_0. Write t_0 in terms of x, the distance from the origin, and v, the speed at which the wave travels down the string.

b. If we want to describe the motion of the string at any point x using the same clock that we used for the point $x = 0$, we need to factor a time delay into the function like so:

$$y_{\text{at } x} = A\cos\left(\frac{2\pi}{T}(t \pm t_0)\right)$$

Decide whether you should add t_0 or subtract t_0 to describe the y motion of a point x. Remember, this point is making exactly the same motion as the point at $x = 0$, but t_0 *after* the point at $x = 0$. After you have decided, rewrite the function above with the correct sign for t_0 and use the expression you found for t_0 in part **a.**

c. The second green dot to the right is a special point because it executes exactly the same motion as the green dot attached to the driver. What is the time delay between the motion of the driver green dot and the second dot to the right?

d. Write the distance between $x = 0$ and the second green dot in terms of the wave speed v and the time you found in part **c.** Use this to rewrite the function you arrived at in part **b.** You should now have a general mathematical function describing for the motion of a wave.

e. Compare the function you devised to Equations 11.2 and 11.4 on pages 320 and 321 in the textbook.

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Eugenia Etkina
Admin

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March 2 at 3:24 PM

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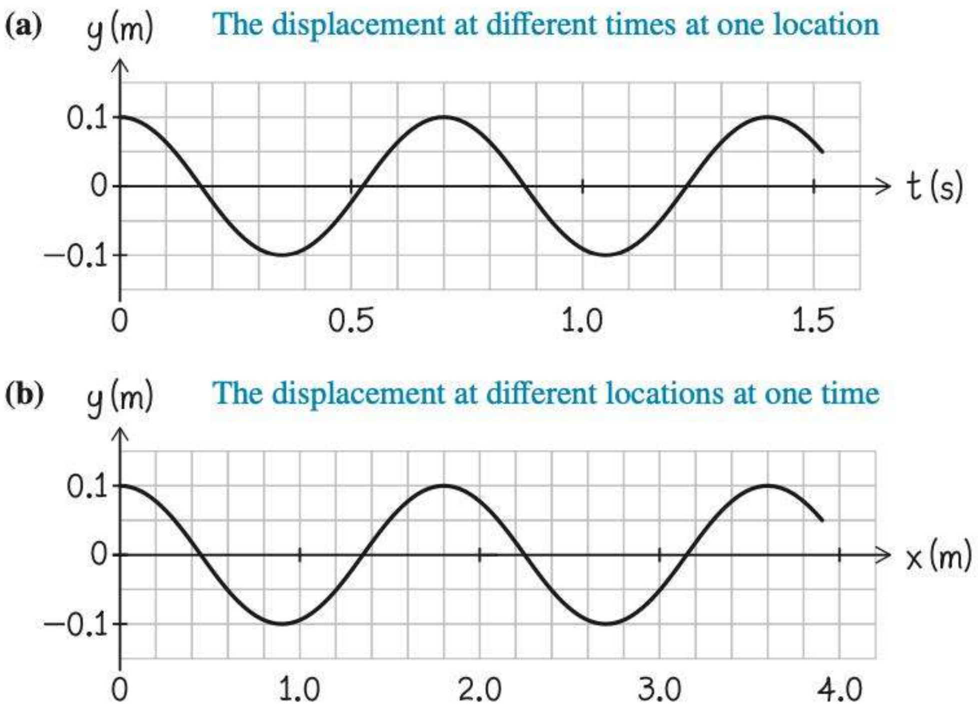
#waves
Hi all Exploring and Applying Physics people! I continue with waves today. We discussed how to help students devise the functional relationship for the waves - the function of two variables. Once the devised the function, it is great to proceed to graphical representations - y(t) and y(x).
On those graphs they can clearly see the temporal period - T and thus f (this graph represents ONE POINT on a wave as the time progresses); and the spatial period - wavelength (this graph represents ONE TIME INSTANT for all points of the wave). Labeling the axes is crucial for this purpose, as the students need to realize that they cannot find the wavelength on the y(t) graphs or the frequency on the y(x) graph.
They can also see that while on both graphs the amplitude is the same, the periods are different - one is T and the other one is lambda (see the screenshots and the scales on the graphs). People often draw wiggles to represent waves, and this is not correct. What does the wiggle represent? One point in time or many points in space? Thus LABELING the graphs is super-important.
Another issue is important here. In a traveling wave, different points are in different positions at the same time, we can also say that they are in different phases. This will not be true for standing waves, thus it is important to emphasize this aspect when the students are learning traveling waves, so that they see the difference later with standing waves.



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Eugenia Etkina
Admin
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March 3 at 3:15 PM
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#waves
Hi all Exploring and Applying Physics members! I continue with waves today. We discussed how students develop the wave equation yesterday and the day before (please read those posts before you read this one).

Today I focus on how students learn what the speed of a traveling wave depends on. This is a great activity to develop students quantitative inductive reasoning, emphasize the role of dependent and independent variables, improve their graphing skills and simply engage them in an activity that mirrors what physicists do when they analyze daya collected by somebody else. We use this method for many quantities, but, in my opinion, this is one of the best examples of our approach.

And it is very time efficient! Do the activity yourself and you will see its power. Please do not forget to like the post or comment on it to make it more visible. Thank you.

PS: The activity is in the OALG Chapter 11 file posted here i nthe FILES.

11.3.1 Observe and explain

Imagine that you have three long springs. If you measure the speed of transverse wave pulses along the springs, you would accumulate the data given in the following table.

Spring number	Force exerted on the end of the spring (tension, N)	Amplitude (cm)	Frequency (Hz)	Mass/length (kg/m)	Speed (m/s)
1	4.0	10	2	0.16	5.0
1	8.0	10	2	0.16	7.1
1	16.0	10	2	0.16	10.0
1	4.0	10	2	0.16	5.0
1	4.0	20	2	0.16	5.0
1	4.0	30	2	0.16	5.0
1	4.0	10	2	0.16	5.0
1	4.0	10	3	0.16	5.0
1	4.0	10	4	0.16	5.0
1	4.0	10	2	0.16	5.0
2	4.0	10	2	0.080	7.1
3	4.0	10	2	0.040	10.0

a. Come up with an expression that can be used to determine the speed of the wave as a function of different properties of the springs. Explain how you came up with your expression using the data in the table. Evaluate the units and extreme cases. Does your expression pass the evaluation?

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Eugenia Etkina shared a link.

Admin

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March 4 at 9:32 PM

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#videosofexperiments

Hi all Exploring and Applying Physics people! I wanted to remind you that the videos for the textbook observational experiment tables, testing experiment tables and problems are available without logging into Mastering Physics at https://media.pearsoncmg.com/aw/aw_etkina_cp_2/videos/

If you need OALG videos, they are in every chapter posted here in the FILES. You need to download the chapters and then click on the links to relevant videos. We also just updated the Instructor Guide to include Chapter 1 activities, the new file is attached here. Even if you do not have the textbook, the IG is an enormous resource for your teaching. Please download and read before you plan every unit! The introduction will give you the understanding of how our system works and how to help students participate in science practices and develop scientific abilities. I can't attached the IG to this post, I will have a separate post for it.

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Eugenia Etkina uploaded a file.

Admin

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March 4 at 9:34 PM

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#InstructorGuide

Hi all Exploring and Applying Physics people, here is the updated file of the Instructor Guide. Please do not forget to like or comment on the post (something like "Your Instructor Guide is AMAZING"). Thank you!

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Eugenia Etkina
Admin
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March 5 at 2:59 PM
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#waves
Hi all Exploring and Applying Physics people! Today I continue with waves and simultaneously discuss how to review the material. We talked about tow major stages of learning new stuff - invention, through the ISLE process (students work on activities) and "time for telling" (the teacher summarizes what the students have learned and sometimes expands new ideas). But there is a third step, which is equally important.
Reflection and consolidation. The students need to be able to see the big picture of all the new things that they have been learning. How do they all fit together? There are many ways to do it, one of which is attached here as a screenshot of the activity in chapter 11 for waves (see the OALG file posted here in the FILES). The students need to work in groups, go through their notes, consult the textbook and fill out the table. Please take a look at the table and see how the students put together all their knowledge about physical quantities characterizing waves. We have a similar activity for kinematics - any topic where students meet several new physical quantities will benefit from such analysis. Thank you for reading, please do not forget to comment or like the post to make it more visible.

11.3.4 Represent and reason

Waves are commonly described using four physical quantities: (1) amplitude A, (2) frequency f, (3) wave speed v, and (4) wavelength λ. Indicate how you would define these four quantities. Illustrate your definitions with reference to the pictures and graphs in previous activities. What types of change(s) in the source or in the medium would lead to a change in each of these quantities? Create a table like the one that follows.

For help, use Sections 1-3 in Chapter 11 in the textbook.

Quantity	**Write a definition of the quantity.**	**Illustrate your definition of the quantity.**	**Does quantity depend on the source or the medium? Explain why.**
Amplitude			
Frequency			
Wave speed			
Wavelength			

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Eugenia Etkina shared a link.
Admin

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March 7 at 3:39 PM

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#waves

Hi all Exploring and Applying Physics people! This is my 7th post on WAVES. If you missed the previous posts, scroll down and read them all before reading this one.
This post is about how students construct the ides of the superposition of waves. The ISLE process is based on PER research. It also represents a perfect example of the ISLE process as the students come up with two competing hypotheses explaining the phenomenon that the observe and then reject one of the hypothesis by designing productive testing experiments and using hypothetico deductive reasoning to make predictions. If you teach waves, do not skip these activities. If you do not - do them yourself to practice ISLE-based reasoning. PLEASE respond to the post to make it more visible. Thank you. I am reminding you that OALG files are posted here in the FILES.
OALG 11.6.1 OBSERVATIONAL AND EXPLAIN
a. Go to [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]. Observe and describe what happens. What do you see when two pulses coming from opposite directions meet?
b. Brainstorm one or two ideas to explain what is happening when the two pulses meet each other.
c. If you come up with two competing ideas as to what happened, brainstorm ways in which you could conduct a testing experiment to decide which of these two ideas is correct.
OALG 11.6.2 TEST YOUR IDEAS
Before you watch the video, answer the following questions:
In this video, two oppositely oriented pulses approach each other from opposite directions as shown in the snapshot below:
a. Use each explanation you developed in Activity 11.6.1 part b. to make a prediction about what the Slinky will look like just after the two pulses meet. (One prediction based on each explanation.) Sketch them in your notebook.
b. Now that you have sketched out your predictions, watch the following video [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...] to see which explanation best predicts the behavior in this video. (Which prediction was consistent with the actual outcome of this experiment?)
c. How can it be that two pulses arrive to the same place at the same time and the spring appears to be flat? Where did the energy of the system go in the instant when the spring is flat?

d. Watch the following video at [https://youtu.be/XUPHgm9dLIE]. Is the outcome consistent with the explanation you chose in part b?

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Eugenia Etkina
Admin
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3d
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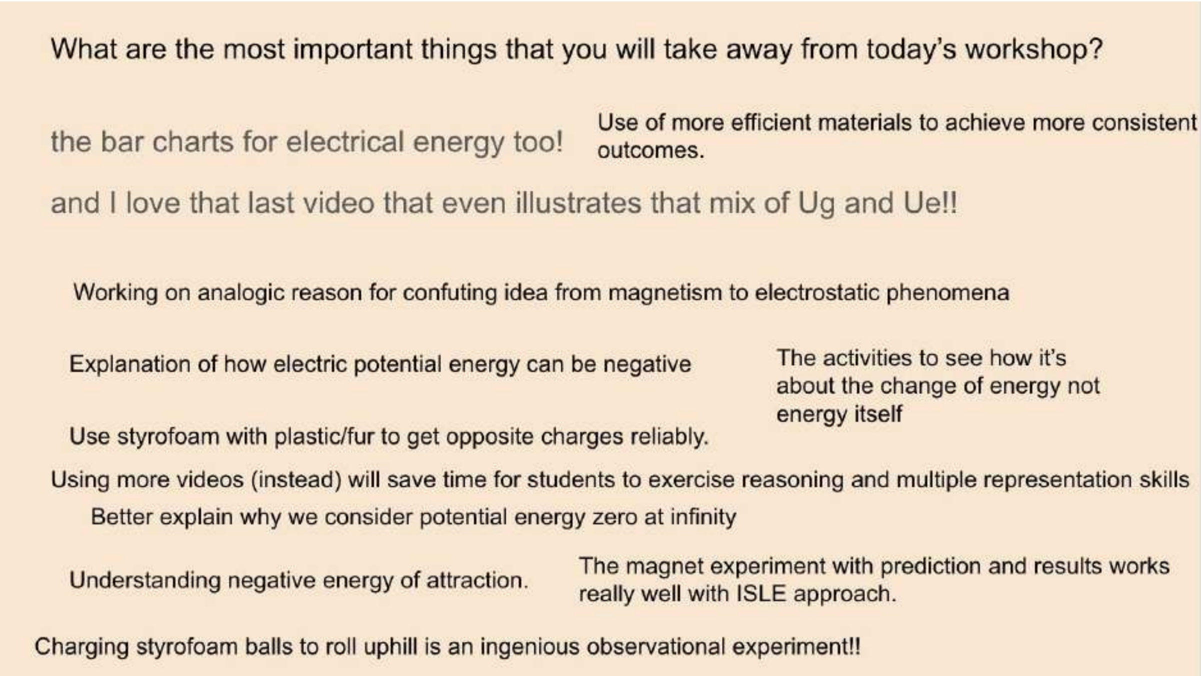
#workshopelectrostatics
Hi all Exploring and Applying Physics people, here is the link to the slides. the video recording of the workshop, and the final reflection slide of what people learned in the workshop. Unfortunately I forgot to push "record"

after I paused it for group work so the end was not recorded. If you have trouble doing activities on the slides at the end, please post questions here and I will explain. Please like or comment on the post, most of my recent posts are invisible - only very few people view them. I do not know why it is but it makes me sad.
https://rutgers.zoom.us/.../A0XzNCsTA538j2G17qu7dPDbBdQcI...
Password: 81%L@*x8
Slides: https://docs.google.com/.../14LoC2YXtTpM1s3s0y5pK.../edit...



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Eugenia Etkina shared a link.
Admin
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1d

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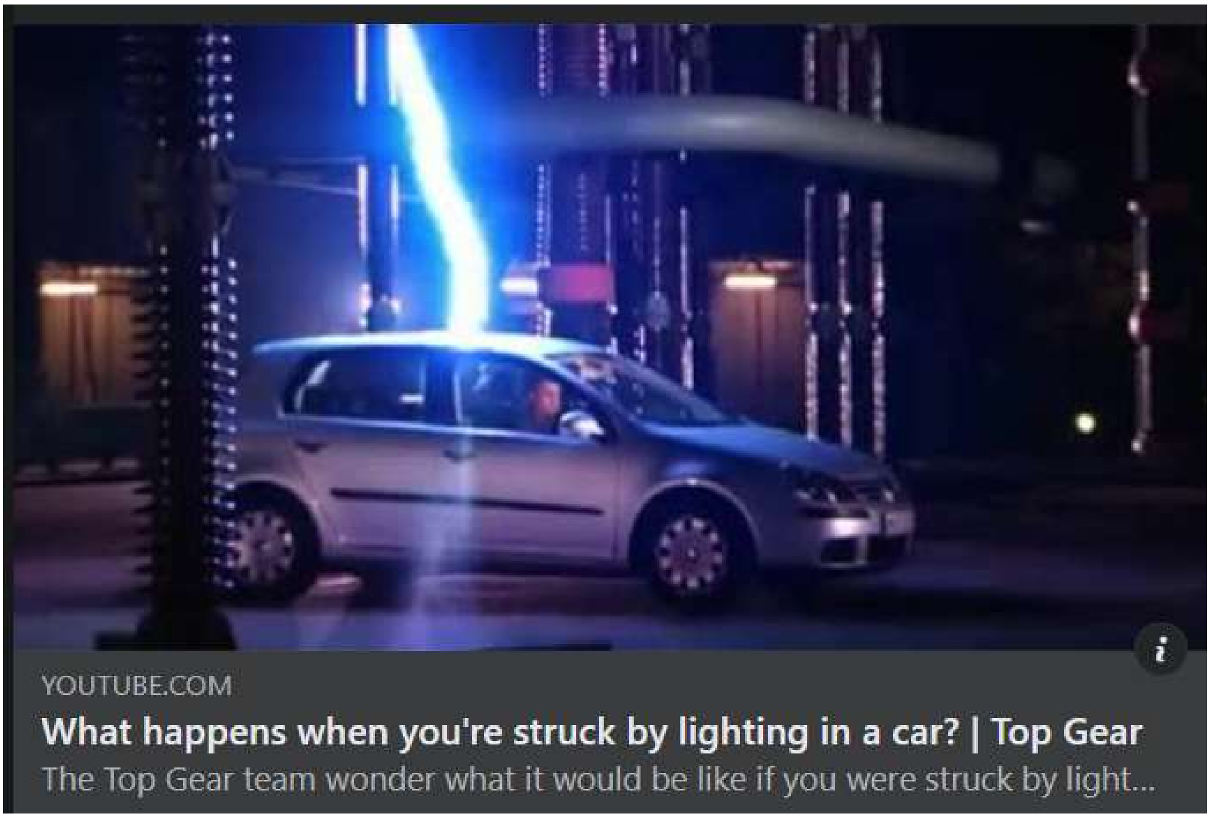
Hi all, yesterday I posted the poll about about our next workshop - Electric fields. Very few people viewed the post and we have 5 responses so far. Please check yesterday's post and indicate your choice for the date. So far we have almost an even split. Thank you.



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Eugenia Etkina
Admin
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March 17 at 2:05 PM
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Hi all Exploring and Applying Physics people! I did not post for 2 days as I was visiting University of Washington and their Physics Education Research group. There, in addition to talking about the ISLE approach, I had an opportunity to try Virtual Reality ISLE-based activities designed by Jared Canright and Suzanne White Brahmia. They use the ISLE logical progression (observe-find patterns, design testing experiments to test those patterns, make predictions of the outcomes and run the testing experiments to compare outcomes to the predictions) in the virtual worlds, some of which behaves like the world we live in and some do not. The students not only have an amazing experience in a 3D virtual world but also participate in a true science process figuring out how particles of an unknown nature interact. The experience is totally our of this world. They are writing a paper about it and their data shows how the students in this virtual environment spontaneously think like physicists. What a fascinating educational innovation! It also shows the power of the ISLE philosophy - you can apply it to any content. Jared Canright, please post a few screen shots of what students work with, including the instruments that they use to measure forces, electric fields and distances.

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Finally - the set of activities for electroscopes! All of those are in the OALG file for Chapter 17 posted here in the FILES. Enjoy!
OALG 17.3.4 OBSERVE AND EXPLAIN
An electroscope consists of a metal ball attached to a metal rod that passes from the outside through an insulating support into a glass-fronted metal enclosure. A very lightweight metal needle is connected on a pivot on the metal rod (see the photo on the right).

a. Watch the following two experiments https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-4a and record the outcomes.

Explain the behavior of the electroscope needle (1) when the charged rod touches the electroscope and (2) then when it is brought closer to the charged electroscope without touching.

b. Watch the following experiment https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-4band explain the outcome. What can you tell about the electric properties of a human body based on the outcome of the experiment?

c. Read and interrogate subsections “Electroscope” and “Is the human body a conductor or a dielectric” in Section 17.3 of the textbook and answer Review Question 17.3.

d. In the following experiment https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-4cthe experiments that you saw in part a are repeated but now the rod that charges the electroscope was rubbed very lightly (it carries a small charge). Describe what you observe and explain the outcome. Why is it different from the outcomes you observed in part a?

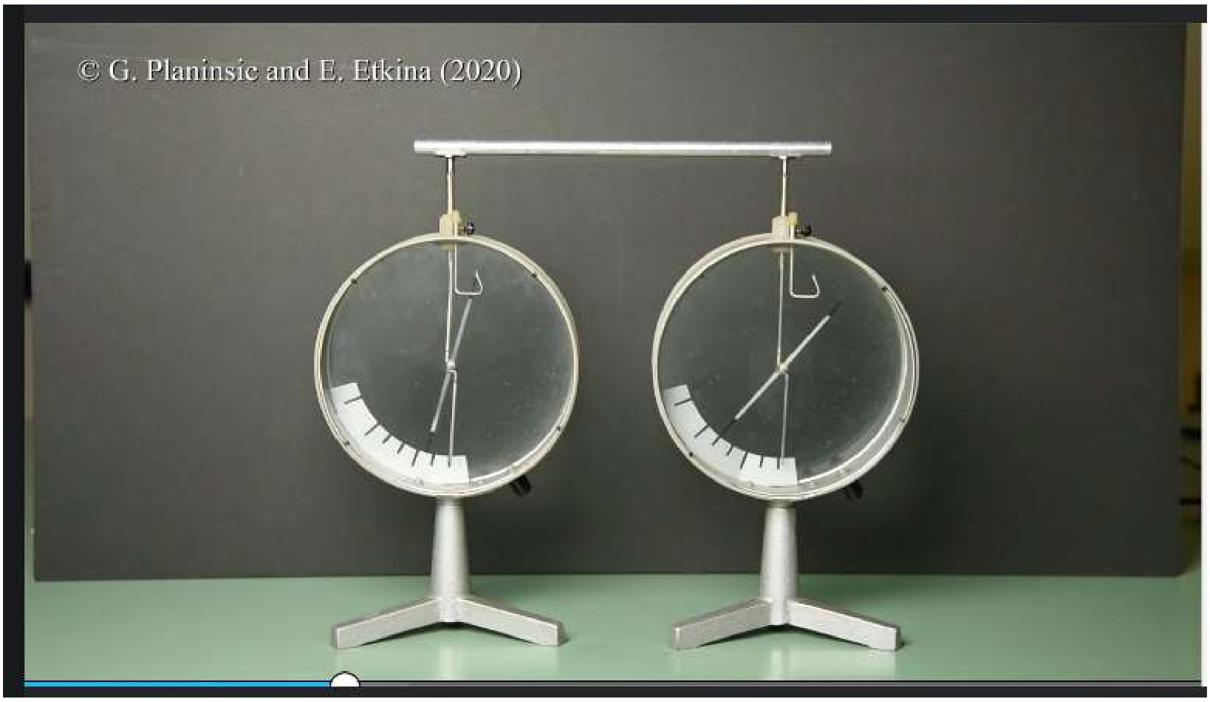
e. In the following experiment, the experimenter connects a charged electroscope with an uncharged electroscope, the first time with a metal rod and the second time with a plastic rod https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-4d. Explain the results of the experiments and why the experimenter uses wooden tongs with the inside rubber to pick up the rods connecting the electroscopes.

OALG 17.3.5 OBSERVE, EXPLAIN AND TEST YOUR EXPLANATION

a. Watch the following experiment https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-5aand explain how it is possible to charge the electroscope without touching it with a charged object.

b. What sign of charge is on the electroscope? How do you know? Hint: do not forget that the human body is a conductor.

c. One way to test your hypothesis is to bring the same negatively charged rod to the electroscope and observe the needle. If the charge on the electroscope is the same as the charge on the rod, it will deflect even more. If it is the opposite charge, then the needle will deflect less. Predict what will happen to the deflection of the electroscope needle if it has the charge that you identified in part b. After you make your prediction, watch the video at https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-5b. Did the outcome match your prediction? Do you need to revise your answer in part b?



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Eugenia Etkina
Admin
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March 19 at 3:37 PM
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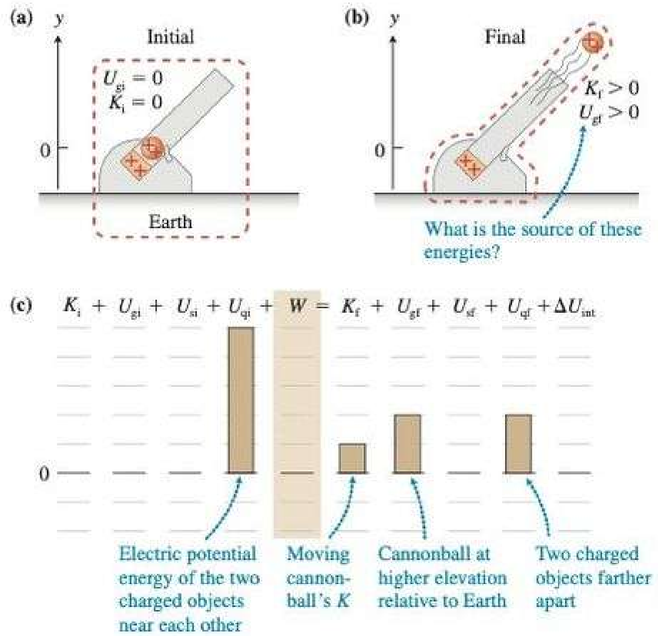
#electricpotentialenergy
#energybarcharts

Hi all Exploring and Applying Physics people! I continue with static electricity. The next two posts are about electric potential energy and how to use work-energy bar charts to represent it. Those who joined the group recently and are not familiar with energy bar charts, search for them in the archived posts or on google drive (Hrvoje Miloloža recently posted the link again). The best thing, of course, to have a copy of our textbook to learn how to make bar charts.
The main idea of different graphical representations that we use in our materials is that they help make a bridge between phenomena and algebra (or calculus). As electric energy is a complicated abstract concept, the bar charts are very useful here. I pasted a screenshot of a discussion of the electric potential energy of the system of two like charges that repel. If you think of the two charges infinitely far away as not interacting with each other, then as some finite distance, when they do interact, should the energy be positive or negative?
Please see the attached screen shot and comment on how to answer my question. And please do nto forget to like the post to make it more visible.

Electric potential energy: a qualitative analysis

Let's begin by looking at the electric potential energy of two like-charged objects that are part of the hypothetical "electric cannon" shown in **Figure 17.15a**. A positively charged cannonball is held near another fixed positively charged object in the barrel of the cannon. This situation is similar to that of an object pressed against a compressed spring. The cannonball, the other charged object, and Earth are the system. Since the cannonball is repelled from the fixed-charge object, the cannonball when released accelerates up the barrel and out of its end (Figure 17.15b). During this acceleration, the system's kinetic (K) and gravitational potential (U_g) energies both increase. If we assume that the system is isolated, then some other type of energy has to decrease so that these two can increase. This other type of energy must be the electric energy suggested above. We will call it **electric potential energy** U_q.

FIGURE 17.15 The electric potential energy of two like-charged objects.



The system comprising the two charged objects has electric potential energy. It seems that the electric potential energy of like-charged objects decreases as they get farther apart from each other. As the cannonball moves farther from the fixed-charge object, the electric potential energy of the system decreases as it is converted into kinetic and gravitational potential energy.

We can represent this process using a bar chart (Figure 17.15c). The initial state is the moment at which the cannonball is near the other fixed-charge object; the final state is when the cannonball is moving at the end of the barrel. For this process we assign the zero level for gravitational potential energy to be at the initial position of the cannonball. We must also make a zero-level assignment for electric potential energy. We say that when two charged objects are infinitely far apart, so that they essentially do not interact, they have zero electric potential energy.

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vQPexoi6sRiDUKnuZAPT7IfezBra14l4&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
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March 20 at 2:42 PM
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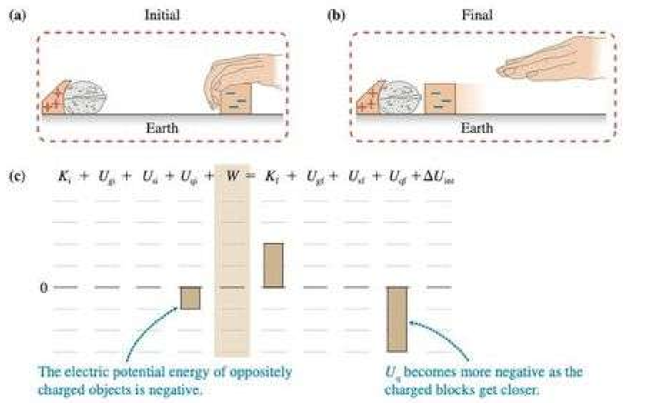
#electricpotentialenergy
#energybarcharts
Hi all Exploring and Applying Physics people, I am continuing posting about electric potential energy and wondering why some posts are visible for group members and some are not. I try different techniques but there seems to be no pattern how Facebook decides what to make visible. The only solution is to check new posts every day and make sure that you are looking at the past posted post not the last commented on post. Liking and commenting on the posts helps tremendously.
So, the electric potential energy of two oppositely charged objects is an extremely difficult concept for the students. Here the magnitude and the sign are important. This is how you can think about it. Imagine a system of two oppositely charged objects at infinity. They are not interacting, the energy of this interaction is zero. Now, imagine them close to each other. To move one (at constant speed) to infinity you need to exert a force in the direction of motion and thus. Do positive work. But doing positive work on the system you brought the energy of their interaction to zero. How can it be? It can only be if the initial energy was negative: +5 +(-5) = 0.
Thus, the energy of ANY object attracted ot each other should be NEGATIVE if you assume that it is zero at INFINITY. This reasoning is true for gravitational interactions, molecular interactions, interactions of nuclear and electrons in the atoms and protons and neutrons in the nuclei. When the objects come closer to each other the MAGNITUDE OF their interactive energy increases, but the energy itself DECREASES as it is a negative number and the larger the magnitude, the smaller the number. If your students grasp this infinitely difficult idea, they will be able to do quantum optics, atomic and nuclear physics with understanding, as well

as chemistry! The screen shot of the textbook material is attached. PLEASE like or comment on the post to make it more visible. Thank you.

Let us consider a situation in which two oppositely charged objects interact: a hypothetical "electrostatic nutcracker" (Figure 17.16a, on the next page). The system consists of two oppositely charged blocks, one of which can slide without friction. When the negatively charged block is released and moves nearer the nut, the kinetic energy of the system increases (Figure 17.16b). Thus electric potential energy must decrease. Assuming the zero level is when the two oppositely charged blocks are infinitely far apart, we conclude that the electric potential energy of a pair of unlike charges is less than zero.

FIGURE 17.16 The electric potential energy of two oppositely charged objects.



The bar chart in Figure 17.16c represents this process. The initial electric potential energy of the system is negative. As the objects come closer together, the kinetic energy of the system increases and its electric potential energy decreases, becoming even more negative. Our next step is to devise a mathematical expression for electric potential energy.

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Eugenia Etkina
Admin
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March 21 at 2:31 PM
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#homework
#electricfieldworkshop
Hi all Exploring and Applying Physics people, two things today. First the Electric Field workshop will be on April 8th (60% voted for it). If you absolutely cannot attend it but you attend our workshops regularly, please post here and I will think of maybe running another one on the 15th. I will create the event for the workshop on the 8th and see how many people sign up. Hope you see this message!
Second, I would like to talk about something that it important but is rarely discussed. It is HOMEWORK.
Homework is probably one of the most contentious issues in education. Some studies show that assigning homework does not improve student learning, some argue that the students need to rest at home, some say that even if they assign homework, very few students would do it. There are lots of arguments against assigning homework. What are the pro-arguments? We list them below.
Argument 1: Homework teaches people plan their work. They need to decide where and when they will do it. They need to rely on themselves to do it. They need to figure out how to communicate with other people if they cannot accomplish the homework on their own. This also requires planning. Planning intellectual work is one of the aspects of metacognition. Therefore the mere need to do the homework develops metacognition. In class, all aspects of the work are planned by the teacher.
Argument 2: Homework helps people remember what they just learned. A long time ago, in the 19th century Hermann Ebbinghaus used himself as a study subject to learn how he remembers some information that he just learned. From his limited research came “forgetting curve” that shows that within the first day (or more precisely, about 10 hours) a person forgets about 70% of what they learned, but if they review the material within this time, their memory brings up the new knowledge to the same level, repeated review reduces the amount of forgotten information drastically. While now we know more about memory and how to boost it in the first encounter with the new information, the main idea remains: we forget new stuff very quickly. Therefore, having an opportunity to work with new ideas

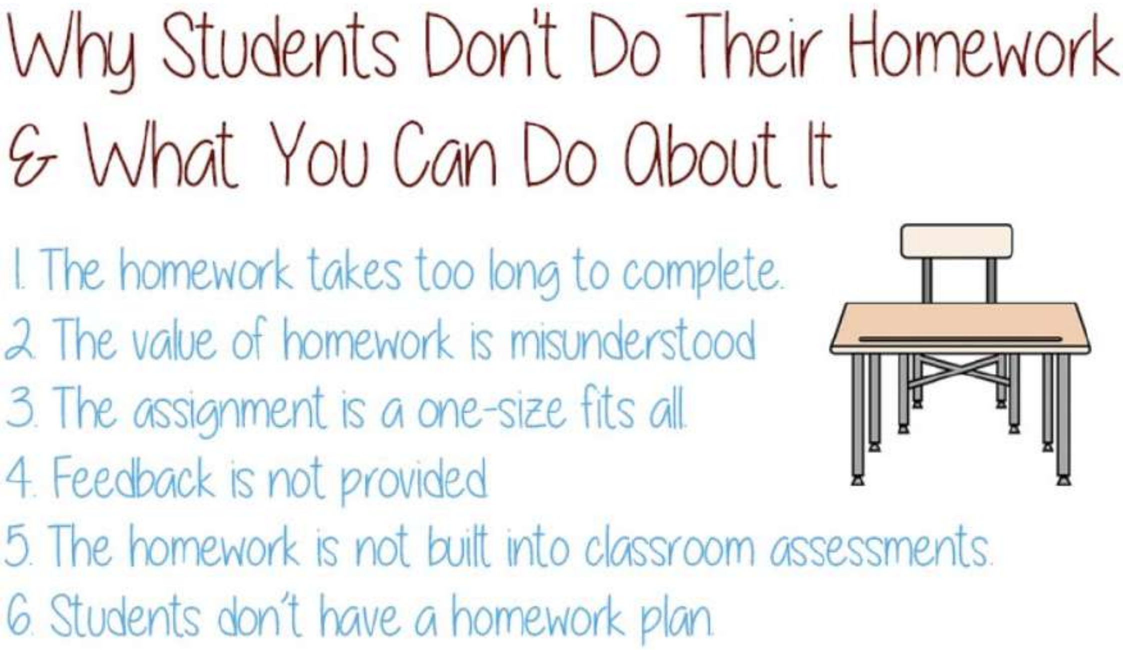
within 10 hours of the first encounter and then again in class, increases the chances that the new ideas will stick in memory.

Argument 3: Homework helps people “catch up”. If something was not clear in class, working on the homework will bring these issues to light and encourage the person to see answers – either with the friends or with the teacher.

Argument 4: Homework prepares people to learn in class next time. Sometimes, it is useful to work on a problem or an experiment before seeing the material in class to create “the need to know” or a question that will be answered later. If an experiment is videoed and data collection is time consuming, the students can collect data at home and prepare for discussion.

Argument 5: Homework help learn to how to interrogate scientific text. There is a great deal of research that shows that our students do not read textbooks. They find the material in the textbooks not helpful and if they open a textbook, then they mostly look for worked examples and mathematical representations. This is unfortunate, as being able to learn from a scientific text is an important skill for current and future education. We have developed a strategy that teaches students to read scientific text in ways similar to how physicists do it (called interrogation strategy and described in the first chapter of the ALG/OALG, in the Instructor Guide and in the textbook)) but to practice it, the students need different amounts of time as everyone reads at their own pace.

Based on the above, we have enough arguments for the homework. Assuming that you decide to assign it, new issues arise: What to assign? How to provide feedback? To grade or not to grade? I will share my thoughts tomorrow. Please comment!



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Eugenia Etkina
Admin
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March 22 at 2:56 PM
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#homework
Hi all Exploring and Applying Physics people! Two things today:
First, I created an event for our Electric field workshop on April 8th and posted about it with the probability of repeat on the 15th but I am not sure yet.
Second, thank you all for your comments about #homework yesterday! I am sharing my thoughts below. They will be in Chapter 6 of our new book about preparing teachers to teach physics through ISLE that Gorazd Planinsic and I are working on.

Based on my post yesterday, we have enough arguments for the homework. Assuming that you decide to assign it, new issues arise: What to assign? How to provide feedback? To grade or not to grade?
What to assign? What to assign for homework depends on your goals.
Do you wish the students to “strengthen” the new brain connections that they just developed? Then assign several interesting problems, experiments to perform or activities to complete which the students need to use the material that they just learned. You can also assign them to read the textbook but this is only if they have learned how to do it (see my posts about interrogation method for learning to read the textbook).
Do you wish to motivate them for the next lesson? Then assign them to observe some experiments (real or videos), collect data and try to find patterns that you will discuss during the next lesson.
Do you wish them to prepare for a test of the whole unit? Then assign them to make a list of the most important things that they think they have learned in the unit and make a test for the unit with the explanations of how each problem assesses those important things. Note that he last assignment requires team work, thus it should be assigned to the teams (2 or 3) of students to work together and they should have ample time to complete it (3-5 days).
How to provide feedback? While there is always an option to collect homeworks (or see them online if the students submit online), read every single one of them and provide feedback, it is a time and effort consuming approach. How can we save time providing feedback? Here there are multiple opportunities.
For the homeworks that serve the purpose of strengthening the material of the previous lesson one way is to start the class with a short quiz with one or two questions that are based on the homework. The quiz should be every day at the beginning of class and take not more than 5 minutes. If a person did the homework, the quiz time should be enough to complete, but if the person did not do the homework, then 5 min would not be enough. (I could post how to create such quizzes and how to grade them quickly in a separate post.) Another way to provide feedback is to have a group activity in class the next day that mirrors the homework and to provide feedback right there to the whole class. You could also post the solutions to the assigned problems a day after the homework is due and to ask those who have questions about the problems to come after class

(or at any designated time) to talk to you. The main idea is that you should not discuss how to solve homework problems in class the next day as it sends the message to those who did not do them that they will learn in class anyway, why bother at home?

For the homeworks that prepare the students for the next lesson, the feedback is provided when you continue the activities though sharing in class. But in this case, there is no accountability – those who did the experiments and collected data will benefit, but those who did not do the experiments would wait passively and not learn. What to do? Here it is good to check the completion of the homework (not correctness) and assign some points for this work to motivate the students to do it. In addition, if you have time and space, you can offer them to come to class after and do the experiments there. It is not the best option but it is better than letting those who did not do the work loose the learning opportunities that your assignment provided.

To grade or not to grade? Homework is work in progress. If you consider it learning, then providing feedback is necessary but grading is not. You could grade for the effort, for completion, for clarity but not for correctness. Bottom line, is that it is not the grade that should be the motivation for a student to do the homework, but the real goals that the homework has. Therefore, it is important to have a conversation with the students about the goals of the homework that we discussed above so that they know WHY they are doing it and how it helps them today and most importantly, in the future. Intrinsic motivation is always better than the extrinsic one. And having exciting homework helps for motivation too!

If you read the post to the end, please do not forget to like it or comment on it to make it more visible for other group members. Thank you!

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Eugenia Etkina
Admin
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6d
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#groupwork
Hi all Exploring and Applying Physics members! Today I will start a conversation about group work as it is crucial for the implementation of the ISLE approach. Collaboration is the key element of the scientific practice and if we wish our students to learn physics by practicing it, they need to learn to collaborate. In addition, being able to collaborate effectively is one of the first skills that they will need no matter where they choose to work.
Here is the first post:
Positioning students, group work, developing accountability.
Every classroom starts with … the classroom. What do students see when they walk in? Do they see the neat rows of desks and tables facing the board, a theatre sitting with the stage in the front or a room with tables for 4-5 people with small whiteboards and markers on each table with no center stage?
These settings send completely different messages to the students. They see what is expected of them – either watch the person on the stage or work themselves. As the ISLE approach assumes the latter, the first routine is clear – to set up your classroom to send a clear message to the students that learning physics is a collaborative enterprise with them at the center of it.
How do we develop this routine?
Our routine is first to set up the whiteboards. As they last for many years with good care, a good chance is that you only need to do it once. Here are a few suggestions:
Size: about 60 (70) X 50 (60) cm
Material: anything that students can write on with dry erase markers (can be any light board, with glued white paper and laminated)
Care: Clean after each use.

Prepare different color dry erase markers, some cloth (old rags work best) and a cleaning solution (any kitchen cleaner will work, water works too).
The next step is the tables and chairs. It is a good routine to come to the classroom (if you are sharing it with some other teachers) a few minutes before class and organize the tables and chairs for group work.
The next step is to put necessary equipment on every desk. It is truly important to develop a habit of thinking about each activity as experimental. Even when the students solve paper-and-pencil problems, it is great for them to have equipment to immediately check their answer.
Your students will be working in groups at those tables, each holding a marker of a different color in their hands. How do you form the groups? There are different approaches to this task. During the first class we let groups be formed naturally, as the students walked in to the classroom and choose seats. Once they are settled, it is good to check that there are no groups with one female and the rest males. You can ask students to move in this case. While some females make themselves heard in a group of males, many have difficulties doing so even when they have a great grasp pf physics. Thus, at the beginning it is a good practice to avoid such situations, later, it is necessary to monitor the groups to make sure every voice is heard. The best size of a group is 3 people. If the activity has one right answer, 2 people are enough, but if it is a creative activity, with multiple possible approaches, then 3 is a minimum number and 4 is probably as large as a productive group should get. As the semester progresses, it is great to change groups to make sure that everyone in the course works with everyone else. As one of your goals is to create a community, the first necessary condition is that people know each other well and experience working together in different contexts (more about it later). With a possible large variability in the group member’s physics knowledge, we found useful to have groups of mixed ability. Thus, as you get to know your students, make sure that the group in each course meeting have both high achieving, medium achieving students, and those who struggle. If the atmosphere in the course is supportive (and this depends on you), then the struggling members will grow and improve quickly.
After the groups finish their activity, they will need to report it to the rest of the class. Who will do the reporting? A good practice is for each group to choose a “spokesperson” for the day. This person will deliver the groups

solution to the class during that lesson. You will need to monitor the list of spokespeople so that everyone gets to play this role before the new round starts. Choosing a spokesperson for the day can be the first assignment for each group at the beginning of each class.

When the groups start working on the assignment, it is a good routine to announce the time that they will have. If you do not do it, the start will be slow and about 4-5 min at the beginning will be lost. It is good to have a timer or some other means to remind students how much time is left. This time monitoring creates “the sense of urgency” in the lesson that prevents it from dragging. How do you know how much time will be needed for a particular activity? First, time yourself doing it when you are prepping the lesson and then multiple it by 2. This would be the minimum time. You can always extend it in class (obscurely), but having the limit is crucial for a quick start of group work.

To have the accountability for student work, they need to put everything on their whiteboards and then present what they found to the rest of the class. But while such approach helps keep the students accountable, it might lead to the drudgery of the lesson and the lack of the “sense of urgency”.

Therefore, a key step in maintaining the sense of urgency is deciding when to cut off the time for the activity and how to organize groups’ presentations. It is tempting to wait until all groups finish and then let them all present their findings taking turns. There are several dangers in this routine. Those who finish first get bored waiting for the rest of the groups and when all the groups have the same solution to the problem, it is boring to listen to the same thing again and again.

To be continued....

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Eugenia Etkina
Admin
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5d
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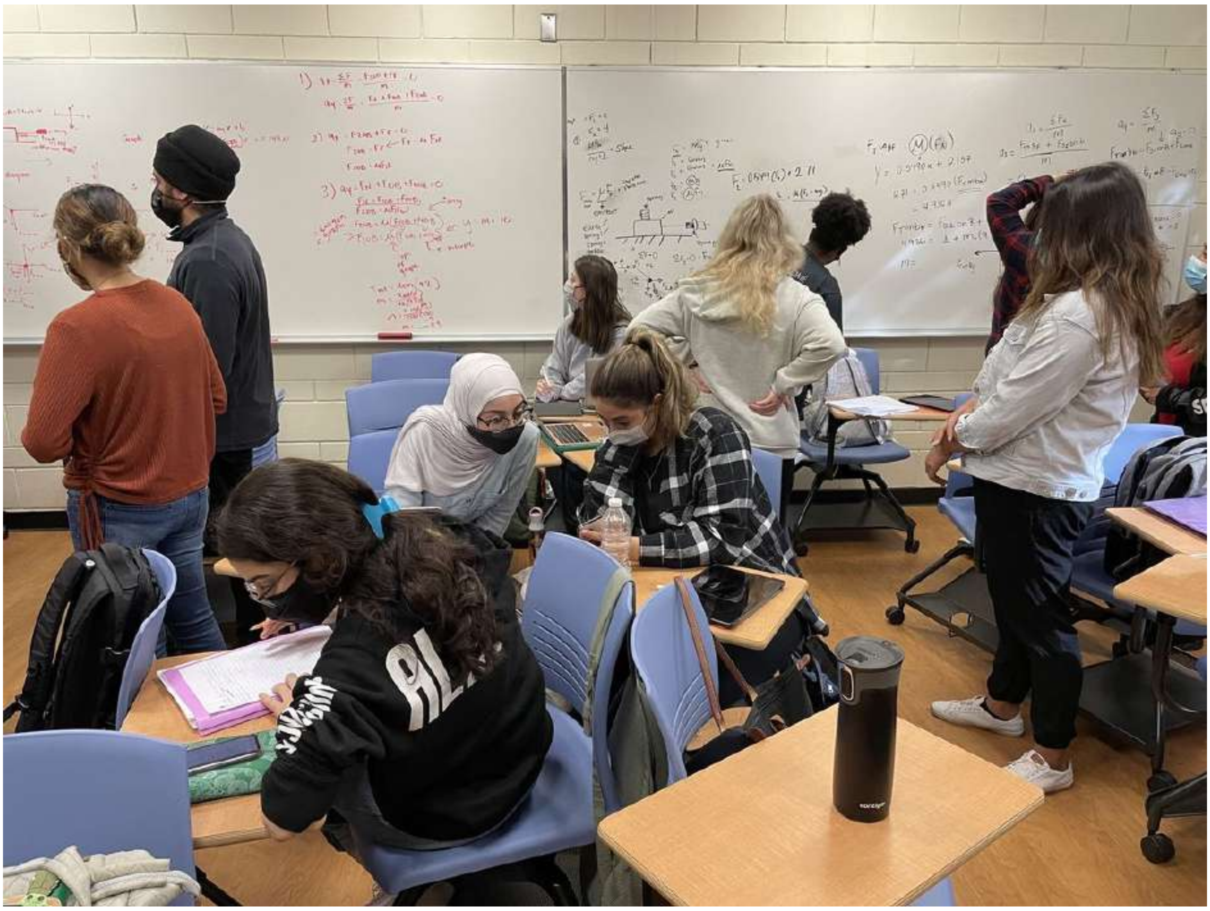
#groupwork
Hi all Exploring and Applying Physics members! Thank you all for responding to my yesterday's post about positioning students and organizing group work. I am reminding you of two intentionalities of the ISLE approach: to help students learn physics by constructing knowledge following the processes that mirror the practice of physics and to help them stay motivated, feeling that they belong in physics and develop growth mindset. Group work fosters both intentionalities as scientists work in teams creating knowledge and group work can help develop the sense of the community, belonging, and extend students' zone of proximal development. The problem is that not all groups are functional. What does it mean a functional group? A functional group is the group when group members work together, listen to each other and support each other to solve a problem. By working TOGETHER they extend each other's zone of proximal development. This sound good in theory, but how do you help them learn to work this way. And does belonging to a functional group make a difference? It turns out that it does!
From the above follows that it is important that the group work is really collaborative, not led by one dominant person while everyone else is either passively listening or is “checked out” until the answer is provided. How can we help group members collaborate? Research by David Brookes, Yuehai Yang and colleagues (I put the citation below, you can download it easily) found that in the groups where the more knowledgeable person “hedges” the answers (makes them sound a little uncertain, for example: “What do you think of this idea?” or “I could be wrong but these are my thoughts…”) instead of declaring them authoritatively, other group members participate and collaborate more equitably. The consequence of this more equitable engagement is that these groups make far more

progress on challenging activities (the activities that are require the students to leap into their zone of proximal development). If there is no equitable engagement, the other group members do not challenge the statements of the person who is perceived as more knowledgeable. It seems that hedging creates some kind of psychological safety that is necessary for effective collaboration. If you read the post to the end, please do not forget to like it or comment on it, thank you!
Here is the reference: Brookes, D. T., Yang, Y., & Nainabasti, B. (2021). Social positioning in small group interactions in an investigative science learning environment physics class. Physical Review Physics Education Research, 17(1), 010103. https://doi.org/10.1103/PhysRevPhysEducRes.17.010103



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Eugenia Etkina shared a group.
Admin
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4d
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#groupwork
Hi all Exploring and Applying Physics, yesterday, in response to my post 2 days ago about setting up the classroom for group work, Martina Bach asked the following questions:
"do you suggest they write notes also in their notebooks in order to have material to study (in my school we have a physics book that in my opinion is unfit for read and interrogate activity)? Second question: what if the class is so lively that you struggle to have a constructive learning environment? Third: in my class, teachers of other subjects are very traditional and demanding, with frequent written and oral tests, and when I propose group activities my pupils feel like they are on holiday and don't take them seriously. They like our lessons but they give more time to other subjects if we do not have tests with marks.. Do you have any suggestion?
Here are my answers: Question 1: do you suggest they write notes also in their notebooks in order to have material to study (in my school we have a physics book that in my opinion is unfit for read and interrogate activity)? My answer: They should. They should first take photos of their whiteboards and save them in their electronic journals. Then, they should have the notebook for individual notes. In that notebook they should have everything that you ever wrote on the class board during "time for telling" as well as their homeworks. Lab reports are better kept in google docs or some other collaborative platform as they do those in groups. Danielle Buggé can more on this issue.
Question 2: what if the class is so lively that you struggle to have a constructive learning environment? My answer: lively is good, but you need to channel it. Announcing the time limit for each activity and sticking

with this time limit is one way to do it. Another way is to use "participation points" as an extrinsic motivation. I would also "race" my students by doing calculations on my own small whiteboard so that they cannot see my solution as I am making it and announcing the competition - who can do it faster (this is for traditional problems). You can invent any system of rules and rewards for group work and follow through. Remember - you are the boss!
Question 3: Third: in my class, teachers of other subjects are very traditional and demanding, with frequent written and oral tests, and when I propose group activities my pupils feel like they are on holiday and don't take them seriously. They like our lessons but they give more time to other subjects if we do not have tests with marks.. Do you have any suggestion?
My answer: I already wrote about everyday quizzes. The quiz needs to be based on the group activities or homework. Our system does not preclude often formative assessment as long as the students can improve their work. You can also institute "groups participation points". For example, each day you have 3 activities. Each activity has a certain number of participation points. Those who are not actively engaged do not get them. You also can explain to your students the value of group activities not only for learning today but for their future lives. And activities need to be engaging. A combination of extrinsic motivation (first) that pulls them into the activity and intrinsic motivation that comes after should do the trick. Your creativity is the most important here.
If you read the post, please like it or comment on it to make it more visible, thank you!

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Eugenia Etkina

Admin

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3d

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#groupwork

Hi all Exploring and Applying Physics people, I continue with my posts about group work. We discussed the "sense of urgency" - how do you make group work time efficient and not drag? Here are my suggestions:

A key step in maintaining the sense of urgency is deciding when to cut off the time for the activity and how to organize groups' presentations. It is tempting to wait until all groups finish and then let them all present their findings taking turns. There are several dangers in this routine. Those who finish first get bored waiting for the rest of the groups and when all the groups have the same solution to the problem, it is boring to listed to the same thing again and again. Here are possible routines here:

1. Notice when the first group finishes and if their work is correct, stop the rest of the groups, let this group present and then ask representatives of the groups that did not finish to ask questions or repeat what the first group said and then give them a few minutes to finish their boards using the work of the finished group.
2. Invite the members of the finished group to visit the groups that are not done and help them. Then the first group presents.
3. Give an additional activity to the finished group and let the rest of the class finish. Then if the solutions are the same, any group can present, and if the solutions are different, invite the groups visit each other, talk and then share the differences that they found without repeating the things that all groups did the same.

It is important not to be the first to validate the results and solutions yourself but let students discuss them. However, at the end it is a good practice to summarize the results of the group activity and clearly state why the students did it and what they were expected to learn from it. A good routine is to keep these summaries short on the class board and let the students take photos for their journals at the end of the lesson.

There are a few other important routines to keep in mind specifically for the group work in the ISLE environment:

1. Before each group activity, ask the students where it belongs in the ISLE process – are they working on an observational experiment, on the

patterns, on the testing experiment, etc. For example, if it is a testing experiments, it is helpful to put the hypothesis that the students will be testing on the class board for clarity.
2. After every group activity, summarize what the students found so that they can proceed to the next one being “on the same page”. For example, if it is an observational experiment, it is helpful to put on the class board the patterns that students found; if it is an application experiment, it is helpful to put the results on the board and ask how we know that they make sense. The bottom line, is that developing epistemological aspect of reasoning is as important as doing the activities.
The “group work” routines described above work for the lessons when students learn new material and when they do long labs (if you are teaching in college and the course is run in a traditional mode, having the labs separate from other activities).
If you are teaching a large enrollment physic course using the ISLE approach and have “lecture time” (we call it “large room meeting”, Diane Crenshaw Jammula already talked about it) when all 200-300 students or more are in a theatre-sitting environment, it might feel that no group work is possible. But team work is always possible. A student needs to turn to their neighbor to discuss the activity. Their consensus can either come from direct sharing with the rest of the class, or by choosing an answer among the choices that you provide using student-response system. While it is much easier to implement the ISLE approach in a studio setting or a high school classroom, a large enrollment course also provides opportunities for team work. Even if you cannot organize team work in a large room meeting, the students can still work in groups in the labs or in problem-solving activities. Then the routines described above are relevant.
I wanted to mention that the photos I posted before were from the classes of Diane Crenshaw Jammula (university) and this one is from the classes of Danielle Buggé (high school).
If you read to the end, do not forget to like or comment to make the post more visible. Thank you.

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Eugenia Etkina shared a link.
Admin
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#summerworkshop and #WELCOMENEWMEMBERS
Hi all Exploring and Applying Physics people, two things today: first, I am announcing summer in-person ISLE workshop for high school teachers

(college people are welcome too) at Rutgers University. The workshop is run by Danielle Buggé and Rob Charles - Rob Zisk. Danielle Buggé is an award winning teacher (PhysTEC teacher of the year 2023) who has been using the ISLE approach for over 10 years with amazing success and did her PhD studying the effects of ISLE on high school students. Rob Charles is a professor at Rutgers GSE who is now running the physics teacher preparation program using the ISLE approach, his experience with ISLE is also over 10 years and he has ran numerous workshops for high school and middle school teachers. Both are amazing teachers. The workshop will run June 26-30, the cost is $500. An official flyer will the details will follow, this is just a preliminary announcement. Rob will organize lodging at Rutgers for those who are not from NJ. His email is rzisk@gse.rutgers.edu, contact him ASAP if you are interested in coming. The lodging is not expensive. We will also run our traditional 2-day ISLE workshop online some time in July. I will announce possible dates. And there is an in-person 8 hour workshop on ISLE at the AAPT meeting this summer. If you are going to the meeting - sign up!

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Eugenia Etkina shared a group.
Admin
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#supportiveatmosphere
Hi all Exploring and Applying Physics people! Thank you for your comments yesterday, it was probably the most "comment-rich" day. Yesterday Shih-Yin Lin asked the following question:
Eugenia Etkina Could you talk about how to form groups of mixed ability without hurting the feelings of those struggling students? Also, about

creating supportive atmosphere in the course, do you have any suggestions for what we should or should not do?
I will try to answer both questions here. Prepare for a long post.
How to form groups of mixed ability without hurting the feelings of those struggling students? There are many ways of doing it, but one is to change groups often. When setting up the groups, prepare the lists in advance and make cards with group numbers. that you will give to the students. Then put the numbers on the tables reserved for the groups and everyone will go to their table. Another way to do it (having the list for yourself is important) is to "count" the students using the numbers of the groups (1, 2, 3, 4, 5, 6) and those who are ones - go to table 1, those who are twos go to table two and so for. As long as you create the routine that you set up the groups, and the groups change, it will just a be a routine. In any case, you need to monitor the groups carefully that everyone participates and teach the students about hedging. See my post from a few days ago.
Second question: Also, about creating supportive atmosphere in the course, do you have any suggestions for what we should or should not do?
One of the intentionalities of the ISLE approach is to help students feel successful, motivated, capable and belonging in physics. Almost everything that we do (if done correctly) addresses this question.
First, when the students observe initial experiments to start constructing a new idea, they are not asked to predict the outcome. They are asked to say in simple words what they observed. This step removes the feeling of failure that exists if they are asked to make a prediction and this prediction does not match the outcome. This step also removes the feeling of not belonging that might occur when other students are using scientific terms that you do not understand. At the stage of observational experiments everyone is successful. Everyone starts on the same page. Everyone feels that they can do it. More, the students working together form a community of shared expertise, making every student feel that their contributions are valued and that they belong.
Second, as the students develop their own hypotheses to explain the outcomes of observational experiments, we call them “wild” ideas, which do not need to be correct but need to be experimentally testable. As they work in groups, they share their possible designs and make predictions based on their wild ideas. When they run the experiments and the

outcomes do not match the predictions, it is not their personal intuition that fails, but the “wild idea”. Therefore, no harm is done to their self-confidence, on the contrary, they feel that they accomplished something that is very valuable in science – they ruled out a possible hypothesis! How many of your students have an experience of ruling out a physics hypothesis? Additionally, this experience teaches them that knowing the right answer is not important here, but creativity and persistence are!

Third, a consistent use of graphical representations as bridges between words (or physical phenomena) and algebra/calculus helps those students whose need concrete imagery to describe a process with mathematical symbols.

Finally, the set-up of the course when the students are not only allowed but encouraged to resubmit their work for improvement (lab reports, homework, quizzes and even exams) creates the atmosphere of learning in the course. The students get accustomed that they might not succeed on the first try but if they persevere, they do succeed and thus are successful in physics. Our research shows that students do indeed feel that they can success in physics and that what they are learning in a course following the ISLE approach is useful for their studies in other courses, for their future in the workplace and in their lives in general.

But this said, the most important person in creating supportive atmosphere is YOU. Research shows that the teachers who have "fixed mindset" promote this mindset in their students. If you believe that everyone can be successful in physics, your students will feel it and persevere. If you respect every answer and support every attempt to reason, they will too. If you see ruling out of a hypothesis through a testing experiment a victory, they will too. Our students follow us, mirror us, and base their behavior on ours. Thus, think what can you do yourself to send the message that everyone welcome in class and everyone is capable? Encourage and reward questions. Listen and hear your students and change the lesson based on their questions/comments and let them know that it was their comment that made you change the path. Put their names in the problems. Use their names to name the ideas that they created. Use self-deprecating humor. There are so many little things that you can do to help students feel welcome, belonging, capable and seen as individual human beings, not just students. Does it make sense?

If you read the post to the end, please like or comment on it to make it more visible. Thank you.

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Eugenia Etkina
Admin
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April 1 at 4:06 PM
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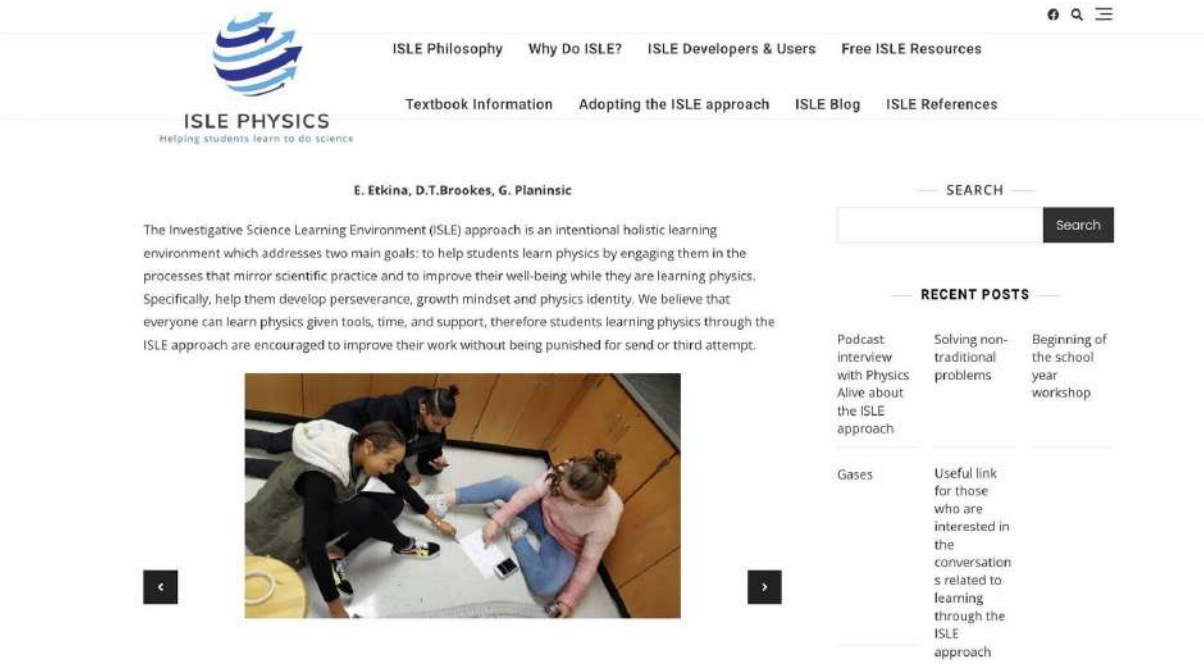
#askingquestions
Hi all Exploring and Applying Physics people! Today I start a series of posts about asking questions. I posted about questions about a year ago, but now my thoughts are more organized and systematic. So, here is the first installment. Please do not forget to like the post or comment on it to make it more visible. Thank you.
If you ever attended a physics research seminar or a conference, you probably noticed that physicists never take any statement for granted. They question. How did you know? What were the uncertainties in your experiment? How does it compare to the experiment done by XX? Such questions are common and they show that authority is not the reason to believe in anything. However, there is more. Without asking a question about something that they observe, there is no development of new ideas of physics. While observations of the real world always come first, the next step in the physics progress is asking a good question. In the US Next Generation Science Standards asking questions is one of the important science practices that students are required to master. The question is (no

pun intended here), how do we teach our students to ask good physics questions?
As always, we need to start modeling this practice ourselves first. This means developing a habit of asking our students good questions when they are learning. We can think of all questions that we ask our students as belonging to two big groups. One group we will call “closed questions” and the other group we will call “open questions”. Open questions assume multiple correct answers or they even do not care about the correctness, just students' ideas. Multiple students are welcome to answer.
Closed questions assume one right answer and one person who knows it. For example, you are interested in how your students understood the concept of acceleration. You might ask:
· Who knows what acceleration is?
· Or: What is acceleration?
· Or: What is the definition of acceleration?
All these questions assume confidence in those who answer and the existence of one right answer. These are closed questions.
How to turn them into open questions? Here are some examples:
· Please tell me what you "see" when I say the word "acceleration".
· Please give me two examples of real objects that move with acceleration. How will you know?
· Think of a few differences between velocity and acceleration.
· Eugenia says: "Acceleration is the change in velocity". Why would she say this? Do you agree with her? If you disagree, how you help her agree with your point of view?
· David says that an object with acceleration of 5 m/s/s speeds up and an object with acceleration of -5 m/s/s slows down. Eugenia disagrees. What can be possible reasons for her disagreement?
· How would you explain the idea of acceleration to somebody who has never studied physics?
· Please give me an example of an object that has a positive acceleration and is slowing down and negative acceleration and is speeding up.
· How do you know if an object is accelerating?
· What are your thoughts about acceleration?
· How would you represent an object slowing down with a motion diagram?

If you compare the first set of questions to the second, you will find that in the second set each question assumes the existence of multiple answers and no one needs to know all of them. Therefore the "fear of the wrong answer" barrier is reduced and many more students can participate.
In general, it is a good rule of thumb to avoid starting your questions with: What is the answer to XX? Who knows XX?
To be continued... And please do not forget! Like or comment! Thank you!



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Eugenia Etkina shared a link.
Admin
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April 2 at 4:13 PM
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#AskingQuestions

Hi all at Exploring and Applying Physics people! Today I continue with asking questions theme. Please do not forget the like or comment on the post to make it more visible. Thank you!
Yesterday we talked about how to ask a good open question. The next step is how to elicit answers to the questions. Here the routines are important. Sometimes we think that a question is easy and everyone should be able to answer it. Then we ask the whole class and wait for volunteers. Try not to call on the same person the second time before all others had a chance to participate and try not to miss girls holding their hands (as you know, they are often invisible). But if after 10 -15 seconds no hands rise up, say: OK, let's have 2 minutes in your groups to come up with ideas and then we will share them. This routine reduces the need for an immediate personal right answer even more.
In general, to invite more students to answer your questions, it is useful to start them with: Please share are your thoughts about XX. What are your ideas? How can we explain XX? How can we test XX? How would you approach XX? How do you know XX? What is your image of XX? How can we convince XX in XX? Tell me more about XX... Who can add to XX? Any ideas about how we can explain XX? Any ideas how we can test XX?
Another issue is important. We often ask a question in a whole class discussion or when students are reporting on their group work, and a student answers with one word. If this word is correct, we often validate and move on. But does it always mean that the student really understands what they said? A good routine to make sure is the ask the questions: "What do you mean?". This is a simple way to elicit their real understanding. The next step, even if they provide a good answer is to NOT validate it, but to toss it back to the class- do you, people, agree? Sometimes, when one student answers a question, the others do not listen or do not understand. "Do you agree?" question for the whole class and the expectation that somebody else would answer makes everyone focused on what the first student was saying. Habitually asking the rest of the class to evaluate each other's answers will become routine for them. The goal is to communicate the message: “I am not the final authority; you need to figure it out yourselves.” ("What do you think?" is called a Reflective Toss - the name coined by Jim Minstrell a long time ago.) When somebody in the class responds, stay back until the discussion between

the students starts. Open questions invite or trigger discussions, closed questions do not.

Now, the most difficult step comes. How do we encourage high school students to ask good questions when they are learning physics? Although asking questions" is the #1 science practice in the Next Generation Science Standards, in a teaching practice we have tools and routines to reward students for good answers but not for good questions. Have you ever given a grade to your student for asking a good question or just extra points? And what are good questions?

If you look at the history of physics, the scientists who we all know are those who dared to ask a question about something that everyone else accepted as true (dogma in a way). Galileo asked whether it was true that all objects fall at constant speed with that speed proportional to their mass (Aristotelian dogma). Newton asked how the Moon orbits Earth. Einstein asked how we can figure out what would happen if we could travel on a light ray or be placed in a closed elevator in a free fall - would you know that you are not standing on Earth? So, bottom line, asking good questions is as important, even if not MORE important than giving good answers.

When I was teaching high school, I would tell my students on the first day of class that questions were very important and if anyone asked a great question (I would be the person to judge that), this person would receive the same number of points as they would on a perfectly correct test. Usually about 1 person per term would get these points. And everyone clapped when I would say: "This question is a great question, such and such scientist asked it too and this is what happened after" - I would tell a short story - and the student who asked it would receive the points." Of course, it is a subjective decision but in all my years of teaching no student ever argued that some question that I found worthy of the points was not. Often, a good question would change my lesson plan and we would continue our investigations to answer it. This is true even for questions that were not that remarkable - I tried to show my students that almost every question they asked made me change what I planned to do and follow the "need to know". However, we all know, that sometimes the questions are irrelevant or distracting. For those we need all our tact to show the student that we respect the question but it is out of the field of our studies or that it will be answered later.

Now, how do we teach students to ask good questions? First, the students should feel safe to ask. Neither we, nor other students should ever comment or make fun of a person asking a question. But this is not enough. The same way as we teach students to reason like physicists, or to read the textbook as experts (interrogation method that is described in the first chapter of our textbook and in the activities in the 1st chapters of the ALG and OALG), we need to teach them to ask good questions. The whole ISLE approach lends to good questions. To be continued. Please do not forget to do your part now. Thank you!
https://www.facebook.com/groups/320431092109343/posts/1388952458590529/?__cft__[0]=AZU7II0CvKBATR1J1XSd4wX2zkg259e2-Np1J8qsd0kLW83u_IsohEhWDkhlIE25T-4bhyCHr1uhvyrHJdJMGRqMs9_8jLG4PfkrryuETVX4AwBsZIhIJN6JPAMDnHXi3LtcTHSxD39XukijHswyxnJp3zZB-RsyLV8ZqWckUCE63875-ZVxQzSYJcATd-_o_uw&__tn__=%2CO%2CP-R

Eugenia Etkina shared a link.
Admin
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April 4 at 3:48 PM
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#studentsaskingquestions
Hi all Exploring and Applying Physics people! Three things today. First, I am reminding you of our electric field workshop on April 8th. Please sign up for the event if you plan to attend. I will post pre-workshop homework tomorrow.
Second, based on the group activity, you might not see the notifications for the posts, thus I strongly recommend checking posts every day even if there is no notice as there will be a post every day.
Third, I continue with questions. The previous post was about how to encourage your students to ask questions. This post is about how to teach them to ask good questions in the ISLE environment. Read on.
Below there are few examples of good questions that the students learning through the ISLE process might ask:
Observational experiments questions:

How do we infer a pattern from these data?
How do we best represent the data?
How do I know if it is a good idea to linearize data to find the pattern?
Model/explanation/hypothesis development questions:
How do I start thinking about making mathematical model for the pattern?
How do go about finding a mechanism?
How do I know that my explanation is correct?
How do I design and experiment to test the model/explanation/hypothesis?
How do I know if this is a good experiment?
Testing experiment questions:
How do I make a prediction of the outcome of the testing experiment using the hypothesis under test?
How do I know if my experiment would give me the outcome that will allow me to differentiate between two hypotheses that I have?
Were there any additional assumptions did I make when I made the prediction?
How can I validate the assumptions?
How do I determine the uncertainty in my result?
How do I know if my experiment ruled out the hypothesis/model/explanation?
We can go on the make a list of good questions for application experiments and for different multiple representations, but you probably already see the pattern here. Almost all good question start with How do I know this? (the best question ever) or How do I do such and such? and NOT with the word WHAT. Note also, that we did not list any good questions that start with the word WHY. Why is that? While the students often ask the questions starting with the WHY, those are in fact the questions that have the HOW in them. Sometimes though "Why" questions hide the purpose of the phenomenon, not how it happens. And if you answer them, then often the answer is anthropomorphic (Anthropomorphism is the attribution of human traits, emotions, or intentions to non-human entities. It is considered to be an innate tendency of human psychology).
For example: why do objects fall down on Earth? Answer: because they want to be in a state with the smallest gravitational potential energy. In fact, the objects do not want anything, and we just gave them human

characteristics with our answer. Most famous answer to the question WHY was given by Newton who was asked WHY gravity exists. He said that he did not care why, he only cared HOW to describe it.
To teach your students to ask good questions the teacher needs to model them (see the above discussion) and to explain to the student why a specific question is good. And of course, to reward them, as we described above. We have examples of such questions in our materials, for specific elements of the ISLE process - in the labs at [https://sites.google.com/.../scientificab.../isle-based-labs]
A long time ago we did a study correlating the quality of the questions that students asked about the material once a week as a homework assignment and their learning gains (Harper, K., Etkina, E., & Lin, Y. (2003). Encouraging and analyzing student questions in a large physics course: Meaningful patterns for instructors.Journal of Research in Science Teaching, 40, 776-791). Those who asked questions that we described as "good" above had significantly higher learning gains than those who focused on "what" type of questions.
Bottom line, if you want your students to ask good questions and think like scientists, first model this practice yourself, then teach them what a good questions is, and, finally, reward them for asking good questions. This is the end of the "questions" story.
Please do not forget to like the post or comment on it to make it more visible. Thank you.

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Eugenia Etkina
Admin
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April 5 at 3:50 PM

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#firstPERhandbook

Hi all Exploring and Applying Physics people! Two things today: 1) please sign up for the workshop on Electric fields that will take place on Saturday at 10 am PST, 1 pm EDT and 7 pm Central European Time. Check your time zone to make sure you can make it. Electric field is one of the most abstract and difficult concepts for the students. We are trying our best to help them. Please go to the EVENTS and sign up!

2) The very first handbook in physics education research is published! Editors of the whole book are Fatih Tasar and Paula Heron. I had the honor of being section editor together with Eric Brewe of the section on learning environments and one of the authors of the chapter on holistic learning environments. ISLE and Modeling Instruction are in that chapter. The book is huge and lots of people contributed to its creation. If you are at a university, the university should be able to get it for its library.

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Eugenia Etkina uploaded a file.

Admin

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April 6 at 3:37 PM

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#ISLEworkshop

Hi all Exploring and Applying Physics people! As I promised, I am attaching the flyer for one week long ISLE workshop at Rutgers. notice the sates and the person to contact to apply - Rob Charles (Robert Zisk). He will be running the workshop with Danielle Buggé. If you decide to travel

to Rutgers, make sure you email him right away. As I already said, we will have a two day online ISLE workshop in the summer too as well as an 8-hour in person workshop at the AAPT. If you are new to ISLE, any of those will help you learn the basics. For details on every topic stuff you have to attend monthly workshops of this group. The next one is this Saturday - Electric fields. Please do not forget the like or comment on the post, recently my posts are invisible. Not sure why Facebook does it. Thank you.
https://www.facebook.com/groups/320431092109343/posts/1391014478384327/?__cft__[0]=AZWDOjiXm_26n8r3WvKc2tOdg09Md1EfaK-yWL1CMv_jKF_5VaaaMSJ4FWeyoqERCdHwjGKO8QOSDkaU6De1GUOra0EDBLGdsYR-HKO13aFzO0ukwj3lRiA_GyGrq9W0x-jC3KmYDJwgqBV9KAL2Lisa45QFuq97gfTsfiaG3ck2Czqf7mhZ9oEk_3AxvCiJhVl620m360t4fDgvMTkcjwuu&__tn__=%2CO%2CP-R

Eugenia Etkina shared a link.
Admin
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April 7 at 3:43 PM
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#electricfieldworkshop
Reminder: if you are planning to attend the Electric Fields workshop tomorrow, please watch the following video before joining the zoom meeting:

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Eugenia Etkina
Admin
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April 9 at 2:09 AM
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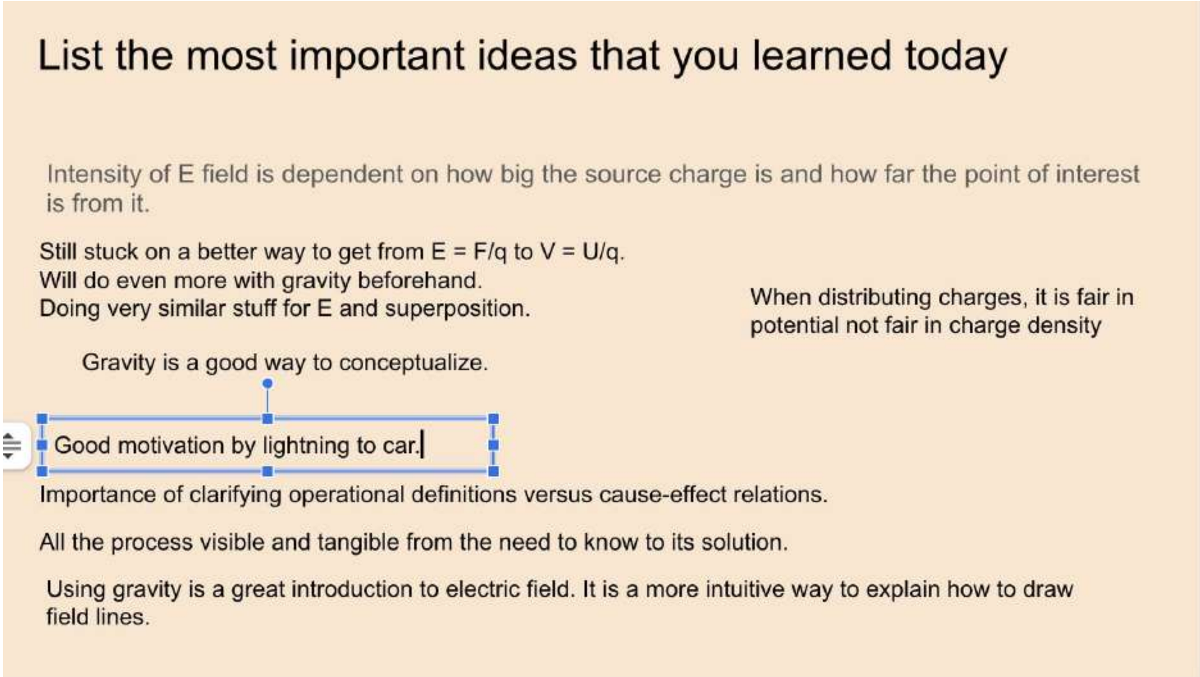
#electricfieldworkshop
Hi all Exploring and Applying Physics people! We had a great Electric Field workshop today. Here is the link to the slides
https://docs.google.com/.../18uTQ5GrpThF6y5tvvF3x.../edit....
Here is zoom recording:
https://rutgers.zoom.us/.../RcB2WqcpJiTz0eWmZW7JPYAWhL2eT...
password is &2g3f$g9
The reflection slide is below. Those who missed it, if you have questions after you watched the zoom video and did the activities on the slides, please let me know and I will run a 1-hour session next Saturday at the same time to answer your questions.
Our May workshop will be for LEDs and it will be 3 hours as 2 hours are not enough. I will put possible dates tomorrow so that you can vote. PLEASE LIKE OR COMMENT TO MAKE THE POST MORE VISIBLE. Facebook makes my posts invisible. Thank you.



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Eugenia Etkina shared a post.
Admin

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April 10 at 8:13 PM

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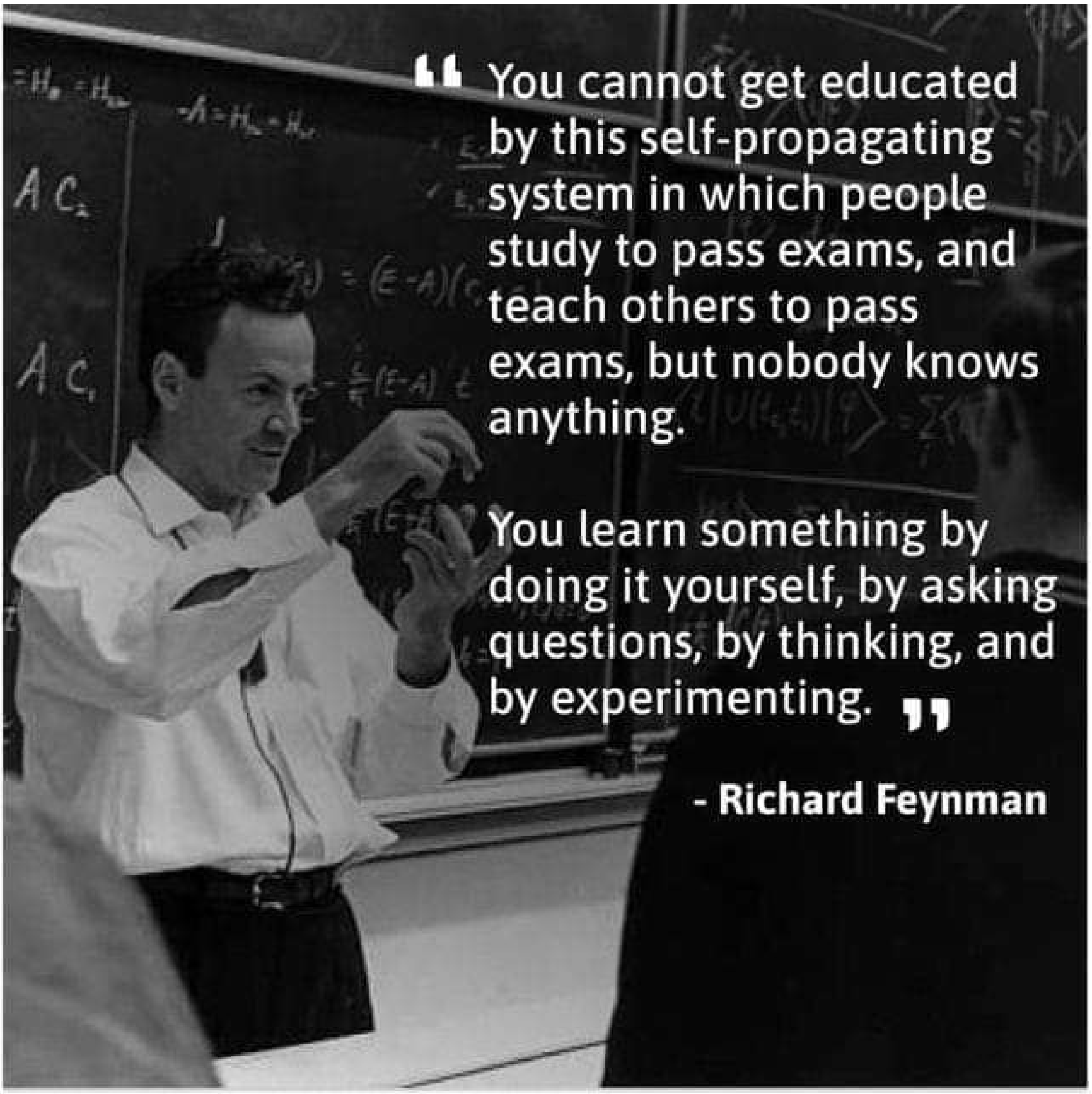

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Eugenia Etkina
Admin
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6d

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#WELCOMENEWMEMBERS and #mathematicalrepresentationsofelectricfield

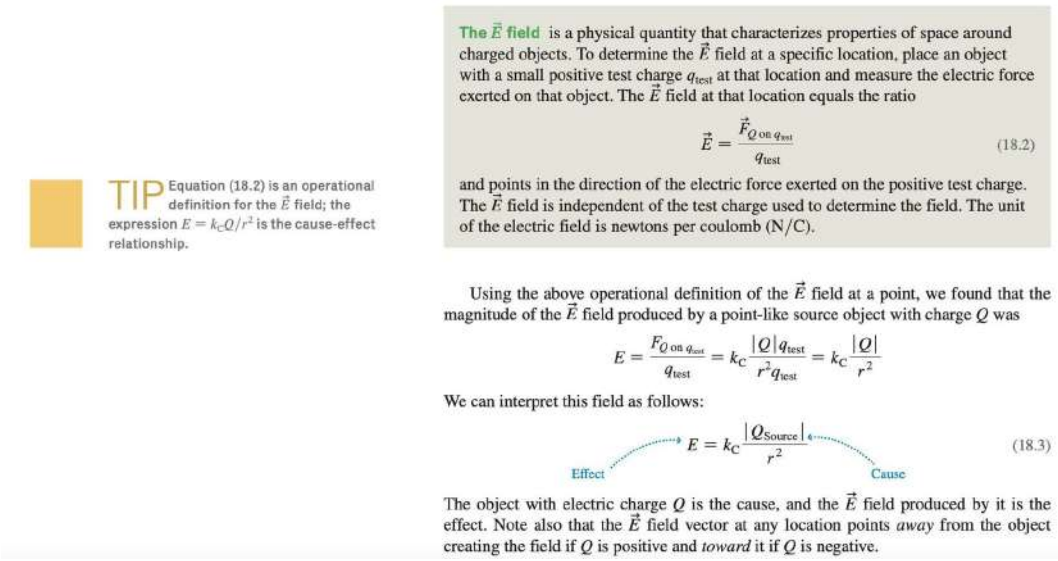
Hi @everyone I am trying a new way to make my posts more visible. Two things today: we welcome new members and we talk about Electric Field. There are two things about electric field that I wanted to discuss. First: traditionally the same term is reserved for field as an entity, a thing, a model that explains interactions at a distance and the physical quantity characterizing its force-like, vector properties. Our textbook is the only one that distinguishes between electric field as model of interaction and the physical quantity E, we call it E-field (with an arrow on top of E to signify that it is a vector). later we call electric potential V field for symmetry. We have two quantities characterizing electric field - E-field and V-field.

In addition, we discuss the difference between the operational definition of the E-field (F/qtest) and a cause-effect relationship for the E field when the field is created by ONE point like charge (kQsource/r^2). When there are more charges or charged planes, the former remains the same but the latter is different. We discussed the difference between operational definitions and cause-effect relationships before, if you need a refresher, please say here. I am attaching a screenshot from the textbook to help you see the difference.

Let's welcome our new members:
Yalchin Islamzade,
李夏安,
Bill Reitz,
Hrisilda Matathia,
Viviana Poli,
Lamar Wildes,
Fatih Tasar,
Mohammed Basha,
Gajanan Patil,
Victoria Valdenegro,
Nenad Nikolic,
Nassim Sarirah,

Sagar Tripathy,
Jessica Moro,
Jess Wawrykow,
Irwandi Irwandi,
呂冠源,
張富竣

You will only benefit from this community if you log into the group EVERY DAY regardless of the Facebook telling you that there is a new post and read the posts, like or comment on them and participate. You all saw the welcoming message when you first logged in, if you did not, please see the posts pinned to the top of this group home page. WELCOME! And please, do not forget to like or comment on this post too!



TIP Equation (18.2) is an operational definition for the $\vec{E}$ field; the expression $E = k_C Q/r^2$ is the cause-effect relationship.

The $\vec{E}$ field is a physical quantity that characterizes properties of space around charged objects. To determine the $\vec{E}$ field at a specific location, place an object with a small positive test charge q_{test} at that location and measure the electric force exerted on that object. The $\vec{E}$ field at that location equals the ratio

$$\vec{E} = \frac{\vec{F}_{Q \text{ on } q_{test}}}{q_{test}} \tag{18.2}$$

and points in the direction of the electric force exerted on the positive test charge. The $\vec{E}$ field is independent of the test charge used to determine the field. The unit of the electric field is newtons per coulomb (N/C).

Using the above operational definition of the $\vec{E}$ field at a point, we found that the magnitude of the $\vec{E}$ field produced by a point-like source object with charge Q was

$$E = \frac{F_{Q \text{ on } q_{test}}}{q_{test}} = k_C \frac{|Q| q_{test}}{r^2 q_{test}} = k_C \frac{|Q|}{r^2}$$

We can interpret this field as follows:

$$\underbrace{E}_{\text{Effect}} = k_C \frac{\underbrace{|Q_{Source}|}_{\text{Cause}}}{r^2} \tag{18.3}$$

The object with electric charge Q is the cause, and the $\vec{E}$ field produced by it is the effect. Note also that the $\vec{E}$ field vector at any location points *away* from the object creating the field if Q is positive and *toward* it if Q is negative.

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Eugenia Etkina
Admin
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5d

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#doingderivations #LEDworkshop

Hello @everyone two things today.

First, our LED workshop will be on May 20th, 3 hours, 9 am Pacific time, noon Eastern, and 6 pm Central European. I will create the event for it tomorrow and you can start signing up.

Second, today I will talk about derivations. As the students learning physics through the ISLE approach are expected to construct their own knowledge working in groups with our guidance (and the guidance of the materials that we have created), the question comes up - How do they derive mathematical representations that do not arise from data analysis? I am pasting a screenshot of the activity in Chapter 18 Active Learning Guide (see OALG Chapter 18 posted here in the files) that shows an example of how we approach the derivations. I would say that there are three different ways to do it. I list them below with the progressive increase of the difficulty.

The teacher is at the board and asks questions related ot the steps of the derivation. After each question the teacher gives the students 1-2 min in groups to come up with an answer, then the students share their answers and the teacher puts the answer on the board for everyone to write down. Then the next question follows. Bottom line - the teacher does not put anything on the board without the students suggestions.

The students work in groups, the questions are in the activity (ALG or OALG) and each question already has an answer to each step but the students need to figure out how to get to this answer (See examples in OALG Chapter 12, Activity 12.3.2, the file posted here in the FILES). After the students go through each step, the teacher holds a whole class discussion about each step.

The students work in groups on the activity that only asks guiding questions and they need to find the answers. The teacher holds a whole class discussion after each step to make sure that all groups are on the same page. At the end the teacher goes over each step again. The discussion focuses on whether the result makes sense to the students.

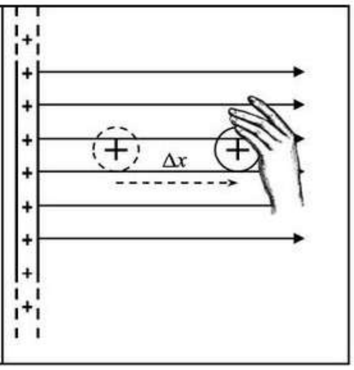
If possible, all new expressions need to be examined for limiting cases, units, and tested experimentally (see OALG 18.4.4)

I am attaching a screen shot of the activity of type 3 for the relationship between E field and electric potential (V field). Please share your ways of helping students derive new mathematical expressions. And please do not forget to like the post or comment to make it more visible. Thank you!

18.4.2 Derive

***PIVOTAL* Class:** *Equipment per group:* whiteboard and markers.

Consider a uniform $\vec{E}$ field produced by an electrically charged infinitely large glass plate. We will place a small object with charge $+q$ at some initial point in the field and move it (by hand) at a *constant* speed to some final point, through a displacement Δx, as shown in the diagram. Work with your group on a whiteboard to calculate the work done by the hand and use that to estimate the difference in potential between the initial and final points in order to find a relationship between the $\vec{E}$ field and the potential difference ΔV. Use the guiding questions below to help structure your derivation.



a. Draw a force diagram showing forces exerted on the charged object by other objects. How are those forces related to each other? Remember, we move the charged object at a constant speed through the field.

b. Calculate how much work is done by the hand in moving the charged object through a displacement Δx?

c. Use the generalized work-energy principle to relate the work done by the hand to the change in potential energy of the charged-object-glass-plate system.

d. Set your work equations equal to find an expression for the $\vec{E}$ field in terms of ΔV and Δx. Discuss with your group: Does the equation you derived make physical sense? In what way? Come up with specific examples to justify your reasoning.

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Eugenia Etkina
Admin

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4d

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#LEDworkshop

Hi @everyone I just created an EVENT for our LED workshop on May 20th (this is what people indicated is the best date). Please let me know if you see the event and sign up for it. To my knowledge, our materials (the textbook and the OALG) are the only materials that systematically help students learn what an LED is, how LEDs work and why we use them. We also have an absolutely unique approach to help students understand their microscopic structure (you will be amazed). The workshop is 3 hours, please plan accordingly. I am attaching a screenshot of just one place where we talk about LEDs in the textbook, but there are many more, so - sign up for the workshop! And please like or comment on the post to make it more visible. Thank you.

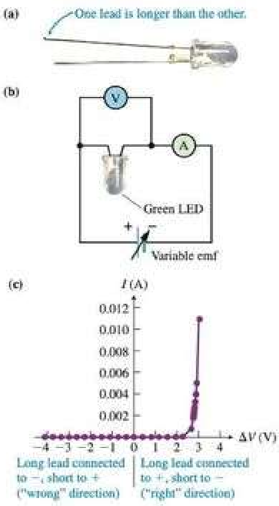
Light-emitting diodes (LEDs)

Another non-ohmic device that is present in every house is an LED–a **light-emitting diode**. LEDs are the basis of the lightbulbs that are replacing incandescent lightbulbs. How are LEDs different from incandescent bulbs? Examining an LED shows that it has two leads, one short and one long (Figure 19.14a). LEDs also come in different colors; we choose a green LED for our investigations in this chapter. We now connect the LED to a variable power supply, as we did with the resistor in Table 19.3, and collect data in the same way using an ammeter and voltmeter (see Figure 19.14b).

We observe several interesting patterns. First, when we connect the long lead of the LED to the *negative* terminal of the power supply, the LED does not light, no matter how much we increase the potential difference across it (as long as the potential difference across it does not exceed 10 V; above that, LED breakdown occurs, which leads to a large current and damage of the LED). Second, when we connect the long lead of the LED to the *positive* terminal of the power supply, at first the LED does not light. When the potential difference across it reaches a certain value (about +2.1 V for a green LED), it suddenly lights, and when we increase the potential difference by a small amount, its brightness increases dramatically. Can it be that the LED only allows current to pass through it in one direction, and that it glows when there is a current through it and the potential difference exceeds +2.1 V?

When we analyze the I-versus-ΔV graph from our experiment in Figure 19.14c, we find support for both aspects of our hypothesis: (1) there is no current through the LED when its long lead is connected to the negative terminal of the power supply (we will call this the "wrong" direction), and (2) the current is still zero even if the long lead of the LED is connected to the positive terminal (the "right" direction) for all potential differences below about +2.1 V.

FIGURE 19.14 A green LED. The electric circuit in (b) is used to collect the I-versus-ΔV data plotted in (c).



We also notice that the current "shoots up" when we increase the potential difference above +2.1 V. Note that at a certain voltage above 3 V, the LED stops glowing, even though it is connected the right way, and never lights again, even if we decrease the potential difference back to +2.1–2.3 V. The current through it becomes so large that it burns and destroys the LED.

Based on the I-versus-ΔV graph, we can say that the LED is a non-ohmic element and has asymmetric resistive properties. The resistance of the LED is infinitely large when its long lead is at a lower potential than the short lead, and it is variable (it depends on the voltage across the LED) when its long lead is at a higher potential than the short lead. For example, the resistance of a green LED is very large (infinite) below +2.1 V and becomes very small when the potential difference across it is above +2.1 V. The 2.1-V potential difference is called the **opening voltage** of the LED. Note that the opening voltage does not have a precisely defined value. When the potential difference across the LED is approaching this value, the current through the LED starts to increase, and eventually the LED starts glowing.

LEDs come in different colors. The color of an LED's light does not come from the plastic cover, but from the physical materials that comprise it. LEDs of different colors have similar properties, but different opening voltages. For example, the opening voltage for a red LED is about 1.6 V and that for a blue LED is about 2.3 V.

To represent an LED in a circuit diagram, we use the symbol shown in Figure 19.15. The triangle resembles an arrow and points in the direction in which the LED could conduct current. The long lead of the LED must be at higher potential than the short lead for the LED to glow (assuming that the potential difference across it is above its opening voltage).

FIGURE 19.15 The LED circuit symbol.

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Eugenia Etkina

Admin
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3d
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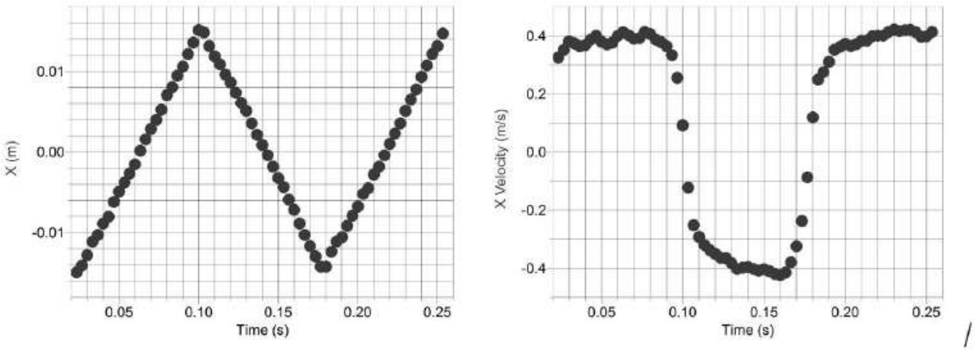
#ledworkshop #electricfields
Hi all Exploring and Applying Physics people, first: I am reminding you of the LED workshop on May 20th, please sign up going to EVENTS. So far only 6 people signed up. The workshop requires a lot of preparation on our part and we would like to have more people benefit from it.
Second, I wanted to show you an example of an activity that allows you to experimentally study electric charges and electric fields. It is in the ALG and OALG (chapter 18). I am posting the text of the activity with the solution (I never post solutions, but this one is a must, it is in Italics). You can let the students watch the video and then give them the graphs to save time. Or you can assign the graphs for the homework andthen have a discussion in class. It is a very sophisticated activity, it is good for college students or AP2 students. It is also great for physics teachers. Please watch the video and then try to collect the data before you read the solution! And please do not forget to like or comment on the post to make it more visible. Thank you.
18.4.4 OBSERVE AND EXPLAIN
Class or Lab: Equipment per group: whiteboard and markers.
Watch the high-speed video of a conducting sphere vibrating between two charged plates connected to a device called a high-voltage source that creates a constant potential difference between the plates [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]. The sphere is hanging on a nonconducting (insulating) string. The video is recorded at 600 frames per second. Note: if some charges are removed from the plate, the high-voltage source replaces these charges with new ones, so the potential difference between the plates remains constant.
a. Working with your group, describe your observations as fully as possible (you can use the video to collect data).
The sphere is oscillating back and forth between the plates. Every time the sphere touches one plate it abruptly changes the direction of motion. Although the sphere is relatively large it does not seem to slow down due to air drag as one would expect for a simple pendulum of the same size.

b. Explain your observations using your knowledge of forces, and the relationship between the E and V fields. Provide qualitative and quantitative explanations. Put them on a whiteboard and share with another group.
We can analyze the video frame by frame to obtain the and graphs for the center of the sphere (x axis points to the right and its origin is in the middle of the plates; graphs show three passages between the plates): See the graphs in attached screen shot.
The graph tells us that after the sphere hits the plate it re-bounces with a speed that is smaller than the speed before the collision with the plate. We also see that after every collision the sphere accelerates towards the opposite plate. These observations help us to compose the following explanation:
The sphere is covered with a metal (aluminum) foil. Let’s assume that we start with a neutral sphere that is initially moving towards one plate (assume the sphere is moving to the left, toward positive plate). When the sphere touches the positive plate, some electrons from the sphere move to the plate until the sphere and the plate are at the same potential (the transfer of charge happens very very quickly; voltage source takes care that the plate is at the same potential all the time). At this point the sum of the forces exerted on the sphere points to the right (positively charged sphere is in the region of E field that is pointing to the right). The sphere starts to accelerate to the right. As the speed of the sphere increases, the drag force exerted by the air on the sphere increases, reducing the acceleration of the sphere compared to the case when the sphere would accelerate only due to electric force (we neglect the effects of gravitational attraction between the sphere and Earth). When the sphere hits the (negative) plate, two things happen. 1) Some kinetic energy of the sphere is converted to internal energy, therefore the speed of the sphere after the collision is smaller than before the collision; 2) some electrons from the plate move to the sphere (until the sphere and the plate are at the same potential), the sphere is now negatively charged. At this point, the sum of the forces exerted on the sphere points to the left and the sphere starts accelerating to the left. From now on, the steps repeat with appropriate signs.



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Eugenia Etkina
Admin
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2d
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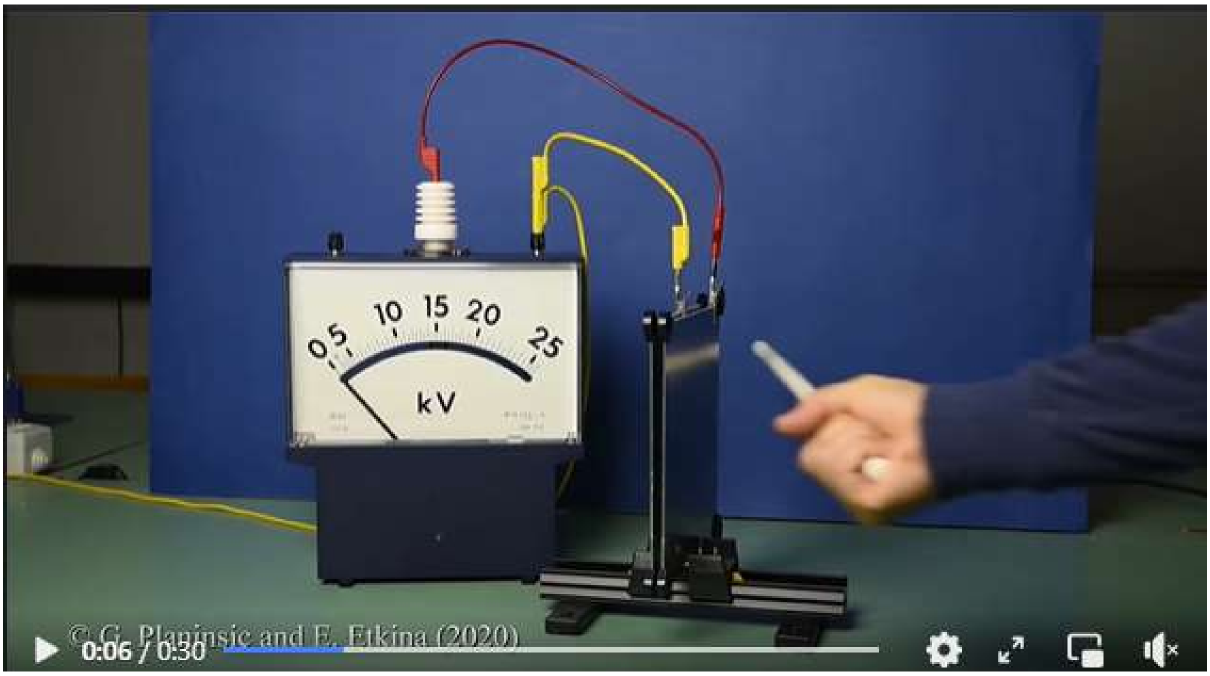
#eandv
Here is a great video showing the relationship between the E field and the V field made by Gorazd Planinsic . You can use it as a testing experiment after the students did the derivation that I described 3 days ago. Enjoy!



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Eugenia Etkina shared a post.
Admin
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I already posted about Emmy Noether before, but no number of posts will do justice to this incredible woman. All laws of conservation are the consequence of Noether's theorem of symmetry - energy, momentum, rotational momentum, etc. We can see Newton's laws as the consequences of energy and momentum conservation laws. Thus, almost everything that our students study can be explained by Noether's theorem. What an amazing woman and what a tragic life of a woman in math and science at her time.

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Eugenia Etkina shared a link.
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#studentsquestions

Hi all Exploring and Applying Physics people! Two things today - first, please sign up for the LED workshop in your EVENTS page. Second, I am picking up our conversation about questions. We talked about how to ask good questions and how to help students learn how to ask good questions. Today - how to respond to students' questions. It is a long post but please do not forget to like it or comment on it after you have read it. Thank you.

How to decide when to answer a student’s question, when to toss it back to the class, when to provide a hint, and when to return it with “what do you think?” reply. Of course, the choice depends on the question, on the situation in which it was asked, on the timing, and on many other factors. Here I consider several common types of questions that a student or a group of students might ask during a lesson or a lab and possible routines in response to these types of questions are. Although the questions and responses are different, they all have a common approach: to engage the person asking the question with some intellectual effort related to the answer. This is needed because we want the student themselves to make the connections in their brains, listening to our answer will not help them remember it. The routines described below are pure suggestions, it is impossible to provide the exact advice for a specific situation without knowing your students and the context in which the question was asked.

1. Questions about a definition of a quantity or a mathematical expression the answer to which can be looked up easily and the answer that the student forgot (What is “a prediction”?).

Possible Response: Answer the question directly to save time. Especially, if the definition that you wish the student to use is different from the ones that they can look up online. For example, searching on line for the definition of prediction you find in Wikipedia: “A prediction, or forecast, is a statement about a future event or data. They are often, but not always, based upon experience or knowledge. There is no universal agreement about the exact difference from "estimation"; different authors and disciplines ascribe different connotations.” (https://en.wikipedia.org/wiki/Prediction) However, this is not how we wish the students to think about a prediction if they are learning physics through the ISLE approach. We wish them to think that a prediction is the statement of the outcome of a testing experiment that follows from a hypothesis/explanation under test. Therefore, it is more useful to repeat the definition for the student and then ask back: Do you remember a situation when we made a prediction? How did we do it? The point is that even though you are "giving the answer" you are still engaging the student in some intellectual effort needed to remember what you said. This can only happen if the student connects the term, relation, etc. to the knowledge in their brains.

2. Questions about a procedure that is content independent (How do we find a pattern?)

Possible Response: Show how to do it on a different example, explain every step, and then make the students find the pattern in their data themselves (these steps follow the apprenticeship approach steps: model proficiency, reflect on what you did, let the novice try themselves with feedback and reflect on what they did). Here again, while it looks like you are "giving the answer", in fact, you are engaging the students in active learning experience.

3. Questions about a procedure that is content dependent (How does the assumption that the system is isolated affect the prediction?)

Possible Response: Ask why they made this assumption and how the calculations would be different if they did not make it. What energy would be less and what energy would be larger? Here there is no direct answer to the questions as in the examples above, as your goal is to help the students reflect on their previous actions to be able to do it themselves.

4. Questions about the experimental result or an answer to a problem (We got 0.3 for the coefficient of friction, is it correct?)

Possible Response: Is this a reasonable value? What are the uncertainties in the value? Have you used the second independent method to get the same quantity? Did the results overlap within the uncertainties? If not, did you examine the assumptions in both methods? Here again, there is not direct answer as your goal is to help the students learn how to evaluate their result themselves.

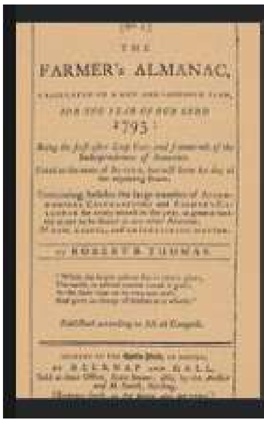
5. Questions about steps in a derivation (How did you get from A to B?)

Possible Response: Ask the class if anyone can help. If no one volunteers, ask everyone to close their eyes and open if they also did not understand the step. If you see that many students did not understand but they did not ask the question, repeat the step slowly asking small question of the class of how to proceed after each step, and then ask the first person if the whole derivation is clear and then ask to repeat the explanation of the step. Then repeat the trick with closing eyes and see that no one opens theirs. The trick is a metacognitive help for the students to ask themselves: Do I really understand? And then, if they realize that they don't, the question provides the "need to know".

6. Questions about help when stuck (We don't know what to do, can you help?)

Possible Response: Despite the variations in the context of the question (this can be a difficulty starting to solve a problem or to design an experiment, or something else) it is tempting to help by asking leading questions that would take the students along the path of your reasoning. But it is probably not a very helpful approach as when you lead them though your reasoning path, you are utilizing connections in your brain that the students might not have. They can answer every small leading question, but the whole picture will escape them. There will be an illusion of help, but when you leave the group, they might have difficulties moving forward and will call for your help again. A better strategy in this case is to try to identify what obstacle they have and what knowledge that THEY have might help them overcome this obstacle. Then, ask a question or give a hint that will help them fall back on this knowledge or skill so that they can make the conceptual leap themselves. Here is an example: The students are working on the horse-buggy problem that comes after they learned how to draw force diagrams and how to apply Newton's second law. This problem seems like Newton's third law problem but in fact, it is still the second law problem. "The horse is pulling on the buggy exerting a force, and therefore the buggy is pulling back on the horse exerting the force of the same magnitude in the opposite direction. The sum of these two forces is zero. How can the buggy start to move?" The students are stuck and do not know what to do. A good "fall back" question would be: "What system did you choose for analysis?" Once the students decide that the buggy is the system, the force that it exerts on the horse is irrelevant for the answer as it is not exerted on the buggy, but the force exerted by the ground is important. Same for the horse. In this case the students, make the conceptual leap themselves and the teacher only helps them identify the knowledge that they need to be successful.

To summarize, there is no one routine for responding to students' questions. But there are some common habits of mind that might help you decide what to do. If the question is factual or about a routine procedure – answer it directly but then engage the students in some reflection and application. If the question is conceptual or involves a complex procedure, engage the students in an activity that will help them figure out what to do. Tossing the question back to the class ("What do you think?") is a good habit but it should not become a routine as not every question should be reflected back based on the examples above.



EN.WIKIPEDIA.ORG

Prediction - Wikipedia

A prediction (Latin præ-, "before," and dicere, "to say"), or forecast, is a statement about a future event or data. They are often, but not always, based upon experience or knowledge. There is no universal agreement about the exact difference from "estimation"; different authors and disciplines as...

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Eugenia Etkina shared a link.
Admin
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April 19 at 10:28 PM
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Hi all, remember I told you about the new international handbook on physics education research? One of the editors fo the whole book Fatih Tasar just posted that it is available for free at this website. ISLE is described there in the chapter on holistic learning environments. Here is the link to the book. Enjoy!

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Eugenia Etkina shared a link.
Admin

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April 21 at 3:36 PM

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#reflection
Hi @everyone Today I start a series of posts about reflection. We already talked about it before, but this time is will be an overview and details. Please do not forget to like or comment on the post after you read it to make it more visible.
The word reflection is common in educational practice. We can think of reflection is an act of looking back in order to process experiences, or a way of thinking about one's thinking in order to grow. A habit of reflection is crucial for one’s development as a teacher. After every lesson we ask ourselves: How did it go? What went well? What should be improved? Without such thoughts we will repeat the same mistakes next year and will not emphasize the aspect of the lesson that went well. But it is even more important to ask the questions: Why did it go well? Why didn’t it go well? What made that experiment trigger productive thinking in my students and that experiment not? How could I have better responded to that comment, or that question? From the above examples, it is clear that without habitual reflection there is no progress. How do we teach our students and future teachers to reflect and what are productive routines for doing reflections in a physics classroom?
At the end of a lesson, save 3-5 min to ask your students: What did you learn today? How is your understanding of XX changed? How did you learn?

Such reflection can be done individually. At the end of the class the teacher says: “Close your eyes and make a mental list of all the things you learned today.” After 1-2 minutes the students open their eyes and you ask them to raise their hands when they are ready to share. The rule is that one person can only say one thing from each category and they cannot repeat what was already said. This means that the students who go first have an easier time choosing what to say. The last people will find difficult to add to what was already said, so next time they will raise their hands first. At first your students will be hesitant to reflect but with time they will get really good at it and will enjoy the practice. Another thing that you can do is to tell them to listen to their peers' reflections carefully and raise their hands if they also learn the thing that the speaker just mentioned.

If you have too many students in the course to have individual reflections, you could have group reflections. Give your students who have been working in groups during class, 2-3 minutes to put on their white boards what that have learned (same questions) and then ask them to share. Each group says one thing from each category on their whiteboard and the reflection goes from a group to a group until all new things are said.

Is there an explanation why reflection is important? YES! Indeed, our knowledge of how the brain works provides two mechanisms for the importance of reflection for learning. First, is when a person who is asked to reflect on what they have learned searches through their mind for the answers, they activate the electric circuits that have been just formed, this activation makes the circuits stronger and thus easier accessible later. But there is more to the role of reflection, oral or written, in learning. According to Kolb’s brain cycle when the brain learns, it goes through the following steps: sensory experience, reflective observation, hypothesis formation, and active testing. The active testing involves motor function – some kind of movement in out body. For example, you walk into a room at a party and see a person by the window (sensory experience). You start “searching” in your memory where you could have seen that person before (reflective observations) and what her name is. You hypothesize that you saw her at the hostess wedding and her name is Jill (hypothesis). You approach her and say with a question mark in your voice: “Jill? Nice to see you again!” (active testing). If you never spoke her name, you would not know whether your hypothesis was correct; you had to test it!

You can think of oral reflections on learning new material or anything else that happened during the lesson as one form of active testing (another one is the actually testing experiments that are a part of the ISLE process). You can see the reflection at the end of a lesson as instant non-threatening formative assessment technique. Did the students mention everything that you wanted them to learn? Could they explain how they learned it? To be continued...
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Eugenia Etkina
Admin
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April 23 at 3:16 PM
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#reflection
Hi @everyone today I continue with reflection - last post. See my post from the day before yesterday to read the whole thread.
In addition to oral reflections, you can ask your students to reflect as a part of the homework (Etkina, 2000). Asking them to answer the following prompts:
· What did I learn this week?
· How did I learn it?
· What remained unclear?
· What questions would I ask if I were the teacher to find out whether my students understood the material?
does not only illuminate what and how students learned, by providing feedback to us as teachers, but also helps the students recompile and reconcile all of the week's experiences and ask themselves how they learned what they did. Our research shows that when the students focus

on the ideas and relationships instead of definitions writing what they learned and when they can articulate how they learned something by connecting experiments and reasoning and when they ask high level questions, they have higher learning gains (see May & Etkina, 2002 and Harper et al., 2003).

Another important reflection routine is the reflection on the solution of a problem or an experimental result. The habits of mind that are used in reflections on problem solving solutions involve checking the units, doing extreme (or limiting, see White et al., 2023) case analysis, considering how reasonable result is and how consistent it is with different representations used to analyze and solve the problem. But the important next step is to go back and fix the solution if any of these techniques show a mistake. How to help future teachers develop such habits and what routines can we use in this process? Again, as in all previous cases, we, as educators, need to model it and to reflect on when we assess students' solutions. How do you catch mistakes that students make? While every case is unique and there is no unique recipe, one good routine is to use students themselves to find those mistakes when evaluating the solutions of another peer group.

Reflection on experimental results is also extremely important. You probably experienced a student asking you to validate their experimental result: "We did the experiment and found the coefficient of friction between the shoe and the floor tile. It is 0.3. Is it correct?" Although the students wrote the findings with the experimental uncertainty, it does not help them learn whether it is a “good” result. They need to compare it to something. This something is often an “accepted value”. But what if there is no accepted value? Imagine, the students need to find the coefficient of static friction between their shoe and the floor tile. They design an experiment in which they attach a force meter to the shoe and pull it until the shoe starts moving. They repeat the experiment several times and determine the random uncertainty of the result (as shown above). How do they reflect on the value that they found?

You probably realized that this experiment belongs to the group of Application Experiments in the ISLE process. These experiments require the students to use multiple models to determine some unknown quantity or build a device to achieve a specific goal. For the former type of experiments reflection is crucial as it helps the student find another experiment (not the repeat of the first one) to determine the same quantity. Only comparing the findings from two experiments they can decide whether they are “correct.” To help students learn how to reflect on the experimental result in application experiments, we guide them with self-assessment rubrics (see al rubrics at https://sites.google.com/site/scientificabilities/)

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Etkina, E. (2000). Weekly Reports: A two-way feedback tool. Science Education, 84, 594-605.

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Harper, K., Etkina, E., & Lin, Y. (2003). Encouraging and analyzing student questions in a large physics course: Meaningful patterns for instructors. Journal of Research in Science Teaching, 40(, 776-791.

White, G., Sikorski, T. R., Landay, J., & Ahmed, M. (2023). Limiting case analysis in an electricity and magnetism course. Physical Review Physics Education Research, 19(1), 010125.

RUBRIC D: Ability to design & conduct an application experiment					
	Scientific Ability	Missing	Inadequate	Needs improvement	Adequate
D4	**Is able to make a judgment about the results of the experiment**	No discussion is presented about the results of the experiment	A judgment is made about the results, but it is not reasonable or coherent.	An acceptable judgment is made about the result, but the reasoning is flawed or incomplete. Or uncertainties are not taken into account. Or assumptions are not discussed. The result is written as a single number.	An acceptable judgment is made about the result, with clear reasoning. The effects of assumptions and experimental uncertainties are considered. The result is written as an interval.
D5	**Is able to evaluate the results by means of an independent method**	No attempt is made to evaluate the consistency of the result using an independent method.	A second independent method is used to evaluate the results. However, there is little or no discussion about the differences in the results due to the two methods.	A second independent method is used to evaluate the results. The results of the two methods are compared correctly using experimental uncertainties. But there is little or no discussion of the possible reasons for the differences when the results are different.	A second independent method is used to evaluate the results and the evaluation is correctly done with the experimental uncertainties. The discrepancy between the results of the two methods, and possible reasons are discussed.

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Eugenia Etkina
Admin
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April 24 at 3:49 PM
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#dccircuits
Hi @everyone, today I am starting the series of posts for DC circuits as we do not have a workshop for those and jump right into LEDs (if you did not sign up for that workshop, please go to the EVENTS and sign up).
The most important points for understanding DC circuits are:
1) there is a path for the electric charge to flow (conducting path). This path is a closed loop.
2) there is a mechanism that makes the charges continuously flow (drift) in one direction.
To start our students thinking about both conditions they work through the following activity (Observational Experiment). Think of what conditions about the charge flow can be inferred from this experiment? How does it motivate the need for a battery (or some other similar device) in a circuit?
Please do not forget to like or comment on the post after you read it. Thank you.
OALG 19.1.1 OBSERVE AND EXPLAIN
a. Watch the following experiment https://mediaplayer.pearsoncmg.com/.../sci-OALG-19-1-1. Describe what you observed, and explain why both electroscopes got discharged. Explain what is happening inside the metal rod right when it touches the electroscopes and at the end of the experiment.
b. Read and interrogate Observational Experiment Table 19.1 in Chapter 19 in the textbook. What do you think is needed for continuous charge flow?

c.Read and interrogate section “Fluid flow and charge flow” on page 574 in the textbook. How does this section explain the experiments with electroscopes and experiments in Table 19.1?

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Eugenia Etkina shared a post.

Admin

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April 25 at 4:07 PM

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Watch it. It is really good. And might make you want to explore some of the ideas that those women are responsible for.

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Eugenia Etkina
Admin
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April 26 at 3:29 PM
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#dccircuits
Hi @everyone, I continue with DC circuits today. In my previous post I showed an observational experiment that helps students construct a hypothesis that you need a conductor for the electric charges to flow and some difference between the electroscopes (the experiment is at https://mediaplayer.pearsoncmg.com/.../sci-OALG-19-1-1).
But what is this difference? The students can come up with two different "wild ideas": it is the charge difference or the potential difference. How can we test these ideas? I am inviting you to propose testing experiments. Remember that at this step of the ISLE process you need to design an experiment whose outcome you can predict using hypotheses under test and two different hypotheses should make two different predictions about the outcome. Once the predictions are made, you run the experiment and compare the outcome to the prediction. When the prediction does not match the outcome it does NOT mean that the prediction is wrong (a prediction is ONLY wrong when it is NOT based on the hypothesis under test) but that the hypothesis might be wrong (here you need to examine the assumptions that you had in addition to the hypothesis when you made the prediction). So, please go ahead and share your designs and predictions based on the two hypotheses above.

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Eugenia Etkina shared a post.
Admin

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April 27 at 6:07 PM

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As a former ballerina I appreciate the physics. If you have any students who dance in your classes and they have studied torque and rotational momentum - please share - they will appreciate it too. You feel every law of physics through your body while doing a fouette.
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Eugenia Etkina shared a link.
Admin
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April 28 at 3:24 PM
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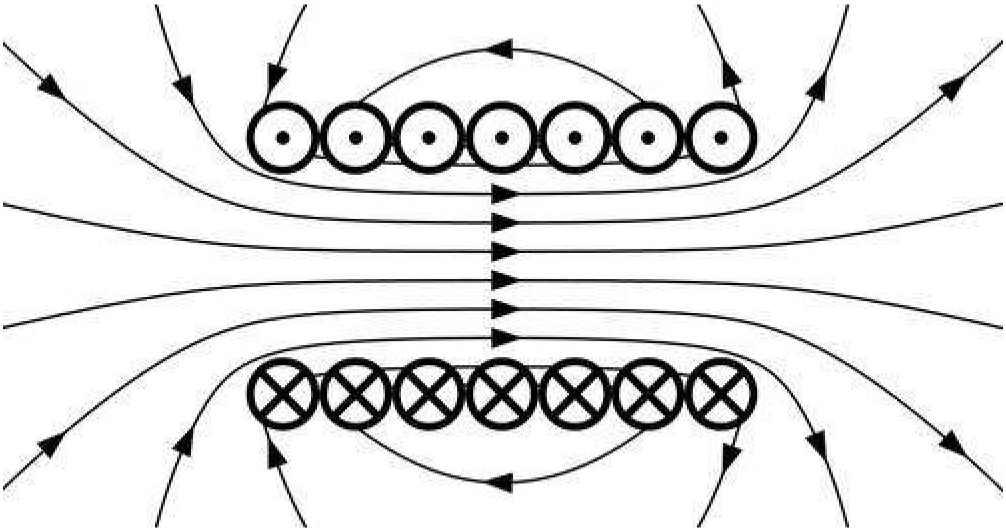
#dccircuits
Hi @everyone, today I continue to discuss DC circuits. Thank you, Matthew L. Jacobs and Owen Rigby for designing experiments to test whether the charge difference or the potential difference is needed for the charge to flow. If you missed their responses, please go back the read, the experiments are excellent!
But, as you know, electrostatic forces lead to the equalizing potentials very quickly - see again the video with electroscopes. Therefore we need a device that would maintain potential difference between two ends of a conductor. For this to happen, the circuit needs to be a closed loop and some device that does not use electrostatic forces to maintain potential difference between any two points in the closed circuit. You probably guessed that this device is a battery (or something else that works in a similar way). To characterize how "good" this device is we have a new physical quantity - EMF or electromotive force (see https://en.wikipedia.org/wiki/Electromotive_force). Understanding the difference between potential difference or voltage and EMF was a source of continuous arguments between me and my co-authors. So, I am putting a question here - how do YOU understand the difference between voltage and emf? Where in our physics curriculum does this difference become very important? Please share your thoughts! And please do not forget to like the post or comment on it.



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Eugenia Etkina
Admin
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May 1 at 3:53 PM
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#dccircuits
Hi @everyone, I continue with DC circuits today. First, thank you all who contributed to the discussion about the difference between voltage (potential difference) and emf. It is a very important difference, that becomes crucial when the students learn about batteries with internal resistance, when they study Kirchhoff's laws and most importantly, electromagnetic induction. While most batteries and other power sources use electric or electromagnetic forces to create electric field in a circuit, these forces are non-Coulomb's forces and they do work on electric charges when the charges move along a closed loop.
We have had several discussions about operational definitions and cause-effect relationships. In DC circuits this difference is very important. How

do you write Ohm's law? Many books write it a Voltage=Current times Resistance. But this mathematical representation does not communicated the cause-effect relationship in the circuit. That is why we write it as Current = Voltage (potential difference)/Resistance. For all elements voltage (potential difference) is an independent variable and for ohmic elements the resistance is also an independent variable. You can have both of those when there is no current in the circuit but you cannot have current without potential difference.

I asked ChatGPT t define Ohm's law and its answer shows all the confusion I talked about. While it defines Ohm's law correctly as I said above, it writes is as V=IR. This is an example of how the mathematical relationships that we write contradict the words representations of the same phenomenon.

The language is important here. We say "current through" and "potential difference across" and "resistance of". This terminology underscores that you need two points to measure potential difference (voltage). Another important issue is that sometimes we use the term voltage drop. This construction does not make sense as voltage is the change in potential difference by definition, so it is already a drop. Is voltage drop the drop of a drop? This confusion comes from defining voltage at a point with respect to earth. But if we define voltage as a potential difference between two points in a circuit (and this is what we do in physics), then voltage drop does not make sense. I will continue with the discussion of Ohm's law tomorrow as there is a very important issue there that is often confused by both teachers and students.

Please do not forget to like or comment on the post to make it more visible. Thank you!

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Eugenia Etkina
Admin
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May 2 at 4:55 PM
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Hi all Exploring and Applying Physics people! I want to congratulate Valentina Bologna Longo who just successfully defended her PhD dissertation focused on the implementation of the ISLE approach in Italy. Valentina Bologna Longo created an amazing professional development program helping Italian teachers implement the ISLE approach and documented the changes in teachers and the students. This is the fourth PhD dissertation exploring direct effects on the ISLE on students and the second dissertation exploring the effects on the teachers. Congratulazioni!

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Eugenia Etkina
Admin
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May 3 at 3:55 PM
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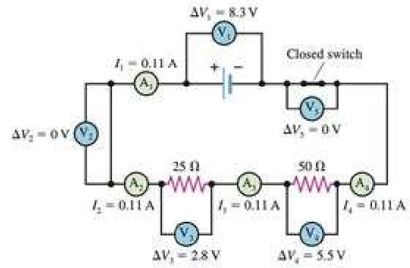
#dccircuits
Hi @everyone first, thank you for your response to my post about Valentina Bologna Longo defending her dissertation yesterday. It is wonderful to see over 80 congratulatory comments - I feel like we are a real community. Thank you!

Today, I will continue with Ohm's law. First, it is important to remember that this law is valid for ANY element other than a battery in a circuit (even a switch). Second, as the exploration of the law often starts with measuring current through and potential difference across commercial resistors in a specific range of currents, many think that resistance in the question means the slope of the line deltaV(I) graph, however, the resistance is just a ratio of Voltage over current and not the slope fo the graph. You can check it yourself when measuring the resistance of an incandescent light bulb at different voltages/currents. For commercial resistors it does not matter what you calculate - ratio or slope but for resistors such as incandescent light bulbs or LED bulbs it matters a lot. The resistance of ANY element other than a battery can be determined as R=deltaV/I .
Another important idea that I would like to discuss today is the switch. What is the potential difference across a switch when the current though the circuit is zero? One might be tempted to say that it is a zero, but is it really so? The answer to this question comes from electrostatics and an important concept of an equipotential surface of a charged conductor and from Ohm's law if we remember that the switch has infinite resistance. Which means that dividing any number by infinity will give you zero. See the activity for the students to figure it out. In the screenshot start with reading Testing Experiment 19.4 Table first, then going to the circuit and then making the prediction. If you have the textbook, go Section 19.4 to read the whole story.

FIGURE 19.16 Examine the ammeter and voltmeter readings.



Voltmeter 2 across a connecting wire and voltmeter 5 across the closed switch both have zero readings. This is only possible if the resistance of the connecting wire and the closed switch is very small, or almost zero: $\Delta V = IR \approx I \cdot 0 = 0$. Now let's open the switch and use Ohm's law to make predictions about the meter readings.

TESTING EXPERIMENT TABLE 19.4 Applying Ohm's law to an open circuit

VIDEO TET 19.4

Testing experiment	Prediction	Outcome
Use the circuit in Figure 19.16 but with the switch open.	We predict that the current in the circuit is zero, the ammeters will measure zero current $I = 0$, and according to Ohm's law, voltmeters 2–5 will measure zero potential difference $\Delta V = IR = 0R = 0$.	**Ammeter readings** Ammeter 1: 0 A Ammeter 2: 0 A Ammeter 3: 0 A Ammeter 4: 0 A **Voltmeter readings** Voltmeter 1: 8.5 V Voltmeter 2: 0 V Voltmeter 3: 0 V Voltmeter 4: 0 V Voltmeter 5: 8.5 V

Conclusion

We predicted 0 for voltmeter 5, but it measured 8.5 V. The outcome of the experiment does not match our prediction. We need to either revise Ohm's law or examine how we apply it.

When an outcome does not match a prediction, we need to evaluate the reasoning that led to the prediction. When the switch is open, there is no current in the circuit, so on first glance Eq. (19.3) written as $\Delta V = IR$ predicts a zero potential difference. Let us look at the battery first. Even when there is no current in the circuit, the battery has potential difference across the terminals equal to its emf. Thus, the nonzero reading of voltmeter 1 makes sense. But why would there be potential difference across the switch when there is no current in the circuit? When the switch is open, it stops being a conductor; its resistance becomes infinite. We cannot apply relation $\Delta V = IR$, as we do not know the result of multiplying zero by infinity. Therefore, when we made a prediction that did not match the outcome, it was not Ohm's law that failed us, but how we applied it. How do we explain the existence of the potential difference across the switch? When the switch is open, the whole part of the circuit connected to the positive terminal of the battery is at a potential of 8.5 V. The part of the circuit connected to the negative battery terminal is at a potential of 0.0 V (**Figure 19.17**).

We can find a similarity in the behavior of a switch in a circuit and an LED. Remember that for the "wrong" direction of an LED, the current through the LED is zero. The same holds also for an LED that is connected in the "right" direction but has a

FIGURE 19.17 Electric potential in a circuit with an open switch.

Minus signs indicate that the electric potential of this part of the circuit is 8.5 V less than the potential of the positive terminal of the battery.

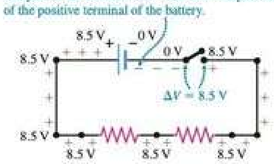


FIGURE 19.18 An LED is similar to an open switch when (a) the LED is connected in the

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Eugenia Etkina shared a link.
Admin
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May 5 at 4:03 PM
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#dccircuits
Hi @everyone, I continue with the Ohm's law and an open circuit. Here is an activity that helps student test their true understanding of Ohm's law - it does apply to every element of a circuit if you consider carefully the element's resistance and the potential difference across it (except the battery). The beauty of this activity is that you can do it with phet simulation for speed, or with real equipment, or with a video as shown in the OALG file. It also helps your students practice the hypothetic-deductive reasoning chain so important in the ISLE process: IF my hypothesis is true (state the tide under test here, in this case it is that I=deltaV/R) AND I do such and such (in this case connect the equipment is it is described in the problem), THEN such and such should happen (describe the predicted outcome of the experiment) BECAUSE (the explanation of HOW the prediction follows form the hypothesis). This last BECAUSE is the crucial step to make sure the prediction is based on the hypothesis, not the intuition. Try it with your students and you will see how long it takes before they develop a habit or basing their prediction on the hypothesis under test and not their intuition. Avoid the constructions: If I do such and such, what should happen? In this case, there is no hypothesis after IF, what comes after IF here is the description of the experiment, so it is better to avoid the description fo experiment after IF and use WHEN instead. Here is the activity:
OALG 19.4.4 TEST YOUR IDEAS
Use materials at https://phet.colorado.edu/.../circuit-construction-kit-dc...to build a circuit consisting of a battery (rated 9 V), a lightbulb, and a switch connected in series. Keep the switch open.
a. Draw the circuit diagram of your circuit.
b. Predict the potential difference across the battery, across the lightbulb, across a connecting wire, and across the switch. Now use a voltmeter to check your predictions. Write down the readings. Discuss any surprising results you found and reconcile them with your prediction.

c. Now close the switch and repeat the experiment. Write down the readings. Do they make sense?
d. Watch the following video https://mediaplayer.pearsoncmg.com/.../secs-experiment.... How do the readings of the voltmeters compare to the readings in your circuit?
e. Discuss whether Ohm's law in the form of I=deltaV/R applies to a battery and to a switch in an open circuit. Discuss whether Ohm's law applies to a battery, a switch, and a connecting wire in a closed circuit.
Please do not forget to like or comment on the post to make it more visible. Thank you.

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Eugenia Etkina shared a post.
Admin
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May 5 at 7:48 PM
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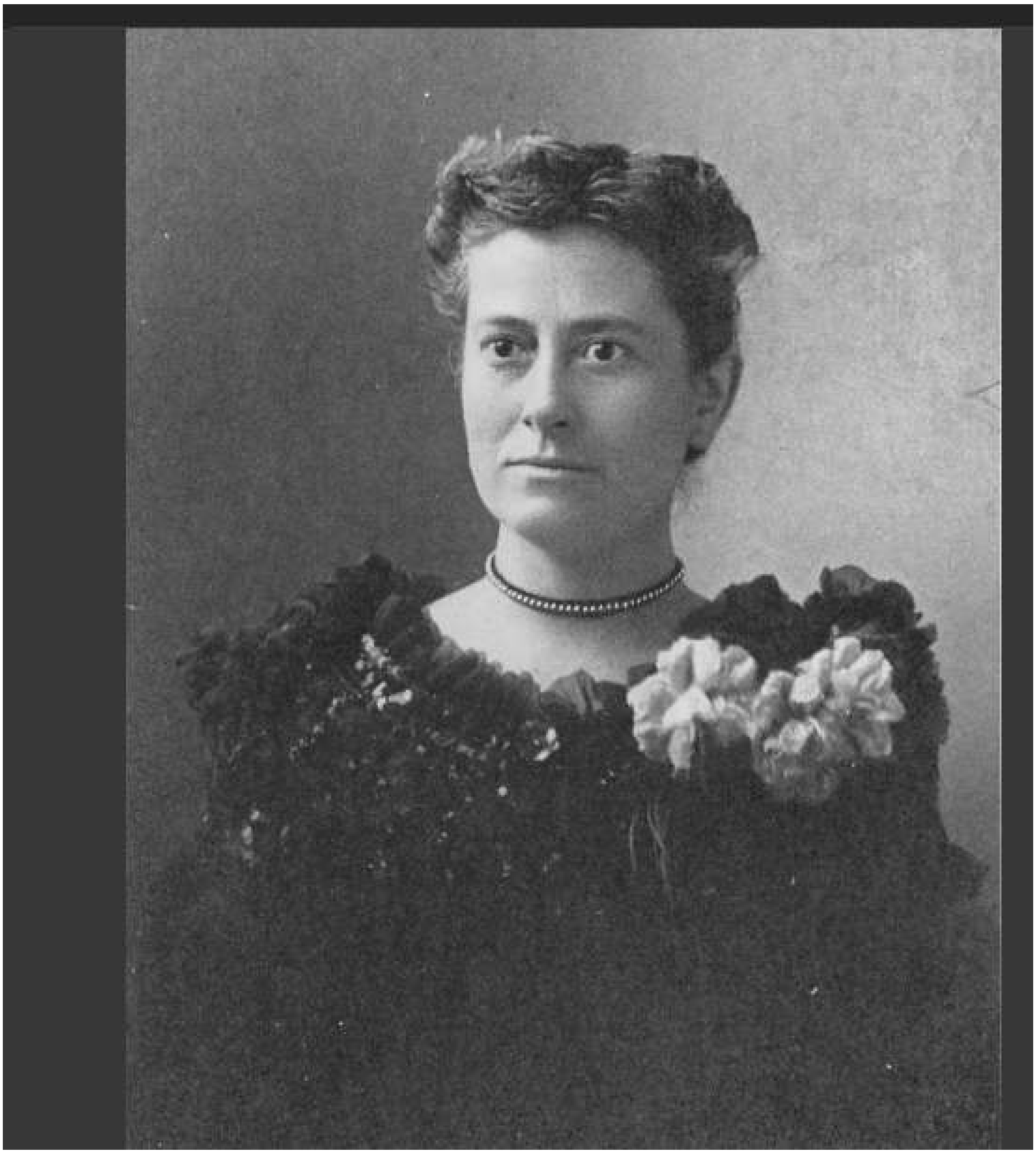
For your collection of women in science.



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Eugenia Etkina shared a link.
Admin
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May 6 at 3:35 PM

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#resonance
Hi all, today I am taking a break from DC circuits
Every chapter in our textbook starts with chapter opening - a story that serves as the "need to know" for the whole chapter. In our vibrations chapter #10 the opening story is about soldiers marching on a bridge that collapse - Fontanka bridge in S-Petersburg in the 19th century. It is a true story. What is amazing, is that the same mechanism can bring stuff out of vacuum. Read the attached article, it is really good.

QUANTAMAGAZINE.ORG
How the Physics of Resonance Shapes Reality | Quanta Magazine
The same phenomenon by which an opera singer can shatter a wineglass al...

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Eugenia Etkina

Admin

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May 10 at 2:42 PM

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#dccircuits
Hi @everyone, I am back to posting. Two things today:
First: if you are teaching in a TYC and use ISLE, please email me ASAP (eugenia.etkina@gse.rutgers.edu).
Second: Today, I will focus on the types of activities instead of a specific concept. A long time ago we came up with a group of activities that involves convincing somebody in something. We developed lots of activities of this kind because argumentation is one of the skills that is necessary in physics and thus it is a part of the ISLE approach. That was long before argumentation became a hot topic in science education in the US. While there are lots of theoretical science education papers about developing argumentation skills in different sciences, there are almost no examples from physics. How do physicists convince other physicists in their point of view? I am pasting two activities that invite students to argue but they do not have examples of argumentation. I am asking you to give examples in your comments - HOW DO YOU ARGUE YOUR POINT IN PHYSICS? And please do not forget to like or comment on the post after you finished reading it.
OALG 19.5.4 EVALUATE THE REASONING
Equipment: 2 different lightbulbs, two identical light bulbs, two batteries, connecting wires.
a. Evaluate the following claim: Your friend says that when two lightbulbs are connected in series to each other and then to a battery, the lightbulb connected closest to the negative pole of the battery will be brighter. He explains this by claiming that the second bulb will get fewer electrons because the first bulb will use up some of the electrons. Do you agree or disagree? How can you convince your friend of your opinion? You can use theoretical arguments or design an experiment to test his suggestion.
b. Your friend says that when two identical lightbulbs are connected in series to each other and to the terminals of a battery, the lightbulb closest to the negative pole of the battery will have a greater potential difference across it. She explains it by saying that it will be harder for the electric field to push through to the second bulb after it has already pushed through the

first. Do you agree or disagree? How can you convince your friend of your opinion? You can use theoretical arguments or perform an experiment to test her suggestion.

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Eugenia Etkina shared an event.
Admin
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May 11 at 9:28 AM
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#argumentation
Hi all, I posted a question yesterday about argumentation in physics, many people liked the post but nobody commented with an answer. Please check yesterday's post and share your thoughts. How do you argue your point in physics?
Also, I am reminding you to register for the LED workshop on May 20th. It is a unique opportunity to learn how to integrate LEDs in your physic course and how to help your students understand how they work.
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Eugenia Etkina
Admin
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6d
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#ISLEsummer workshop
Hi @everyone! Two things today. First, as I promised, the dates for our summer 2-day 8 hour ISLE workshop! The dates are July 21-22. The time is noon - 4 pm US East Coast US time both days. This is an introductory ISLE workshop that helps you see the big picture and be prepared to implement the ISLE approach next year. We hold meetings for specific topics through the year but these meetings assume that you are familiar with the approach as whole. Please comment here is you are planning to attend and I will create google form for you to register.
Second, this will be my last post for DC circuits. In my previous post I showed a new type of problems - for argumentation, here is another example - Jeopardy problems for DC circuits and an activity to help students figure out the existence of internal resistance of a battery, do not miss! What are the reasoning skills that Jeopardy problems develop? How are they different from traditional problems?

OALG 19.7.5 Electric circuit Jeopardy

You have a circuit consisting of a variety of elements including a 9-V battery (measured as 9 V when you put a voltmeter across it without an external circuit), a switch, and several resistors. You measure current through different circuit elements and the potential difference across them (each element has corresponding voltmeter and ammeter numbers). The results are in the table below. Draw a picture of the circuit for which these measurements could have been taken, determine the values of resistances if possible, and show where the voltmeters and ammeters could be located.

Element	Ammeter reading	Voltmeter reading
1	0.071 A	8.86 V
2	0.071 A	7.10 V
3	0.071 A	0 V
4	0.035 A	1.76 V
5	0.035 A	1.76 V

OALG 19.7.6 Electric circuit Jeopardy

You have a circuit with the same 9-V battery as in the previous activity, several resistors, and a switch. You measure current through different circuit elements and the potential difference across them (each element has corresponding voltmeter and ammeter numbers). The results are in the table below. Draw a picture of the circuit for which these measurements could have been taken, determine the values of resistances if possible, and show where the voltmeters and ammeters could be located.

Element	Ammeter reading	Voltmeter reading
1	0	9.0 V
2	0	9.0 V
3	0	0

OALG 19.7.7 Design an experiment

Equipment: Real battery, 3 different lightbulbs, connecting wires, ammeter, voltmeter, switch.

To make a real battery, go to https://phet.colorado.edu/sims/html/circuit-construction-kit-dc/latest/circuit-construction-kit-dc_en.html and make battery resistance 1 ohm.

Then design an experiment to investigate how potential difference across this battery changes as the current through the circuit changes. Make sure you start with the case when the current through the circuit is zero and finish with the maximum possible current (without short-circuiting the battery).

a. Draw the circuit for your experiment. Describe the data you plan to collect.

b. Make a table to record the data, and after you make the circuit put the data in the table.

c. Reduce the resistance of the battery to zero and repeat the experiments. Record the data the same way you did in part b.

d. Describe the differences in the patterns you found in parts b and c. How do the emf of the battery and its internal resistance explain the differences?

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Eugenia Etkina shared a post.
Admin
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5d
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#womeninphysics
Lise Meitner. Another woman who did not get the Nobel prize while she fully deserved it. Fission. She was omitted in the previous story about women in physics and astronomy that I posted a few days ago.

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Eugenia Etkina

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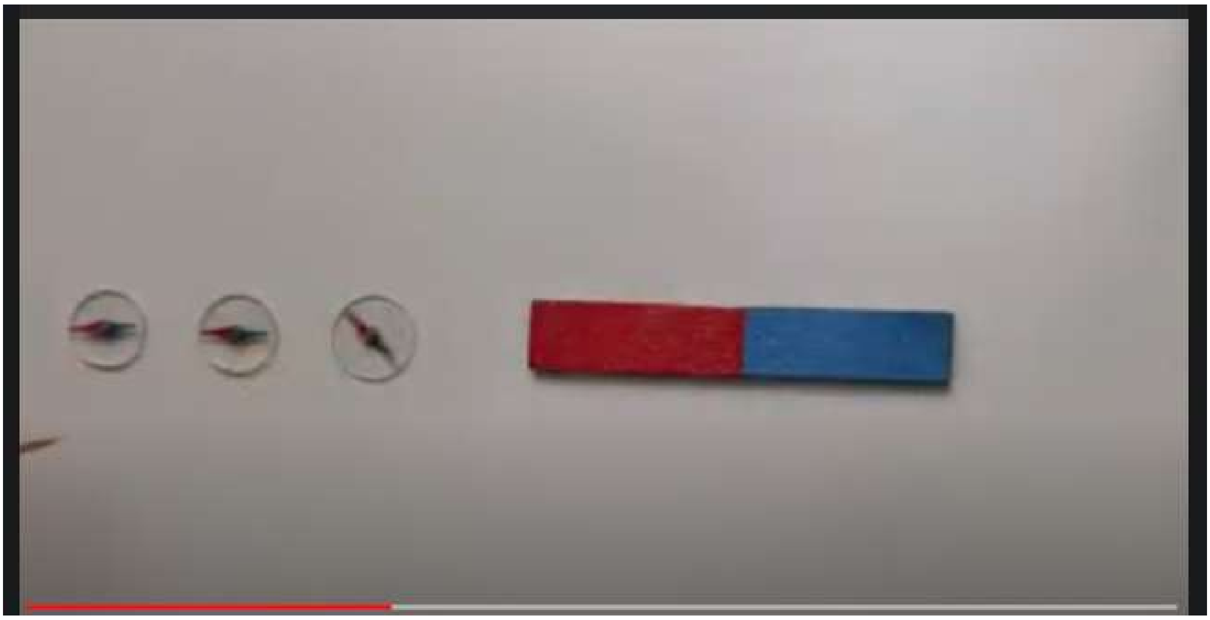
#magnetism #LEDworkshop on Saturday
Hi all Exploring and Applying Physics, two things today: First the zoom link to our LED workshop on Saturday (this is the SAME link we use EVERY TIME, so if you attended any of our workshops, you have the link): https://rutgers.zoom.us/my/etkina...
the password is 164680.
Note that the workshop starts at NOON Eastern Standard Time (East Coast US), 9 am Pacific Coast time (West coast US) and at 6 pm Central European Time. Zoom will ask you to update, so please join about 5-7 min early.
Second, I will start posting for magnetism (Chapter 20). The observational experiment for which I am attaching the video might be new for many. It is the experiment from which the students infer that they can use a compass to determine not only the direction of magnetic field but also its strength. It is easy to perform and while it should not be the first observational experiment that they perform, it is an important one. For the logical progression of student learning see the OALG file posted here for Chapter 20 and read Chapter 20 in the textbook.
https://www.youtube.com/watch?v=n5ulaDQ0ATc



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Eugenia Etkina shared a link.
Admin
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May 22 at 1:20 PM
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#Instructorguide
Hi all Exploring and Applying Physics people, today I continue with Magnetism, chapter 20. I have not discussed how important it is to read the Instructor Guide before planning what the students and you will do in each chapter. I will use Chapter 20 as an example. For the next few days I will show how IG helps you plan a unit. Each chapter in the IG starts with the learning goals. However, these are only this chapter content-based learning goals, while overarching scientific abilities goals are in the Introductory chapter to the IG. (the whole document is posted here in the FILES). Below you see the list of learning goals in Chapter 20:
Students should be able to:

1. Describe the sources of magnetic fields. Explain how magnetic fields are created. “Read and write” with B field line representations.
2. Explain how to use a compass to determine the direction and relative magnitude of the B field at a particular location.
3. Determine the directions of B field vectors when the magnetic field is created by a bar magnet, horseshoe magnet, and by a current-carrying wire, loop and a solenoid.
4. Apply the right-hand rule for the fields and the right-hand rule for forces to analyze situations involving magnetic fields when magnetic fields are created by current-carrying wires.
5. Compare and contrast electric fields and magnetic fields.
6. Determine the magnitude of a magnetic force exerted on a current-carrying wire or a moving charged particle in uniform magnetic field.
7. Apply knowledge of magnetic forces, electric forces and Newton’s laws to solve complex problems. Use force diagrams to analyze situations.
8. Explain how an electric motor works using knowledge of torques.
9. Describe how knowledge of magnetic fields applies to real-life and biological phenomena. Describe and explain quantitatively the differences between dia-, para- and ferro- magnetic materials.
10. Design an experiment to determine the magnitude and direction of the B field produced by a current-carrying wire, current-carrying solenoid and by an unmarked magnet.

After you read those goals, compare them to what goals you usually set for magnetism and consider if you need to add the new ones or stay with yours. It is fine not to expand them, but then you need to read the rest of the chapter thinking of the most important activities for your students to reach the goals that you chose. In addition you need to think what scientific abilities goals the activities that you choose will help develop. As we proceed to the examples of the types of activities, we will discuss what general scientific abilities-related goals those help achieve. For those who are new to our group, please read about scientific abilities at https://sites.google.com/site/scientificabilities/

Here is a brief summary of what scientific abilities are:

Scientific abilities are "habits of mind" of scientists and engineers, things that they do on a regular basis in their work. But as these things are not automated and always require deep thinking and self-evaluation, we do not call them science skills, We call them scientific abilities. Next

Generation Science Standards and new AP Physics courses use the term "science practices". There is a lot of overlap in all of those, but basically it is through science practices that people develop scientific abilities. The word ability does not mean innate. It means that it is not an automated skill. Measuring temperature with a thermometer is a skill. Evaluating the uncertainty in a particular measurement and minimizing it is an ability. As the main goal of ISLE philosophy is to help students learn physics by practicing it, development of scientific abilities becomes and integral art of this philosophy. The goal of the project is to help students develop some of the abilities used by scientists and engineers in their work. The abilities we work on include:
an ability to represent knowledge in multiple ways;
an ability to design experiments to investigate new phenomena, test hypotheses and solve experimental problems;
an ability to collect and analyze experimental data;
an ability to devise and test relationships and explanations;
an ability to evaluate reasoning and experimental design;
an ability to communicate.

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Eugenia Etkina
Admin
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May 23 at 2:28 PM
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#instructorguide #magnetism
Hi @everyone, I continue today with the structure of the Instructor Guide. The examples come from Chapter 20 - Magnetism. After we state the content-based goals of the chapter and show which videos are there and

where they are, we make a list of non-traditional problem numbers in this chapter. For example:
Nontraditional end-of-chapter questions and problems
Choose measuring procedure (MEP): Q20.14, Q20.15
Evaluate (reasoning or solution…) (EVA): P20.3, P20.6, P20.27
Multiple possibility and tell all (MPO): Q20.13, Q20.15, Q20.16, Q20.20, P20.1, P20.13, P20.31, P20.36
Jeopardy (JEO): P20.12, P20.33, P20.34, P20.35
Design an experiment (or pose a problem) (DEX): Q20.12, Q20.16, P20.5, P20.25, P20.44
Problems based on real data (RED): P20.18, P20.32
The description of different types of problems is in the introductory chapter of the Instructor Guide posted here in the files. These are crucial hints for AP teachers. All our marked non-traditional problems have the format used in the AP exams, therefore if you download the Instructor Guide posted here and make sure that you assign all of the non-traditional problems to your students (for class work or homework or for special problem solving sets assignments), they will be very prepared for the exam. In addition, many of those problems have real life context and the contexts that especially appeal to females (research finds that females are not interested as much as males in sports -related problems, for example. They are interested in problems related to biology, medicine, etc.)
Below I post a screen shot of a few problems at the end of the chapter. You can see that all of them are experiment related and several are on the above list. I also asked ChatGPT the last problem (#5) and it did not know the method of comparing the magnitudes of B fields that we discuss in the textbook and I showed you here a few days ago. It wanted to use the magnetic field sensor!

20.1 and 20.2 Magnetic interactions and Magnetic field

1. When a switch is closed, a compass needle deflects from the initial to final direction, as shown in **Figure P20.1**. Say everything you can about this circuit.
2. You have a lightbulb connected to a battery. (a) What happens if a compass is placed under the constant current cable, made of two twisty wires that connect the bulb with the battery? (b) What happens if you separate the wires and place the compass under one of the separated wires? Explain your answers for both parts.
3. The current through a circuit is shown in **Figure P20.3**. The deflection of a compass needle is shown in the figure. Is the picture correct? If not, what is wrong?
4. Draw $\vec{B}$ field lines for the magnetic field produced by the objects shown in **Figure P20.4**.

FIGURE P20.1

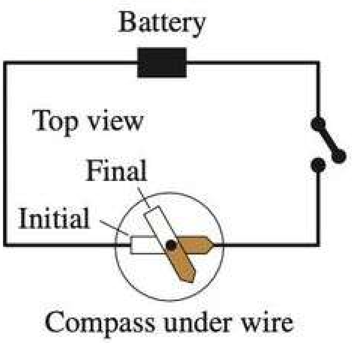


FIGURE P20.3

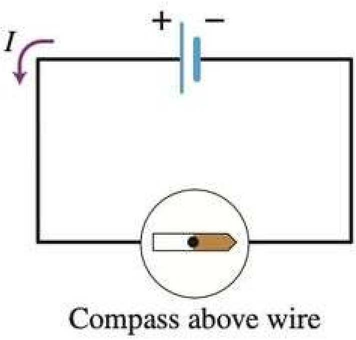
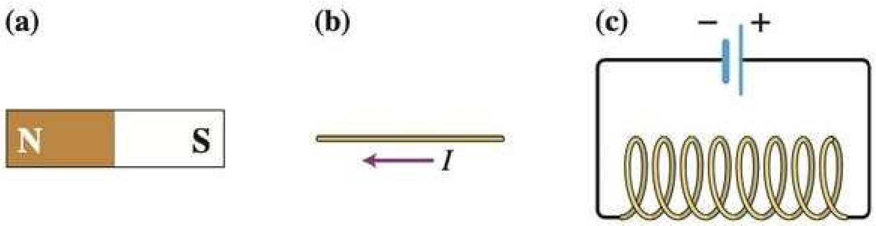


FIGURE P20.4



5. * You need to determine the direction of the $\vec{B}$ field at two points in space and compare the magnitudes of the $\vec{B}$ field at those two points. Describe the experiments that will allow you to accomplish this task.

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Eugenia Etkina shared a group.
Admin
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May 25 at 5:50 PM
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Hi @everyone, I wanted to continue with my posts about Instructor Guide and Magnetism, but Andrew Yolleck wrote a great comment about how he uses the materials in response to my post the day before yesterday. I copied it here, please read it, it is excellent!
And a piece of news: our group is now over 2000 members. Wow!
From Andrew Yolleck
The sequence of steps that I generally go through in order to prepare my lessons has not changed too much and reading the Instructors Guide (IG) is an important step (step #2 for me). The only thing I do before reading the IG is read the chapter in the textbook. I feel that it is important to do each of these steps (see my original post for all of the steps) before EVERY new semester for all of the chapters being covered. I always learn something new or want to do something different in comparison to previous semesters. For example, you'll notice from my post from 3 years ago that I stressed the importance of covering material that will only help my students be successful on the MCAT. Although I still feel that this is important, I do not take it to as much of an extreme as I used to because I feel that other topics not covered by the MCAT (momentum, circular motion, etc.) have value to students too beyond just this one exam.
I am going to copy a part of my post from 5/6/2020 (just over 3 years ago) where I talked about how I use Eugenia's textbook and supporting materials in my classes. It was a long post, but I am only including steps 2 and 3 below. I think this is the link to my original entire post:
https://www.facebook.com/groups/320431092109343/?multi_permalinks=680161029469679
STEP 2: "Next, read the instructor's guide for the chapter you are preparing to teach. I like to think of this resource as the way I begin to craft my lessons. It's where I can decide upon what is most important for students to know by the end of the lesson. I can use the instructors guide to start figuring out how I can go about accomplishing the learning goals

for my lessons. There are wonderful suggestions for relevant Active Learning Guide activities and homework problems."

STEP 3: "Next, you need to start building your lesson by including engaging activities for students to be able to use the ISLE philosophy to construct their own knowledge. The Active Learning Guide is by no means a lesson plan, but it is a phenomenal resource bank for activities that students can engage with to hit upon the learning goals of your lesson. First of all, there is no way that you will get to do all the activities for any chapter, so do not think that you need to! Which activities should you do? Well, that depends on a number of factors. What is most important for YOUR students to know? For me, this is based on what is deemed important for success on the MCAT exam since many of my students will go on to take it. Amongst other questions, one of the most important that I need to ask myself - will this chapter, section, or activity help students learn what they need to in order to succeed on the MCAT? If the answer is no, I do not include it. After having read the instructors guide, I will already have compiled a list of relevant activities, but not all of them make it into my lesson. I essentially narrow it down. First, if it's not relevant to the MCAT, its out. Next, if I don't have the proper equipment or a video to replace the equipment, then it's also out. But that's okay because many ALG's require no equipment at all - this will prove to be even more important as we transition to online learning environments. Ruling out ALG's is also not a bad thing because usually I need to rule out several ALG's since there won't be enough time for students to get to all of them. Essentially, you need to make sure that there is a logical progression of activities and that each activity has purpose in your lesson."

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Eugenia Etkina shared a link.
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May 26 at 9:05 PM
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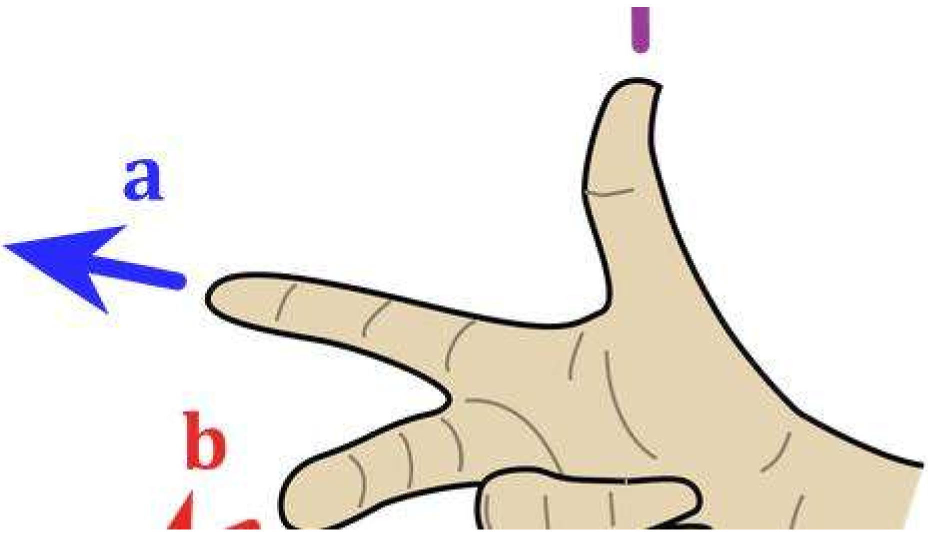
#magnetism #instructorguide
Hi all Exploring and Applying Physics, I continue with the Instructor Guide for Magnetism today. As before, my goal was to show you the structure of the IG and simultaneously comment on the Magnetism chapter.
After setting the concept learning goals in every chapter making a list of non-traditional problems, every chapter discusses student difficulties with the material (notice that we DO NOT use the term "misconceptions").
Here is the list of student difficulties with magnetism:
Brief summary of student difficulties with magnetic fields
The biggest difficulty comes from the three-dimensional nature of magnetic phenomena –students need to use their hands to determine the direction of the B field and of the magnetic force. Students often forget that a magnetic field exerts a force only on moving charged particles but not on the stationary particles, and only if the particles are moving is a particular direction. Students get confused when to apply each of the right-hand rules. Some students think that a solenoid produces a magnetic field even when there is no current through the windings. Students often think that the force exerted by one pole of a bar magnet on a diamagnetic or paramagnetic material will change the direction if the poles are swapped (the magnet is turned around).
Notice, that to help students not to confuse two right hand rules, we call one of them "right hand rule for the fields" - this rule is applied when the source of the magnetic field is known and we need to find its direction at a particular location or draw magnetic field lines for this field. The second right hand rule is called "right hand rule for the force". This rule is used when the source of magnetic field is not known but the test object placed in the field is known and we need to find the force exerted on it.
Here is what Wikipedia says about right hand rules - fascinating!
https://en.wikipedia.org/wiki/Right-hand_rule....



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Eugenia Etkina uploaded a file.
Admin

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May 28 at 4:46 PM

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#instructorguide #magnetism
Hi all Exploring and Applying Physics, today I will do my last post showing how the Instructor Guide works. If you did not download it yet, please do, it is posted here in the Files and I am attaching it to this post again. If you have our textbook and the ALG/OALE (these files are posted here too), then the Instructor Guide helps you organize the material for each chapter or unit.
I showed how each chapter introduces content-based goals, students difficulties and new types of problems. After that it walks you though all the activities that we have and explains why we do stuff the way we do. So, here is a small part of the Chapter 20 text:
I. A qualitative description of magnetic interactions and magnetic fields

Textbook Section 20.1 and ALG Activities 20.1.1–20.1.3 introduce students to the phenomenon of magnetism. ALG Activity 20.1.1 helps students characterize the interaction of a compass needle with permanent bar magnets. It builds the first step to the representation of a magnetic field in space with the arrow pointing from S to N inside the compass (without naming the magnetic field). If you want to devote laboratory or recitation time to introducing magnetism, students should start with the ALG activities while using the textbook as summary reading.

Textbook Section 20.2 introduces students to the concept of magnetic field, the physical quantity of the B field, and the compass needle as an indicator of the magnetic field in a region. Unlike an electric field, whose vector characteristic preceded the concept of electric field lines, B field lines come up before any quantities. We use multiple compass needles to help students explore the direction of magnetic field (using the orientation of the needle) and the magnitude (using the period of oscillation of the needle placed in a particular location). Use ALG Activities 20.2.2 for the former and 20.2.3 for the latter. In Activity 20.2.3 students learn that the farther from the magnet, the weaker the magnetic field.

A fun and useful activity that can be done in recitation or a studio classroom is to have groups of students use compasses to map B field lines of different configurations of permanent magnets (such as dipole, quadrupole, and horseshoe magnets) on whiteboards and present their results to the rest of the class. Make sure the magnets are strong because students can be confused by the additional interaction of Earth's magnetic field. (Watch for conduit pipes under tables, too!). If you want to encourage students to explore magnetism, we recommend cow magnets as the most economical, safe, and student-proof magnets we have encountered.

ALG Activity 20.2.4 addresses a common student difficulty when they confuse magnetic poles with oppositely charged objects. It is a variation of a similar experiment that they did in Chapter 17. They again find that charged objects of both signs attract both poles of the magnet due to the fact that a magnet (it does not matter whether it is a metal magnet or a ceramic magnet) has charged particles inside it that lead to the electric polarization of the magnet so that the side closer to the charged object becomes charged oppositely and thus attracts. This interaction is different from the interaction of two magnets where a pole of a magnet attracts one pole of another magnet but repels the other.

The next step is to establish that current-carrying wires produce a magnetic effect on a compass similar to that of a permanent magnet. ALG Activity 20.2.4 mirrors the historical experiment done by Oersted and simultaneously helps student construct the first right-hand rule for the direction of magnetic field created by a known source (a right-hand rule for determining the direction of the B field lines produced by an electric current in a wire). Students observe the effect that the current-carrying wire exerts on the orientation of the compass needle and find patterns in that orientation. If you are starting this topic in a lab and have enough equipment, it is best if students perform this experiment in groups. If this is not possible and you are doing this experiment in a lecture setting, students can watch you perform the experiment while they look for patterns. Orient the wire without current along the natural orientation of the compass (aligned with Earth's magnetic field), so that when you turn on the current, students can observe the biggest deflection. After observing and discussing the experiment, students can read about the experiments in Observational Experiment Table 20.1. ALG Activity 20.2.5 helps students visualize the "circles" for the field lines using a wire and iron filings. If you want to map the field around a wire with compasses, it is best to conduct a carefully prepared lecture demonstration. A current of at least 15–20 A is needed to swamp the effect of Earth's magnetic field. The simplest way to produce currents of these magnitudes is to use a car battery. Make sure you do not keep the current on for more than about 10 or 15 s.

ALG Activity 20.2.7 helps students practice the newly established right-hand rule for the fields by applying it to determine the direction of the B field created by currents through a wire, a wire loop or a solenoid. Textbook Conceptual Exercise 20.1 only uses a solenoid but shows students how to draw the B field lines for the current-carrying solenoid. We suggest that students first attempt the ALG activity and then work though the textbook exercise. The B field lines produced by a bar magnet are found to be very similar to the field lines produced by the current in a coil of wire—a useful idea needed later in the chapter. You can use EOC Questions 1, 4, 5, 12, 13, 14 and Problems 1–6 for practice and formative assessment.

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Eugenia Etkina shared a link.
Admin
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May 29 at 4:49 PM
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#electromagneticinduction
Hi @everyone, today I am starting Chapter 21 - Electromagnetic Induction. Please let me know if it is useful to go through the rest of the textbook chapters during the summer, or should I focus on specific aspects of ISLE that are important for those who are implementing it? I have been posting almost every day for 3 years now and I wonder whether specific topics or general posts are more useful What do you think?
In any case, today is E/M induction - creation of electric current in a circuit with no battery! Here is the sequence of activities in a studio classroom, high school classroom or a lab (at Rutgers we do these activities in a lab). If you do not have materials, the same activity numbers in the OALG allow students to work with the videos. The point of the first activity is for the students to figure out that they can create electric current without a battery in a circuit if they move a magnet with respect to it in a certain way. But is this the only way to induce a current (test this idea!) and what is a more general rule for making it happen? Two activities below work great and students usually figure them out with no extra help. For the first one try to give them a coil with a few loops so that they cannot accidentally induce the current, but need to do it purposefully.
21.1.1 Observe and find a pattern
PIVOTAL Lab: Equipment per group: whiteboard, markers, a coil with many turns, a bar magnet, and a galvanometer (or a multimeter).

a. Examine the equipment that you have on your desk. The galvanometer registers current through the coil. It needs to be connected to the coil (with no battery). Now that you have connected the galvanometer to the coil, work with your group members to figure out what you can do to make the galvanometer register current through the coil. Once you found one way, look for others so that at the end you can formulate a pattern for the cases in which the current is induced. Describe your experiments and findings with words and sketches.
b. Develop a rule: Devise a preliminary rule that summarizes the condition(s) needed to induce a current in a coil. What are the assumptions that you made?
c. Now that you found your own way to induce electric current in the coil, watch the video with the experiments and compare them to the ones you designed. [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]
21.1.2 TEST AND REVISE YOUR IDEA
PIVOTAL Lab: Equipment per group: 2 coils, a battery or variable power supply, a galvanometer, a switch.
Working with your group, connect one coil (coil 1) to a battery/power supply and put the switch in the circuit. Connect the other coil (coil 2) to the galvanometer. Work with your group members to implement the following experiments to test the pattern that you invented in Activity 21.1.1. Caution! Never connect the galvanometer to the battery or power supply. It will be burned.
Experiment 1.Use the rule devised in Activity 21.1.1 part b. to predict what will happen if you move coil 1 relative to coil 2.
a. Describe the experiments in words and sketches and make the predictions of their outcomes using the rule you invented in Activity 21.1.1.
b. Conduct the experiments and record the outcomes.
c. Make a judgment concerning the rule that you’re testing. If necessary, revise your rule to incorporate your new findings. Note that your revised rule should be consistent with all the experiments you’ve conducted up to this point.
Experiment 2. Use your current rule to predict what will happen if you place a coil connected to a galvanometer next to the coil connected to the battery/power supply (so that axis of the coils coincide) and (1) close the switch without moving either coil, then (2) let the current run for a period of time, and then (3) open the switch.

d. Describe the experiments in words and sketches and make the predictions of their outcomes using the rule you invented in Activity 21.1.1.
e. Conduct the experiments and record the outcomes.
f. Make a judgment concerning the rule that you're testing. If necessary, revise your rule to incorporate your new findings. Note that your revised rule should be consistent with all the experiments you've conducted up to this point.
g. Now watch the videos of similar experiments. Can you predict their outcomes using the rule you just tested? [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]

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Eugenia Etkina
Admin
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May 30 at 9:00 AM
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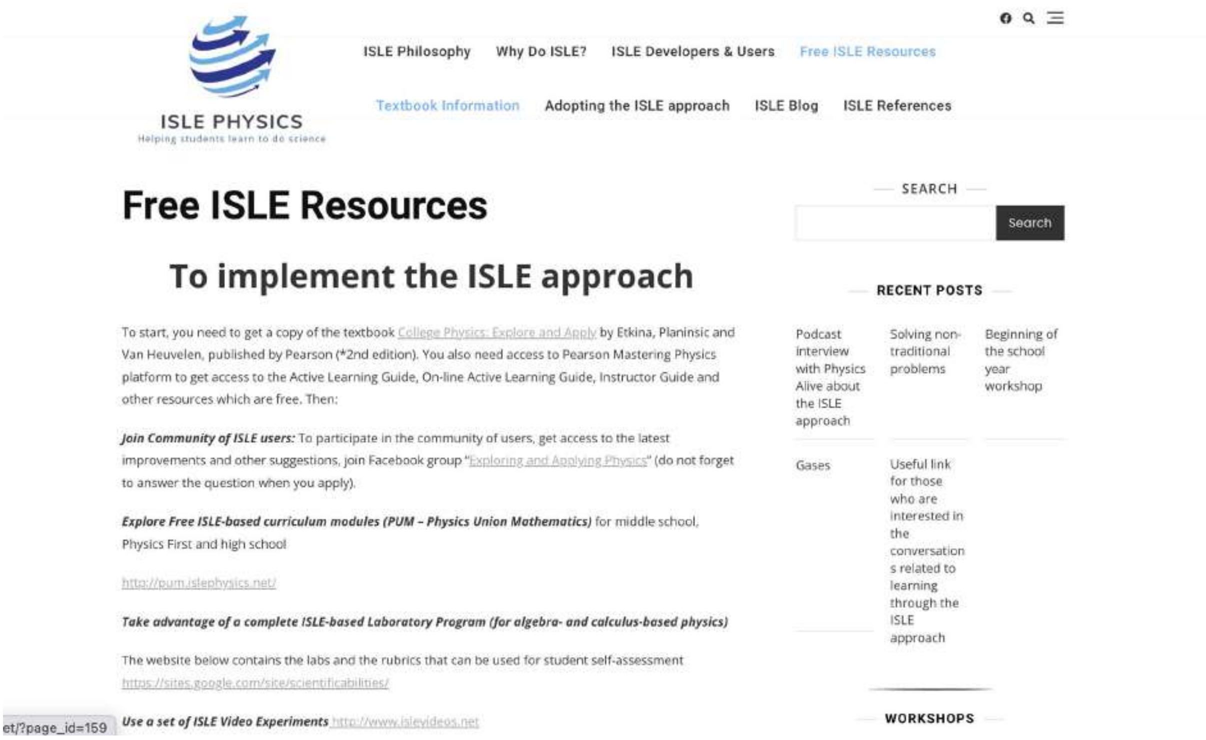
Hi all Exploring and Applying Physics people! Yesterday I wrote: Please let me know if it is useful to go through the rest of the textbook chapters during the summer, or should I focus on specific aspects of ISLE that are important for those who are implementing it?
Nobody responded with an answer. What is more useful - to continue analyzing the material chapter by chapter or to focus on the important aspects of the ISLE approach that are difficult to implement? Please comment! And please ask questions too!
https://www.islephysics.net/?page_id=51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Free ISLE Resources

To implement the ISLE approach

To start, you need to get a copy of the textbook College Physics: Explore and Apply by Etkina, Planinsic and Van Heuvelen, published by Pearson (*2nd edition). You also need access to Pearson Mastering Physics platform to get access to the Active Learning Guide, On-line Active Learning Guide, Instructor Guide and other resources which are free. Then:

Join Community of ISLE users: To participate in the community of users, get access to the latest improvements and other suggestions, join Facebook group "Exploring and Applying Physics" (do not forget to answer the question when you apply).

Explore Free ISLE-based curriculum modules (PUM – Physics Union Mathematics) for middle school, Physics First and high school

http://pum.islephysics.net/

Take advantage of a complete ISLE-based Laboratory Program (for algebra- and calculus-based physics)

The website below contains the labs and the rubrics that can be used for student self-assessment
https://sites.google.com/site/scientificabilities/

Use a set of ISLE Video Experiments http://www.islevideos.net

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Beginning of the school year workshop
Gases
Useful link for those who are interested in the conversations related to learning through the ISLE approach

WORKSHOPS

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Eugenia Etkina
Admin
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May 31 at 3:09 PM
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#electromagneticinduction
Hi @everyone, I will continue with Chapter 21, Electromagnetic induction, as most of those who responded to my questions yesterday, said that they wished me to continue with the book chapters.
Once the students figured out that it is i the change in the magnetic field through the coil that leads to the induced current, and they also probably noticed as they were doing the experiment, that they could change the

magnitude of the current by moving the magnet faster or slower and also change the direction of the current. Both of those accidental observations are important for the construction of Faraday's law of electromagnetic induction. However, the students can investigate both aspects in more detail. Today I show how we address the issue of the magnitude through two equivalent activities: one is done in a lab and one can be done in a "lecture" setting in a large enrollment setting or if you do not have proper equipment for all groups.

Here is the lab-based version:

21.2.1 OBSERVE AND FIND A PATTERN

PIVOTAL Lab: Equipment per group: whiteboard, markers, coils with different diameters and different numbers of turns, 2-3 bar magnets, a galvanometer (or a multimeter).

By now, your group has figured out how to use a magnet to induce a current in the coil. Your goal for this experiment is to devise a qualitative rule that relates the magnitude of induced current to the properties of the magnet, the motion of the magnet, and the properties and the orientation of the coil.

a. Come up with as complete a list as possible of possible factors that might affect the magnitude of the current induced in the coil. Then conduct the experiments to instigate those factors.

b. Briefly describe your experiments using sketches and words.

c. Describe the outcomes of your experiments.

d. Use your experiments and any other information you have to devise qualitative rules (in words) that relate the magnitude of induced current to other factors. Are there any assumptions that must be made for your rule to work?

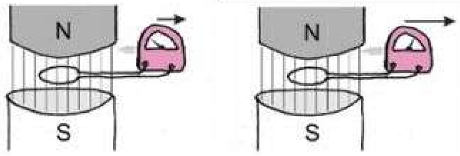
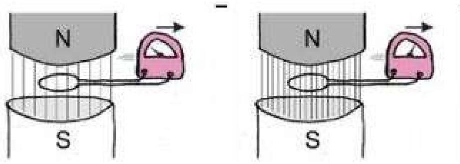
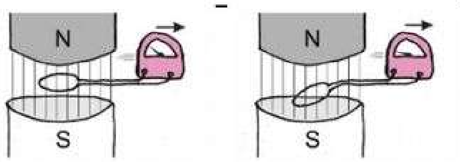
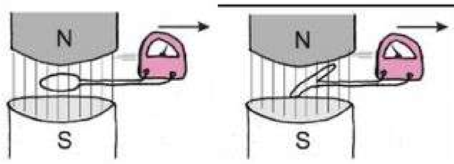
Here is the version out-of-lab (see both the text and the image attached).

21.2.2 OBSERVE AND FIND A PATTERN

Class (alternative to 21.2.1): Equipment per group: whiteboard, markers.

The table that follows describes five new experiments using a galvanometer, an electromagnet, and a coil. The outcomes of the experiments are included.

Work with your group members to devise a mathematical expression that relates the magnitude of the induced current to various properties of the magnetic field, relative motion of the coil with respect to the magnet, and properties of the coil.

Experiment	Illustration	Outcome
a. Position a coil so that the $\vec{B}$ field lines are perpendicular to it and move it slowly out of the magnetic field. Repeat the experiment, moving the coil quickly.		The quicker the coil's motion, the larger the induced current.
b. Position the magnet and the coil as in experiment **a.** and move the coil slowly out of the magnetic field. Repeat the experiment using a stronger magnet.		A stronger magnet induces a stronger current in the coil compared to a weaker magnet when the coils move at the same speed with respect to the magnet.
c. Position a magnet perpendicular to the coil and the coil as in experiment **a.** and move the coil slowly out of the magnetic field. Then position the coil so that the plane of the coil makes some other angle with the $\vec{B}$ field lines. Keep the speed the same.		When the $\vec{B}$ field lines are perpendicular to the plane of the moving coil, the strongest current is induced.
d. Use two identical coils. Fold part of the wire of one coil to make a loop with a smaller area (see the figure). Position each coil and the magnet as in experiment **a.** Move the coils out of the magnetic field at the same speed with respect to the magnet.		A stronger current is induced in the coil with the larger area.

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Eugenia Etkina
Admin

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June 1 at 11:43 AM

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#highexpectations

Hi @everyone, while I promised to continue with the textbook chapters, and we are currently on Chapter 21, I would like to point your attention to the conversation of Tom Prewitt and Danielle Buggé that occurred in the comments to my first post for Chapter 21 2 days ago. Tom commented that he does not get to electromagnetic induction in his school year and asked what to do to help his students move faster. Danielle replied with some strategies, which are very useful. The most important thing that she said is holding your students to high standards or having high expectations of them.

This idea is extremely important. In my 40 years of teaching physics I found that my students always met my expectations. If I expected them (even subconsciously) to be struggling and move slowly, this is exactly what they did - they struggled and the lessons dragged. Especially when I was not confident myself in the material. If I expected them to work hard and created engaging activities, they miraculously worked hard and the lessons flew.

The important thing was that I was confident in them (and in myself) and I projected this confidence. I cheered and reminded them that nobody before solved this problem. Or that it took me 30 minutes to solve it and could they beat this time?

Most importantly I based the pace of the lessons on the best students. You might think that this is not fair. What about those who needed more time? When we do the pacing based on the "average" student, then the best ones are bored and the weakest ones cannot follow. If we base the pace on the weakest students, then the best ones and the average ones are bored. So, my solution was to have groups of mixed skills and base the pace on the fastest groups. For those who struggled I helped individually during group work and then offered out of class time in the mornings before school started. I invited the advanced students to those morning help sessions so that they could help the struggling students. But the most important thing was that I clearly communicated that EVERYONE could be and should be successful in learning physics and my responsibility was to help them be successful. Not to give them grades, but to help them succeed. But to be successful they needed to work hard. And again, I was there to help them work hard. I expected them to work hard and I worked hard myself (always returning their written work with marks the next day, preparing exciting experiments, planning lessons carefully and so forth). The students saw how hard I worked and they somehow felt responsible for working hard too. Many of my former students are the members of this group, I am asking them to comment about what motivated them to work hard in my classes. Please do and thank you!

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Eugenia Etkina
Admin

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June 2 at 1:44 PM

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#welcomenewmembers #electromagneticinduction #Lenz'law
Hi all Exploring and Applying Physics people! Two things today - welcome to our new members - a big group joined recently and my continuation of the posts on electromagnetic induction (Chapter 21). I posted activities following the ISLE process that help students figure out that changing magnetic field induces a current in a coil without a battery. The next set of activities was to help students figure out what affects the magnitude of the induced current (qualitatively). The next step is today - how to find a pattern in the direction of the induced current. Both of those ideas are important as they come together to form Faraday's law of electromagnetic induction (coming tomorrow).
It is possible to infer Lenz' law from experiments, but the process has a high cognitive load as one needs to keep track of many things at once.

Therefore we created an activity that used experimental data but does not involve students doing the experiments themselves (many physicists do not collect their own data but work with the data collected by others). See the attached screen shot form the ALG, a similar activity is in the OALG File for chapter 21 posted here.
Reminder: the term flux in everyday life has a completely different meaning compared to physics. Your students need to have a discussion about the difference.
Second thing - Let's welcome our new members:
Chris Ashmore-Good,
Judy Salvati Collins,
Gena Davis Barnhardt,
Leonardo Montoya,
Niah Portem,
Caroline Grizzle,
Arlene B Chua,
Ken N Lisa Henson,
Kim Little Terry,
Eric Schmutzer,
Susan Vulcan,
Seth Freedman,
Mohammad Amara,
Rachel Neil,
Dawn Carryer Logan,
Gina Kise,
Dane Peagler,
Stacy Bressler,
Ken Galluppi,
Dusty Hughes,
Rebecca Becka Pouy,
Ashley Vidulich,
Ulf Morgan Andersson,
Diana Davis Smith,
Davide De Boni,
Mattias Eklund,
Luca Zanini,
Matteo Melison,

Tara Frazier Sloan,
Christine Stewart,
Marjorie Hernandez

When you first opened the group's page, you should have seen the message explaining what to do to benefit from the group the most. To simplify the message, I will say that you need to do two things: study every tab on the website islephysics.net and check posts here every day and after reading a post, like it or comment. If you do those two things - study the website and check posts every day, you will not miss anything. All out old posts and recordings of every workshop are archived by Hrvoje Miloloža. He will post the link to the google folder where the stuff is. Check it out too. Please post your questions!

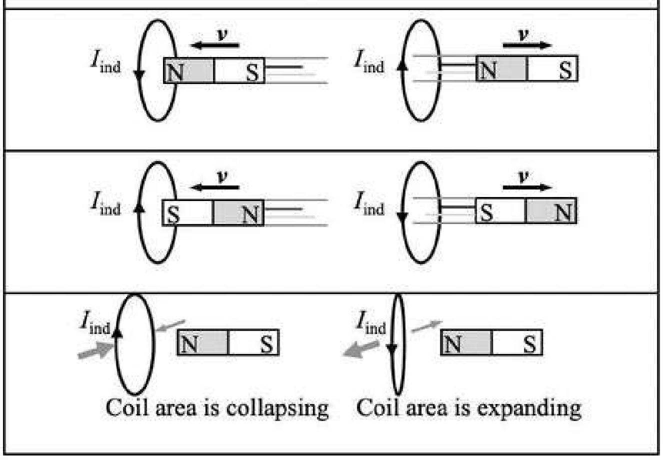
21.3.1 Observe and find a pattern

PIVOTAL ***Class:*** *Equipment per group:* whiteboard, markers.

The experiments below repeat earlier experiments that used a galvanometer, a bar magnet, and a coil and in which a current was induced. The direction of the induced current is shown in the illustrations.

a. Work with your group members to discuss and analyze the 6 experimental scenarios in the table below. For *each* case, on your whiteboard, draw $\vec{B}_{ext}$ field vectors through the coil caused by the moving magnet. Indicate whether the external B field vectors through the coil are decreasing or increasing in length. Draw induced magnetic field vectors $\vec{B}_{ind}$ created by the induced current in the coil.

Experiments:



b. Use the data on your whiteboard to devise a rule relating the direction of the induced current in the coil and the change of external magnetic flux through it. *Hints:* (1) Focus on the direction in which $\vec{B}_{ext}$ is changing rather than the direction of $\vec{B}_{ext}$ itself. (2) Compare the direction of the induced magnetic field vectors $\vec{B}_{ind}$ in relation to $\Delta\vec{B}_{ext}$.

c. With your group, formulate a general rule: How does the direction of the induced current in a coil relate to the *change* of external magnetic flux through it?

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Eugenia Etkina
Admin
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June 3 at 11:21 AM
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#electromagneticinduction and #physicsteacherhabitsofmindandpractice
Hi all Exploring and Applying Physics! Two things today: I continue the story of electromagnetic induction and discuss physics teacher habits of mind and practice.
First - e/m induction. Yesterday, I posted how students can construct Lenz' law using experimental data - basically finding patterns and analyzing them to create a rule. But this is never the end of the story in ISLE! Now they need to test it! A great testing experiment can be done using the following equipment: you have two aluminum rings mounted on flexible support (you can also attach them to a straw and support the straw with a thread, the point is that the rings need to be able to move)). One ring is solid, and the other one has a gap. Aluminum does not interact with magnets, as the students already know. To test Lenz' law the students need to use it to predict what will happen when a magnet is moved towards and away from each of the rings. After the students make the prediction and explain HOW they reasoned to it (using the H-D reasoning chain: If my hypothesis is true AND I do such and such, THEN such and such should happen BECAUSE). Here is the video:
video https://mediaplayer.pearsoncmg.com/.../sci-OALG-21-3-1
The second thing I wanted to share is the photo that I took on our morning run. The sun was low and you could see the reflections of the light from the clouds (which themselves reflect sun light) on the water. I was thinking of how everything we see in the world is due to sunlight being reflected diffusely but the atmosphere and how it is always dark on the Moon

although the same Sun is shining on it. As I run with my phone, I took a picture immediately and on the run I kept thinking how I can use it in my teaching. As our ISLE workshop is coming, I will use it as the NEED to KNOW for the geometrical optics set of activities that we will do. If you are coming to the workshop, you will see. The photo I took is attached. But my point is to illustrate how what I did shows the my habits of mind as a physics teacher - I saw a cool phenomenon, explained it to myself and then recorded it and thought of how I can use it in my teaching. This is a habit that we want to have to that we help our students see that physics is about the real world, not inclined planes and blocks. And to feel the wonder of this world.

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Eugenia Etkina
Admin
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June 4 at 12:27 PM
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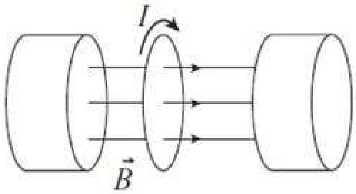
#electromagneticinduction
Hi @everyone, I continue with electromagnetic induction. Now that the students developed conceptual feeling for what is going on - change of magnetic field leads to electric current through a coil and they know what factors affect the magnitude of the current and its direction, how do they construct Faraday's law? emf=-delta flux/delta time?
Here is an activity that we developed so that the students can construct the mathematical expression but your help is needed for them to realize that the product of current and resistance in this case stands for the emf not voltage. We discussed the importance fo the difference between emf and voltage some time ago, but what is crucial here that in Faraday's law there are no two points acrosss which you measure the voltage as the electric field pushing electrons through the coil is not Coulomb's field, its lines are closed loops, they have no beginning and no end.

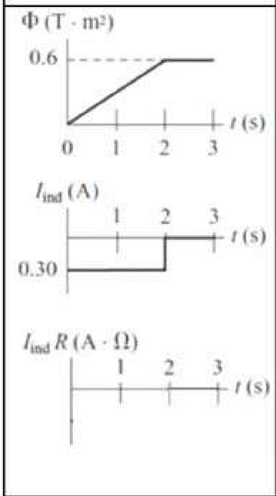
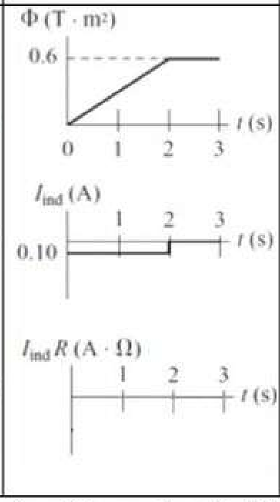
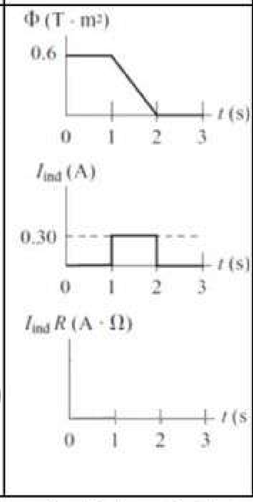
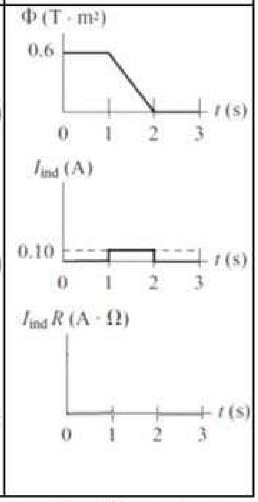
21.4.1 Observe and explain

PIVOTAL ***Class:*** *Equipment per group:* whiteboard, markers.

In the table that follows, the results of four experiments are shown in which a changing magnetic field produced by an electromagnet passes through a loop, as illustrated to the right. This changing $\vec{B}$ field causes a changing flux Φ through the loop and an induced current I_{ind} around the loop of resistance R. The product $I_{ind}R$ is also plotted as a function of time.



a. Collaborating with your group, draw the third graph that shows the product $I_{ind}R$.

Coil resistance is 1.0 Ω	**Coil resistance is 3.0 Ω**	**Coil resistance is 2.0 Ω**	**Coil resistance is 6.0 Ω**
			

b. Discuss what the meaning of the product $I_{ind}R$ is and which equivalent quantity this product may represent. Then devise a relationship between $\frac{\Delta\Phi}{\Delta t}$ and that quantity. Do not forget the sign!

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Eugenia Etkina
Admin
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6d

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#electromagneticinduction #application experiment

Hi all Exploring and Applying Physics people! I continue with electromagnetic induction today. We have been discussing observational and testing experiments for the law of e/m induction, but we did not touch upon application experiments. You also must be waiting for some MATH to appear. Where is the MATH? Here it is - in this amazing application experiment conceived, implemented and videoed by Gorazd Planinsic . Not only the students can apply everything that they have learned so fat but they also see how useful their understanding of Earth's magnetic field is. Additionally, it is a multiple possibility problem - the students can decide which quantities and how many they can figure out. Do not skip!

OALG 21.5.7 REAL-WORLD APPLICATION

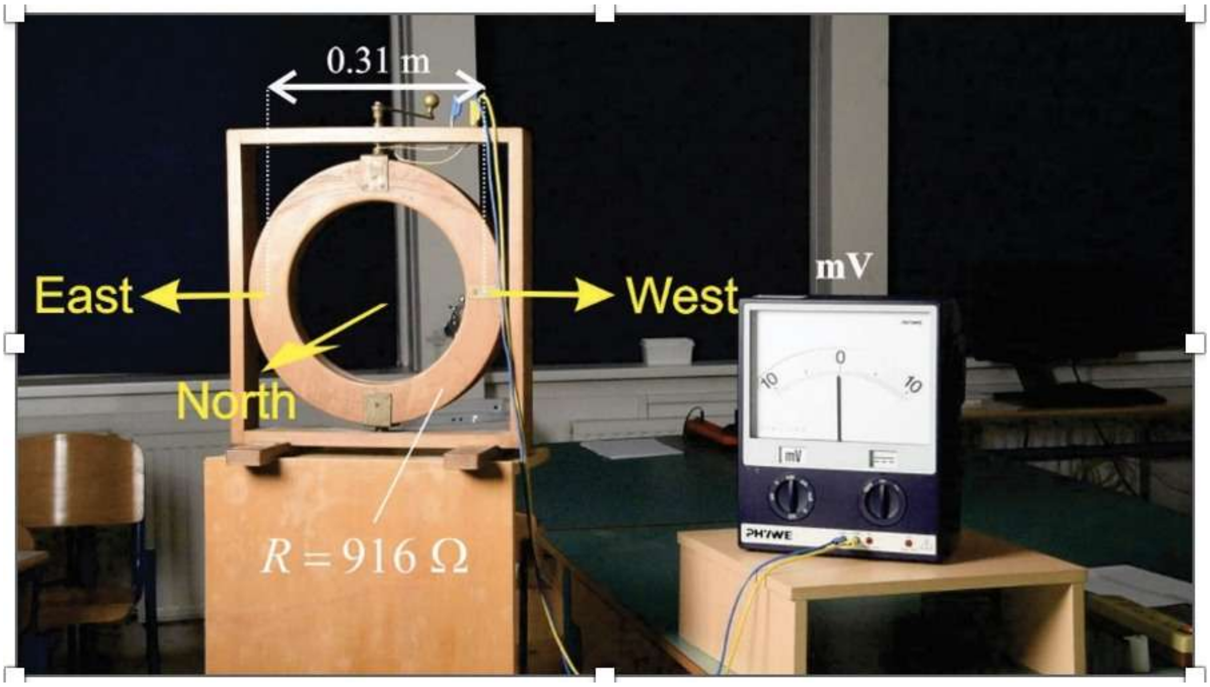
You have a large coil with 1500 turns of copper wire and a voltmeter that can measure potential differences between –10 mV and 10 mV. The average diameter of the coil is 0.31 m and the resistance of the coil is 916 ohm. The coil is mounted in the wooden frame so that it can rotate around the axis that coincides with the coil diameter. The video [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...] shows two experiments. In both experiments, the voltmeter is connected to the coil ends. The experiments were performed on the Northern hemisphere. The photo below shows the initial orientation of the coil (the normal to the plane of the coil points towards the geographical North).

a. Watch the video and, collaborating with your group-mates, propose a qualitative explanation for the outcome of both experiments. Make sure your group's explanation accounts for all changes in the magnitude and in the sign of the voltmeter reading.

You can treat the voltmeter as a device that measures potential difference across its own internal resistor, which has very large resistance (several megaohms). If you connect such a voltmeter across the coil as shown above and an induced emf appears in the coil, then the voltage measured by the voltmeter is equal to the induced emf in the coil.

b. Make a list of physical quantities that you can estimate based on data given above and analyzing the video. The video was recorded at 30 frames per second. (Note: for a vector quantity, you can estimate its magnitude, direction or both). Estimate two of them.

And please do not forget to like or comment on the post to make it more visible. Thank you!



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Eugenia Etkina
Admin
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5d
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#electromagneticinduction
Hi @everyone! Last post about e/m induction. When we teach e/m induction we often stop at Lenz' law and the relationship between changing magnetic field and induced current. But, what causes the current? The magnetic field can cause emf only when a conductor moves

perpendicular to the B field lines and Lorentz force causes the movement of electrons and this separation of electric charges and potential difference between the ends of that conductor. But when there is no movement, just the change of the magnetic field through the area of the coil, what is the mechanism responsible for the creation of the current? It must be some electric field, but not not the electrostatic field as it moves the charges along a closed loop! This reasoning leads the students to the invention of a new type of electric field which is responsible for the phenomenon of electromagnetic induction. The understanding of this field is crucial for latter understanding of electromagnetic waves. Do not miss - I am attaching the whole section in our textbook dedicated to it. In Figure 21.27 you see all 4 Maxwell's equations, presented in a conceptual way. You do not need to memorize any formulas to remember the essence of all 4 of Maxwell's equations.

21.8 Mechanisms explaining electromagnetic induction

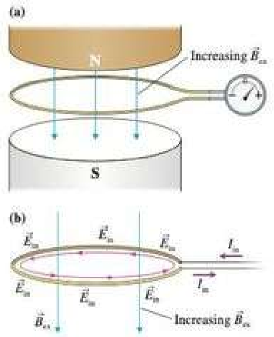
Faraday's law *describes* how a changing magnetic flux through a wire loop is related to an induced emf, but it does not *explain* how the emf comes about. In this section we will explain the origin of the induced emf.

A changing $\vec{B}_{ex}$ field has a corresponding $\vec{E}$ field

We know that a changing magnetic flux induces an electric current in a stationary loop (Figure 21.26). Because the loop is not moving, there is no net magnetic force exerted on the free electrons in the wire. Thus, an electric field must be present. The electric field that drives the current exists throughout the wire. This electric field is not produced by charge separation, but by a changing magnetic field.

If we were to represent it with $\vec{E}$ field lines, those lines would have no beginning or end—they would form closed loops. This electric field essentially "pushes" the free electrons along the loop. We can describe it quantitatively with the emf. But this emf is very different from the emf produced by a battery. For the battery, the emf is the result of charge separation across its terminals. For the induced emf, the electric field that drives the current does not originate on the charges but is distributed throughout the entire loop; thus the emf is also actually distributed throughout the entire loop. You might visualize it as an electric field "gear" with its teeth hooked into the electrons in the wire loop, pushing the free electrons along the wire at every point.

FIGURE 21.26 A changing $\vec{B}_{ex}$ creates an electric field $\vec{E}$ that induces an electric current.



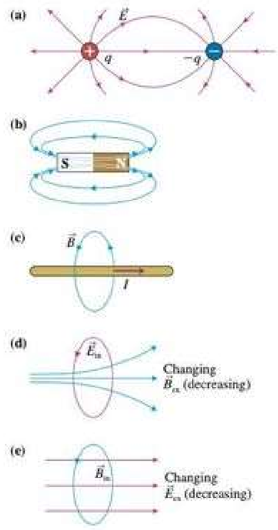
What do we now know about electricity and magnetism?

We have learned a great deal about electric and magnetic phenomena. We learned about electrically charged objects that interact via electrostatic (Coulomb) forces. Stationary electrically charged objects produce electric fields, and electric field lines start on positive charges and end on negative charges (Figure 21.27a). In our study of magnetism (Chapter 20), we learned that moving electrically charged objects and permanent magnets interact via magnetic forces and produce magnetic fields. Magnetic field lines do not have beginnings or ends (Figure 21.27b); they are continuous loops. So far, individual magnetic charges, magnetic monopoles, have not been found.

When we studied electric circuits (Chapter 19) we learned that electric fields cause electrically charged particles inside conductors to move in a coordinated way—electric currents. Later we learned that electric currents produce magnetic fields (Figure 21.27c). In this chapter, we learned about the phenomenon of electromagnetic induction and its explanation: a changing magnetic field is always accompanied by a corresponding electric field (Figure 21.27d). However, this new electric field is not produced by electric charges, and its field lines do not have beginnings or ends.

Except for the lack of magnetic charges, there is symmetry between electric and magnetic fields. This symmetry leads us to pose the following question: if in a region where the magnetic field is changing there is a corresponding electric field, is it possible that in a region where the electric field is changing there could be a corresponding magnetic field (Figure 21.27e)? This hypothesis, suggested in 1862 by James Clerk Maxwell, led to a unified theory of electricity and magnetism, a subject we will investigate in our chapter on electromagnetic waves (Chapter 25).

FIGURE 21.27 A summary of some of the main ideas of electricity and magnetism.



REVIEW QUESTION 21.8 Explain how (a) an electric current is produced when only a part of a single wire loop moves through a magnetic field and how (b) an electric current is produced when an external magnetic flux changes through a closed loop of wire.

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Eugenia Etkina shared a link.
Admin

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5d
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Hi all Exploring and Applying Physics people! Let's welcome more new members! New members - please follow directions in the text that you see when you first go to our group's page to learn what the group is about. Many of you said that you joined to group as you teach AP. While being a member of this group will definitely help you with AP courses, this is not the main goal of the group. The main goal is for you to learn about and implement the ISLE approach to teaching and learning physics. To learn more about ISLE go to https://www.islephysics.net/ and explore every tab. If you decide to implement it, it will change the way you think about physics and about what it means to help your students learn it. I am sure you already do many of the things that we suggest and have developed. But the difference is that we have an overarching philosophy that mirrors physics practice and we implement it consistently for EVERY concept of a physics course. The philosophy is explicit in everything that students do and allows them to feel that they real physics every day.
Explore the documents in the FILES posted here too! Welcome again!
Let's welcome our new members:
Sarah Davis Griffith,
Niffirg S Nodnarb,
Paul Vecchione,
Yam Can,
Amanda Galbincea,
Christine Robben Knabe,
Mehmet Canan,
Aaron Schuetz,
Michael Gyan Donkor,
Xiaomeng Wang,
Todd Bayat,
Kristine Varney,
Juliet Mathews,
Zumou Lin,
Wyatt Keegan,
Josefine Grundström Lindqvist,
Krystal Ramzinski Rios,

Kelsey Henry,
Bridgette Boudreaux

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Eugenia Etkina
Admin
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4d
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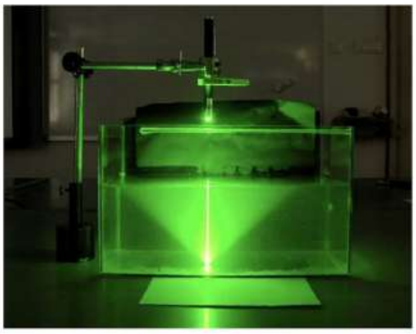
#CoolExperiment
Hi @everyone, I finished chapter 21 - Electromagnetic induction. The next Chapter is 22- Geometrical Optics. As the beginning of this chapter is the topic of our upcoming July workshop, I will not post anything for chapter 22 before the workshop but I will share one amazing activity that we described in our paper in the American Journal of Physics (here is the citation), if you cannot get it online - message here and I will post the file. Etkina, E., Planinšič, G., Vollmer, M. (2013). A simple optics experiment to engage students in scientific inquiry. American Journal of Physics, 81(11), 815-822. To do the experiment, have a tank of water, a green laser pointer and a white piece of paper on under the tank. Dip one finger in milk and put it into the water to have some scattering of light. Then shine the laser on the top of the water surface as in the photo - and you will see an amazing light come. The rest is yours! If you want the answers - they are in the paper. To help students with testing experiments, it is good to have a rectangular prism made of glass or plexiglass. Post here the photos of your students' ideas and testing experiments!
The activity is in the Appendix to the ALG (this is the chapter that has activities for different chapters and is great for a review at the end of the

school year or after the AP exams). It is a perfect ISLE activity as it allows for multiple explanations and lots of testing experiments.

A.6 Propose different explanations and test them

Lab Equipment: aquarium made of flat transparent walls and bottom, green laser pointer, lab stand, few drops of milk (added to water in the aquarium to make the effect more visible), white paper. Additional materials are available upon request.



Direct a green laser beam vertically downward into a partially filled glass aquarium tank that is sitting on top of a flat surface, with a piece of white paper inserted between the table and outer-bottom of the tank. You notice a clearly visible cone with an apex at the bottom of the aquarium (see the photo on the right).

a. Work with your group to devise explanations for the observed light cone.

b. Come up with the ways to test proposed explanations. What equipment do you need?

c. Design testing experiments, make predictions based on your explanations, conduct the experiments, compare the outcomes to the predictions and decide how to proceed. You might need to repeat this process multiple times.

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Eugenia Etkina shared a link.
Admin
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3d
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Hi all Exploring and Applying Physics people, from time to time I have been posting about women in physics. Here is another post about an amazing woman - a woman whose observational experiment lead to the development of the hypothesis of dark matter. It is a wonderfully ISLEish story - how data analysis led to the most fascinating "wild idea" ever. If you do not know who Vera Rubin is - read!

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Eugenia Etkina
Admin
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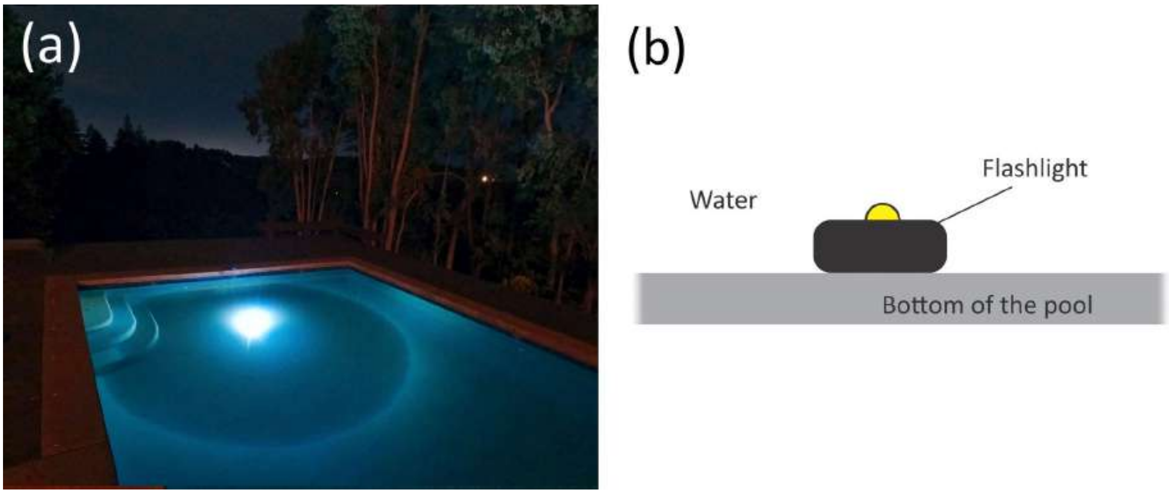
@applicationsofphysics
Hi @everyone! As you know our group is called Exploring and Applying Physics. The name came from the title of our textbook College Physics:

Explore and Apply. The title was suggested by Dawn Sedgwick Buchan, my former student and a physics teacher after I asked my former students to propose titles of the new edition of the textbook reflecting the nature of the ISLE approach. Dawn's idea won and it is now the title of the textbook and the reason for the name of our group. In my posts I mostly often focus on the Explore part - how we help students construct new ideas in a systematic way. But the Apply part is also very important and many of you said that you wanted to join the group to learn more about applications of physics. My last post was about the applications, as well as this one. But this one has a story. And, of course, I am staying with chapter 22.
In our textbook we have a worked example 22.4 called laser beams in the pool (see page 685). It looks like a very textbook like unrealistic situation. And yet...
In the summer of 2022 on the way from Europe to California I got Covid. Gorazd Planinsic (for those who do not know, Gorazd is my husband) and I had to isolate in a friend's house that had a pool. While I was in bed, unable to move battling the infection, Gorazd, being Gorazd, did experiments. He spent three nights taking the picture attached to this post, which replicates the problem situation the textbook. The result is the amazing photo and a great application problem for your students. If you have access to a pool, or any of your students do, you and they can do it too! All they need is a water proof flashlight and lots of patience!
Here is the text of the new problem and the data for it:
At night, we put a small waterproof flashlight on the bottom of a swimming pool and observed an interesting light pattern (see figure 1a). Figure 1b shows the sketch of the setup.
a. Propose one or more explanations for the observed light pattern. Your explanation(s) should include ray diagrams.
b. We also measured the width of the swimming pool (5.5 m) and the depth of water (1.1 m). Are these data consistent with the explanation (or with one of them) that you proposed in step a? Show your work. Indicate any assumptions that you made.
Enjoy the problem! All credit goes to Gorazd Planinsic! And please do not forget to like or comment on the post to make it more visible.



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Eugenia Etkina
Admin
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June 11 at 3:52 PM
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@applicationsofphysics
Hi @everyone! As you know our group is called Exploring and Applying Physics. The name came from the title of our textbook College Physics: Explore and Apply. The title was suggested by Dawn Sedgwick Buchan, my former student and a physics teacher after I asked my former students to propose titles of the new edition of the textbook reflecting the nature of the ISLE approach. Dawn's idea won and it is now the title of the textbook and the reason for the name of our group. In my posts I mostly often focus on the Explore part - how we help students construct new ideas in a systematic way. But the Apply part is also very important and many of you said that you wanted to join the group to learn more about applications of

physics. My last post was about the applications, as well as this one. But this one has a story. And, of course, I am staying with chapter 22.
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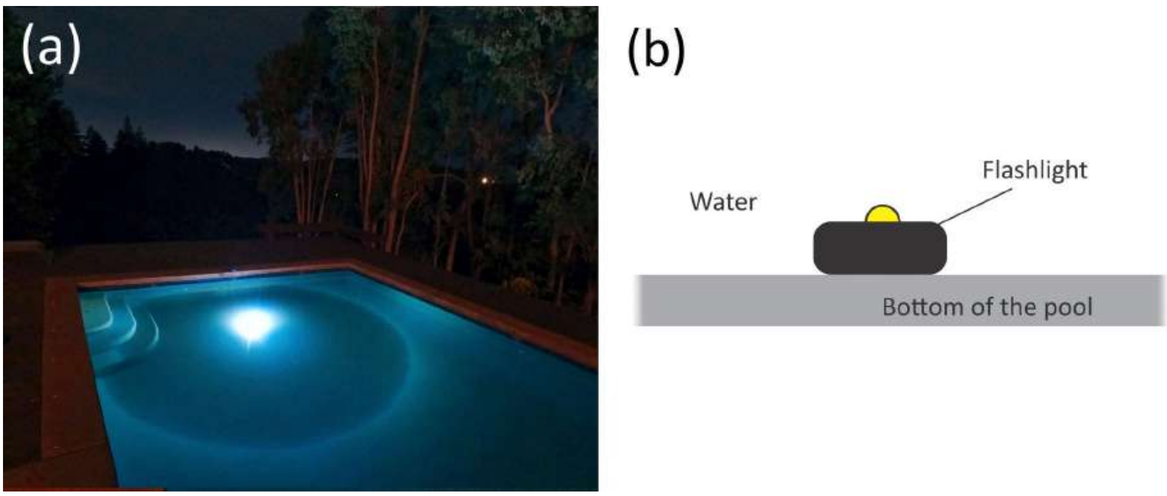

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Eugenia Etkina shared a post.
Admin

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June 13 at 6:47 AM

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#womeninphysics

It it is not about our pool problem, but too good to skip. That solution is coming! I already posted about these group of women, but if you are a new member, you could have missed it. Enjoy!

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Eugenia Etkina
Admin
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June 13 at 4:02 PM
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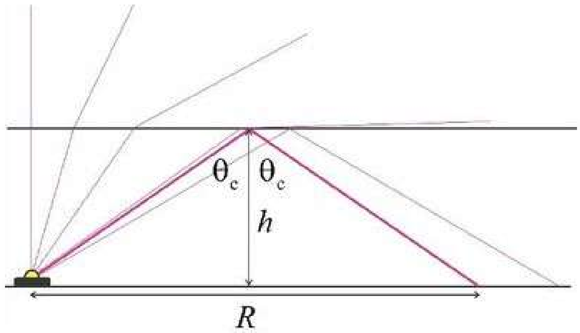
Hi all, many of you posted good solutions for the light in the pool problem. THANK YOU!

Here is our solution. The phenomenon in the problem is explained by geometrical optics (total internal reflection). Chapter 22 in the textbook. A similar problem is solved as a worked example in the textbook in Chapter 22. Take a look!

SOLUTION:

On the photo, we see a circular pattern that forms on the bottom of the pool. A bright ring with gradually decreasing brightness surrounds the dark inner part of the circle. We can explain the pattern using knowledge about light reflection (see the ray diagram below)



a. The light incident at the water surface at angles smaller than the critical angle refracts and emerges from the pool. The light incident at angles that are larger than the critical angle undergoes total internal reflects and reflects back into the pool. This light forms the bright ring. The gradual decrease of the brightness in this ring with distance is the result of multiple effects: the increase of the area on which the light is incident, the increase of the angle at which the light is incident on the bottom and the absorption of light in water.

b. if the explanation is correct, then we can determine the radius of the ring using the geometrical construction shown above and the expression for the critical angle:

$$\sin\theta_c = \frac{1}{n_{water}} = \frac{1}{1.33} = 0.752 \Rightarrow \theta_c = 48.75°$$

$$\tan\theta_c = \frac{R/2}{h} \Rightarrow R = 2h \cdot \tan\theta_c = 2.2\ \text{m} \times \tan(48.75°) = 2.5\ \text{m}$$

This result is consistent with the data given in the problem. We see from the photo that the diameter of the bright ring covers slightly less than the total width of the pool. This is consistent with the data that the pool is 5.5 m wide.

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Eugenia Etkina
Admin
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June 14 at 9:52 AM
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Hi all Exploring and Applying Physics people, we have a huge group of new members who joined our group last week. Before I welcome each of them personally, I would like to repeat that this group is focused on the holistic approach to teaching physics not individual labs and worksheets. The philosophy behind all systematic activities that our students do to learn physics is the Investigative Science Learning Environment approach or ISLE (see islephysics.net).
It is this philosophy that guides ALL our materials which are logically connected and aim to achieve two goals: students learn physics by practicing it and they develop confidence, growth mindset and the feeling of belonging in the process. These goals are achieved by the structure of the materials and by setting up class routines. The heart of the whole process is the new approach to experiments (observational, testing and application, NO DEMOS) and reasoning processes (hypothetico-deductive reasoning through multiple representations, not formulas). Explore the materials at islephysics.net website and ask your Pearson rep to set you up with the Mastering Physics account to get all of our materials. Check what is available without MP on the islephysics.net website. Browse through the FILES posted here and login into the group EVERY DAY to see and respond to the new posts. Welcome to our community!
https://www.facebook.com/groups/320431092109343/posts/1431205051031936/?__cft__[0]=AZXfm-uwhL0LHxYFmcA_CuwVeyeS1csCAbwVS1K0kFQrkDmpHT8wXTC-BOzqyfUKfSUBOOPN35mOYJC7W_oJu2GuSPnyRL_-FisaF_gNMq3ziwpSdEMpBpWtc5AY3cam0BvSUzPMgdIdEHFoZiVOzNh5ScfAy4kSvFF-KPJladJBf2H19HAfl6BCtJeoOPTQ6IU&__tn__=%2CO%2CP-R

Eugenia Etkina shared a link.

Admin

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June 15 at 7:07 AM

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Hi @everyone, Joe Milliano yesterday asked about specific videos for teaching non-inertial reference frames. I responded to his question with the link, but I realized that many of you might not know that ALL our videos for the textbook and ALG and OALG are available on Mastering physics and without it. Here is the link to the textbook and ALG videos, OALG videos are in the FILES here, I will check for the one link later today. We also have our own ISLE youtube channel, Gorazd Planinsic has his own youtube channel (just search for those names) and we have an old ISLE website with the videos. Here are some links:
https://media.pearsoncmg.com/aw/aw_etkina_cp_2/videos/ - textbook and ALG, those are all related to the observational, testing, applications experiments, activities and problems.
http://islevideos.net/ - ISLE video website (oldy but goody)
Explore!

[https://www.facebook.com/groups/320431092109343/posts/1431792860973155/?__cft__[0]=AZVHY5UaREiLjstWDW9-i-aiiYxPnfaoX_gQAQgbf_wYOdR2l24Isko7oTDayMOyilBEo4sdIvvy2bpOe9qeOQyq437Oc8eWSDjjmSXfFArM14_q1WauQ6NcY2W7O__0BixVB0na8X0qmdcChXXrdA5x1Swy0Blcl_W5nhHrC-80ejBboR_gJh4QKt3btmgLD5w&__tn__=%2CO%2CP-R](https://www.facebook.com/groups/320431092109343/posts/1431792860973155/?__cft__[0]=AZVHY5UaREiLjstWDW9-i-aiiYxPnfaoX_gQAQgbf_wYOdR2l24Isko7oTDayMOyilBEo4sdIvvy2bpOe9qeOQyq437Oc8eWSDjjmSXfFArM14_q1WauQ6NcY2W7O__0BixVB0na8X0qmdcChXXrdA5x1Swy0Blcl_W5nhHrC-80ejBboR_gJh4QKt3btmgLD5w&__tn__=%2CO%2CP-R)

Eugenia Etkina
Admin

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June 17 at 9:04 AM

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#resources
Hi all Exploring and Applying Physics people! Yesterday Jose Garcia asked to explain the difference between misconception model of student reasoning and resource model. Stephanie Hunt also wanted to learn about

the difference, and I suspect many others will too. I am making a long post answering Jose Garcia's question. Use your patience to read to the end. It is a part of one of the chapters in our new book about teaching with ISLE (the book will come out in 2024). Here it goes.

When researchers or teachers talk about misconceptions (or whatever label they give to those) they usually mean that students hold firm cognitive structures (conceptions) that are strongly help, different from experts, affect how students understand and explain natural phenomena and must be overcome. In other words, if a student has a misconception about something, first, it means that they have some robust conception and second, it means that this conception is wrong and needs to be cleared out from their mind and hopefully replaced by the correct conception. As D. Hammer put it a long time ago (1996), “This view frames research designed to identify misconceptions and instruction designed to reveal, confront, and replace them.”

While this view looks to be consistent with constructivist ideas that students are not blank slates, it also imposes certain tasks on the teacher – identify those ideas in students’ minds and help them get rid of those. That last step breaks the connection with constructivism, as if we “remove” those wrong ideas from students’ minds, then how do we help our students build new ideas which (as brain research tells us, see Dehaene, 2022) can only be developed if they connect to previously existing ones.

But students do come up with incorrect ideas, don’t they? We all have those experiences when students express the views completely inconsistent with the laws of physics. For example, many researchers documented student “misconception” that “motion implies a force, and when there is no force, motion ceases” (impetus theory as described by Hestenes, Wells, & Swackhamer,1992). It looked like in many instances (including standardized assessments, such Force Concept Inventory described in the paper cited above) the students have this robust wrong idea. However, when Brookes and Etkina (2009) conducted a linguistic analysis of student responses, they found that the students do not see the force as a cause of motion but treat it as a property of motion (similar to momentum or kinetic energy) and thus their responses are completely correct and require some language correction not the correction of the conception. Based on similar analysis, “Smith et al. (1993/1994) and diSessa (1988, 1993) challenged the idea of a discontinuity between student and expert knowledge, arguing that it conflicts with the constructivist account of how we develop new understanding.

In focusing only on how student ideas conflict with the expert concepts, misconceptions approach offers no account of productive ideas that might serve as resources for learning. Because they are fundamentally flawed, misconceptions themselves must be replaced. ... "An account of useful resources that are marshalled by learners is an essential component of a constructivist theory but the misconception perspective fails to provide one." (Smith et al., 1994, p. 124 as cited by Hammer, 1996)

At the same time, several researchers started investigating student ideas in detail and found that they are not robust ideas, but depend on the context and the wording of a question (Schuster, 1993 and many others). For example, the students have small experience-based ideas that they put together when asked a scientific question.

Is it possible, that students (and all people) construct cognitive structures based on their every-day experience and then apply these structures to answer physics questions? A. diSessa answered this question positively when he developed the concept of “phenomenological primitives” (means simple ideas that grew out of generalizations of everyday phenomena) or ‘p-prims’ (cite).

As Hammer (1996) writes: “In diSessa's model, intuitive physics is made up of smaller, more fragmentary structures diSessa called phenomenological primitives, or p-prims for short. The misconceptions perspective, diSessa argued, confuses emergent knowledge, acts of conceiving in particular situations, for stable cognitive structures” (Hammer, 1996, p. 98). diSessa identified several p-prims in student reasoning.

Some of them are

- maintaining agency (for example food is needed on a hike),
- actuating agency - the consequence of something lasts longer than this something (for example, if you burn your tongue eating hot food, the pain lasts longer than the contact with the hot beverage),
- closer means stronger (the closer you are to the stove, the hotter it is),
- Ohm’s p-prim – the stronger the cause, the stronger the effect, the stronger the resistance or impediment, the stronger the effect, and several others.

Now, you can see that p-prims can be used to explain many physical and social phenomena but they are not connected to normative physics knowledge. When we ask a student a physics question, they activate one of the available p-prims and sometimes the answer is correct (current though a resistor is directly proportional to the potential difference across it and inversely proportional to its resistance) and sometimes it is not (velocity is not directly proportional to the force and inversely proportional to the mass). Being able to habitually identify the p-prim on which the student based their reasoning is extremely important. If we can do this, we can use the existing p-prim and build on it by tweaking the language or the context. We need to view p-prims as productive resources on which to build students' new knowledge (Smith et al., 1993/4)

David Hammer and his collaborators developed the idea of resources further (see for example Hammer 2000; Hammer and Elby 2003; Hammer et al. 2005). They proposed that resources are bits of prior knowledge that can be activated alone or with other resources as a student reasons about a physics topic. Resources are often context-dependent and may not be robust in their activation, i.e., a student may abandon a resource or change which resources are being activated rather quickly. AJ Richards, D. Jones, and I in the paper "How Students Combine Resources to Make Conceptual Breakthroughs" (Richards, Jones, & Etkina, 2018) describe resources using the definitions of different researchers as "cognitive elements at various grain sizes that may be in different states of activation at any given moment" (Conlin et al. 2010, pp. 19–24); they can range from small, basic elements like Disessa's, to more complex conceptual structures such as "coherent theories about physical phenomena"(Harrer et al. 2013, p. 23101).

Hammer and colleagues discuss conceptual and epistemological resources. Conceptual resources are similar to p-prims but differ from them in size and scope and many of them are physics related. For example, a conceptual resource of energy as a substance can help a student successfully explain how a battery powers a lightbulb but when used to analyze what happens to electric current in a circuit might lead to an incorrect answer that current is used up in a circuit. Epistemological resources relate to the nature of knowledge and learning (Hammer and Elby, 2003). An epistemological resource of knowledge as fabricated stuff can help students think of developing their own explanations but if they

have a resource that knowledge comes from authority, they would want you to “give them an answer”. As the p-prims, both types of resources are activated when we ask students questions or when they are interpreting reading materials and while these p-prims and resources sometimes make the students give answers that are ”wrong” we should try to “diagnose” the source of their ideas and channel this source in a productive direction.
Did you read to the end of this post? Then please comment or like it to make it more visible. Thank you!

https://www.facebook.com/groups/320431092109343/posts/1433467954138979/?__cft__[0]=AZV7xakpjPV-IO6QYp0NV_10un61U-iHoE6w4Q9kcUfwC5MJE-aGHWQPwiqVj3BUHOPvW-VJ7RGCb2H1DAyMzCgPfFekNbbsIFZPXsz8MLT9_26K8PiwRc_TPBvY-zh2YpxY0IqFLaGvZ6SKH1u-9kgScsyqNNWi9JWEsCq291WMkmjVeQIvNMjkFsvYgIfbwY4&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
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June 19 at 9:55 AM
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Hi @everyone! I continue with optics today. Once the students learn reflection and refraction, they proceed to mirrors and lenses (Chapter 23). To draw ray diagrams they not only need a ruler and a pencil but most importantly, the understanding that EACH point on a light source emits an INFINITE number of light rays. We develop this model through the ISLE process in Chapter 22, and in my experience even teachers have difficulties with it. We will also do it in our online workshop in July, so if you are registered, you will learn how to develop this model, but if you are not attending the workshop, then study the beginning of Chapter 22, ALG and OALG in detail.
In Chapter 23 we apply this multiple-ray model to understand how images form in different mirrors and lenses. We start with a flat mirror. While it

seems easy to figure out where the image is, to imagine that it is not real and it is behind the mirror (as I usually say, in your neighbor's bathroom) is difficult. Our ISLE-based sequence of activities helps students develop this understanding and also practice HD reasoning. The screenshot of the textbook pages showing the process is attached. I am also posting the ALG/OALG activities

OALG 23.1.1 OBSERVE AND EXPLAIN

Equipment: a mirror positioned perpendicular to the desk surface, a short battery-operated candle or another small bright object, a meter stick.

To do this experiment alone you need to be creative. First, prop up a plane mirror so it is perpendicular to the desk's surface. Place a small lightbulb or a candle about 10-15 cm in front of the plane mirror. Then use a meter stick to level your eyes with the desk and point the meter stick in the direction in which you see the image of the candle in the mirror (being precise is very important here). Draw a line on the desk along which you position the meterstick to point at the candle. Then repeat at least 2 more times to get 3 or more lines as shown in the figure below (the dashed lines indicate the orientations of the meter sticks).

Extend the dashed lines behind the mirror to locate the image of the candle relative to the mirror. When your eye is at points A, B, and C, light seems to be coming from that image location.

Suggest a rule that explains the location of the image that a plane mirror forms of an object (for example, the flame of the candle).

OALG 23.1.2 EXPLAIN

Use two arbitrary rays to explain why the image of the candle in Activity 23.1.1 is at the same distance behind the mirror as the candle is in front of the mirror.

a.Draw two rays starting from a point on the candle and moving toward the mirror.

b.Draw the same rays after reflection from the mirror. Do the reflected rays ever meet? If not, how does the mirror form an image?

c. Explain why we see an image of the candle behind the mirror.

d. Extend the reflected rays back behind the mirror to find the image of the candle. Use geometry to prove that the image is the same distance behind the mirror as the candle is in front.

OALG 23.1.3 TEST YOUR IDEA (1)

Equipment: plane mirror, candle, cardboard, other materials if needed.

Justin and Isabel are investigating the location of the image of a candle produced by a plane mirror. Justin says that the image is on the surface of the mirror. Test his idea by designing an experiment whose outcome contradicts the prediction based on Justin's idea.

a. Describe an experiment to test Justin's idea.

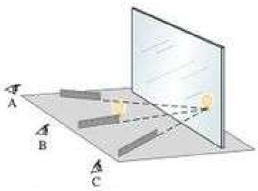
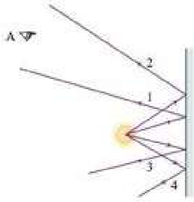
b. Predict the outcome of the experiment based on Justin's idea.

c. Perform the experiment and record the outcome.

d. Discuss whether the experiment disproves the idea that the image is on the surface of the mirror.

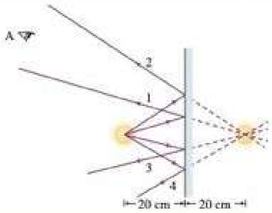
OBSERVATIONAL EXPERIMENT TABLE 23.1 Seeing a point object in a plane mirror

VIDEO OET 23.1

Observational experiment	Analysis
We place a small lightbulb on a table about 20 cm in front of a plane mirror that is held perpendicular to the table, with one side resting on the table. Observers A, B, and C place rulers on the table and point them in the direction of the bulb that they see in the mirror.  Note that the dashed extensions of the rulers all intersect at one point behind the mirror.	For observer A to see an image of the lightbulb when looking at the mirror, one or more rays of light reflected from the mirror must reach his eyes. Rays between 1 and 2 do reach observer A's eyes. 

Patterns

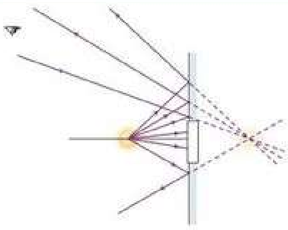
- The rulers all point to the same spot behind the mirror. Rays between 1 and 2 reaching observer A seem to originate from that spot. This is the location of the perceived image of the bulb produced by the mirror.
- The ray diagram shows that the perceived image of the bulb is produced at the same distance behind the mirror as the bulb is in front of it.
- To locate the image, at least two rays need to reach the observer's eyes because the perceived image is at the intersection of those rays.



In Table 23.1 we found that the image of the real object seen in the mirror is located where light reflected from the mirror to the eye of the observer *seems* to originate. This perceived image is behind the mirror and not on the surface of the mirror. We also found, using the ray diagram, that the image is exactly the same distance behind the plane mirror as the object is in front of it. Let us test these findings in Testing Experiment Table 23.2, on the next page.

TESTING EXPERIMENT TABLE 23.2 Testing the image location of a plane mirror

VIDEO TET 23.2

Testing experiment	Prediction	Outcome
We repeat the Table 23.1 experiment for observer A but cover the part of the mirror directly in front of the bulb.	If the image is due to the reflected rays, then even if we cover part of the mirror, some of the reflected rays will still reach the observer's eyes. The location of the image should not change. 	The observer sees the image of the bulb exactly where it was before.

Conclusions

The position of the image formation is consistent with our previous experiment. It also disproves the common idea that the image forms on the surface of the mirror.

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Eugenia Etkina shared a link.
Admin
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June 20 at 5:07 PM
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#planemirrors
Hi @everyone! I continue with plane mirrors. We are familiar with the experiment that shocks all our students and all lay people - how much of yourself you see in the plane mirror does not change is you move away from it. Even professional hairdressers think that if they move away from a mirror, they would see more. But rarely one asks the followup question: How fast is the image moving when the object is moving? See the activity that helps address both ideas. Notice that it is called "Represent and reason". Activities with this title cue you that a graphical representation is the way to solve the problem. Try and you will see how fun it is!
OALG 23.1.6 REPRESENT AND REASON
Draw ray diagrams to answer the following questions:
a. How does the size of an image produced by a plane mirror change (does it increase, decrease or remain the same) when the object is moved away from the plane mirror? How does the size change when the object is moved toward the plane mirror? Notice that to locate an image of each point of an object you need at least two rays.
b. An object moves away from the mirror. How does the speed of the object compare to the speed of the image? A mirror moves away from the object, which is resting on the table. How does the speed of the image compare to the speed of the mirror for an observer who is standing still next to the table?
c. Watch the following video https://mediaplayer.pearsoncmg.com/.../sci-OALG-23-1-5and compare the outcome of the experiment to your prediction in part b. If needed, revise the reasoning that led you to the prediction.

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Eugenia Etkina shared a link.
Admin
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June 21 at 6:50 AM
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Hi all, I post a lot about contributions of women to physics but there are other groups in our society that are underrepresented in the science we love and teach. Research in many fields shows that increasing diversity benefits any intellectual endeavor. But it is not only the field of physics in which diversity is lacking, it is also our field - the field of teaching physics.

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Eugenia Etkina shared a link.
Admin
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June 22 at 6:56 AM
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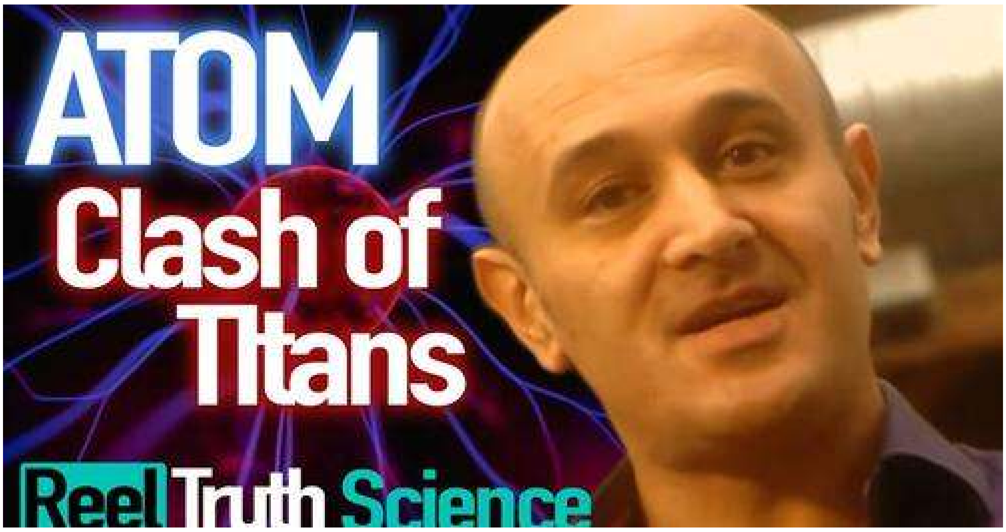
#WELCOMENEWMEMBERS
Hi all Exploring and Applying Physics people! We have more new members who joined our group. Let's welcome them!
Dear new members, to benefit from the group please follow the recommendations in the message that you when you first clicked on the group's link. It is very important that you understand how ISLE works and what to do every day (with respect to the group). Welcome!

For everyone else I wanted to share a movie which explains the history of how people figured out the atomic nature of matter. The lead person in the movie is great and he made several more - excellent historical and physics stuff!



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Eugenia Etkina
Admin
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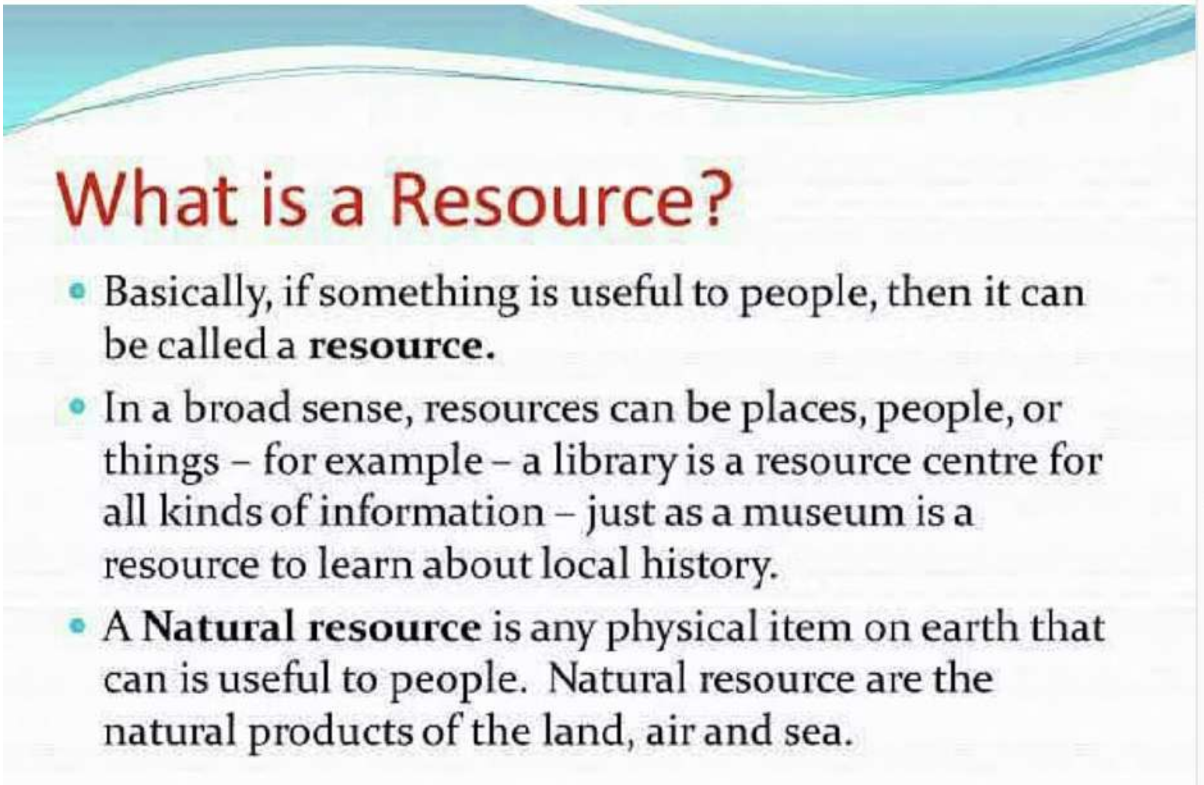
#resources
Hi @everyone ! A few days I posted about resources - bits of knowledge that are context dependent and that students use to develop answers to our questions. Work of Hammer and Elby has two types of resources that students bring to the table - cognitive (for example, energy is a thing and as a thing it cannot disappear without a trace) and epistemological (for example, knowledge is a fabricated stuff). These are great resources that we can build on when helping our students learn physics.
But thinking about resources and the work of Yuhfen Lin and David Brookes on student expertise (they developed so-called Expertise Activity that we use in all our ISLE workshops), I came up with a different class of resources that our students bring to class - learning resources. As Yuhfen Lin and David Brookes found, and we all know from experience, our students are expert learners. They learn a lot of stuff without our help - how to operate their cell phones at a speed that we cannot dream of, how to build very complicated stuff in their video worlds that we cannot even visualize, how to jump off ramps on their bicycles that we would never dare to try, how to do impossible tricks on skateboards that we cannot do even in our dreams. They learned all this through perseverance, failing and getting up and doing it again, watching the experts, getting feedback on their mistakes and correcting them, being creative and inventive, and so forth. This is exactly what we want them to do in our physics classes! Unfortunately, the traditional system of education does not reward them for many of their learning resources as it gives them grades for the first try on anything and they cannot improve those grades and correct their mistakes, as it rewards repetition of what they were told, not their creativity, as it rewards speed not thoroughness, and so forth. You see my point.
The ISLE approach is very different in this respect. When teaching physics through the ISLE approach, we BUILD on students' learning resources by creating conditions for the students to use all of the resources that they bring with them. How do we do it? You might have

examples or want to see examples. Please comment sharing examples of your students learning resources and how you build on them! I will share examples tomorrow if I see that there is interest. Thank you!



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Eugenia Etkina
Admin
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#studentlearningresources

Hi all Exploring and Applying Physics people! I continue with student learning resources. Normally when we talk about those, people mean resources that the students can use - textbooks, websites, etc. to learn. Here, I mean a completely different thing: RESOURCES THAT THE STUDENTS BRING INTO LEARNING. These are the resources that our learning system should build on (and ISLE does).
Think of all the stuff that our students learn without our help (I wrote about some examples yesterday, please see my post before reading this one). What skills do they develop doing it and how do those skills help them learn physics through the ISLE approach?

Our students know how to persevere and to take time to learn something (think of multiple lives in computer games or repeating the same trick on a skateboard). In ISLE this helps them when they design their own experiments, have to come up with a new explanation after rejecting the previous one, and when they are given an opportunity to improve their work by submitting a new version. Here their perseverance is rewarded as the experiment that they have designed works, the new explanations fails to be rejected, and the resubmitted work allows them to learn more and get a better grade. ISLE is the system that rewards perseverance and respects different times and attempts that different people need to learn. It is the final outcome of this learning not the speed with which it is achieved that is rewarded.

Our students know how to work in a group and learn from group mates (they play with other people online and there is a ton of learning going on then, they practice their skills in skateparks where more experienced skateboarders give support and advice to younger people). This helps them with group work in ISLE where most of the learning is through collaboration. This collaboration is rewarded when the students work together designing their own experiments or solving problems and submit one report for the whole group. All members have the same score, so everyone is interested in working together. The same is true for any group activity that is organized well (I posted about group work before and what to do to make it successful).

Our students know how to fail and how to learn from their mistakes (think about those who like to cook, garden and, of course, gamers, skateboarders, musicians, athletes, ALL of them!) This helps them in ISLE when it is difficult to figure out stuff and you need to try again. We build on this resource with resubmissions of work and with encouraging the students and giving them time to rethink their models and redo their experiments. In fact, rejection of a model through an experiment is a good thing in the ISLE approach, not a bad thing.

Our students know how look for feedback and how to deal with feedback (think again about all the activities that they engage in). In the ISLE approach a big part of feedback is done through scientific abilities rubrics which allow the students to engage in self assessment - and this self assessment is crucial when they need to improve their work in the classroom or on a chess board or on the computer screen to survive.

They are creative (my goodness, watching my grandson and my granddaughter play Minecraft humiliates me every time - their creativity is infinite). ISLE builds on it engaging the students to develop their own explanations, design their own experiments to find patterns or test ideas and most importantly, pose and answer their own questions.

Bottom line - our students are expert learners. And then they come into our traditional education where they are rewarded for individual problem solving and speedy answers, where grades are given once and forever for an assignment and they are required to follow instructions in the labs. All these (and many others) are the elements that reject the resources that students bring with them and teach them that failure is not an option, perseverance is only good until the first try, speed is more important than understanding, helping others does not improve your learning and your grade, and there is no room and place for creativity. Slowly, day by day in such environment, they stop brining their wealth to the table and start developing apathy, boredom, and lack of interest to struggle. Or they only focus on grades not on learning. We all are familiar with these issues and often blame the students for the lack of motivation, perseverance, and focus on grades only. But come to think of it - it is the result of our educational system. Now, when you get the students who have been in

this system for many years and stopped applying their real learning resources in school a long time ago, how do you remind them that they have these resources? As without using those, they will not be successful in the ISLE classroom.
If you ever attended our ISLE workshop, you participated in the Expertise Activity, brilliantly designed by Yuhfen Lin and David Brookes. The participants of our June Rutgers workshop, of our July AAPT workshop and of the online workshop will learn how to run it. For the rest - please wait after the workshops and we will post it again, but not before not to spoil the experience for those who will participate in the workshops.
If you read to the end, please comment or like the post to make it more visible. Thank you!

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Eugenia Etkina
Admin
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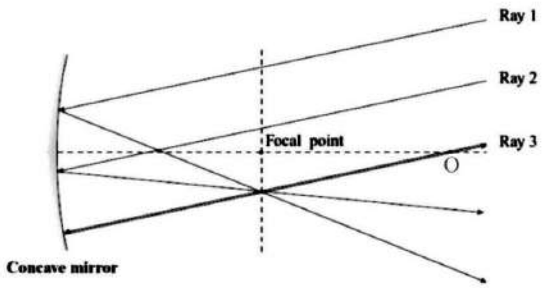
#focalplane
Hi @everyone! I took a small detour from geometrical optics to resources, including the new idea of student learning resources. Now I am back to Geometrical Optics, Chapter 23. We already discussed how important it is for the students to learn that every point of a light emitting object sends our an infinite number of rays. Without this understanding, they cannot understand how we choose the rays to draw diagrams to find images in mirrors and lenses.
Today, I will introduce another important idea that is not present in most textbooks. It is the idea of a focal plane. We usually only use the focal

point in curved mirrors and lenses to draw images, while if we know about the focal plane, we can solve problems that are very hard to solve otherwise. Here is how students construct the idea of a focal plane - see the screen shot of activity in the Active Learning Guide. Tomorrow I will share problems that are easy to solve when you know hoe the focal plane works. The text about the focal plane is in the textbook, page 717. Do not miss! For those who are new to this group, when I say the textbook, I mean ISLE-based textbook: College Physics: Explore and Apply which gave the name to this group - Exploring and applying Physics.

23.2.4 Observe and explain

PIVOTAL ***Lab or class:*** *Equipment per group:* a concave mirror and three handheld lasers.

Aim the laser beams toward the mirror parallel to each other but not parallel to the main axis of the mirror. One of the rays (Ray 3) passes through the center of the sphere from which the mirror was cut (point O). This ray reflects back along the same path. After reflection, the other two rays pass through the point where the center-passing ray crosses the focal plane of the mirror. Use the law of reflection to explain this observation.



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Eugenia Etkina
Admin
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#curvedmirrors
Hi all Exploring and Applying Physics people! Today I am sharing a simple Testing Experiment activity for curved mirrors. Have you aver tried to find the image of a shining object in a concave mirror? Where do you put the screen? To help students figure out how to do it, use this activity. It is based on the knowledge of the mirror equation (the students derive it using the previous activity). But I thought that this one is simple and elegant and helps your students connect ray diagrams, mathematical representations and a real phenomenon. Do not skip if you teach geometrical optics! Note that the activity is called PIVOTAL in the ALG - this means that you should not skip it.
23.3.2 TEST THE MIRROR EQUATION
PIVOTAL Lab: Equipment per group: a concave mirror, a small light source (the light source should be asymmetrical), a meter stick, a paper screen.
a. Place the light source behind the focal point away from the mirror. Do not turn it on yet.
b. Measure the distance s between the light source and the mirror. Draw a ray diagram and use the mirror equation to predict the image distance s'. Write down your prediction. Do not forget experimental uncertainties!
c. Turn on the light source, perform the experiment, and measure s'. Record the difference between your prediction and the measured value of s'. Can you explain the difference using the experimental uncertainties? Note: Use a paper screen between the light source and the mirror to find the image.

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Eugenia Etkina shared a post.
Admin
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Hi all, I read books about Marie Curie and posted several times about here here before and but this is something that I never thought about. If you teach radioactivity, read! and if you don't, read anyway as it shows what it costs to do science.

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Eugenia Etkina
Admin
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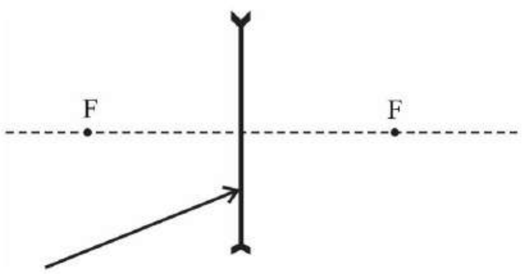
#focalplane
Hi @everyone! I promised to share a problem that is much easier to solve when you use focal plane. This is a problem from lenses, but they also have a focal plane in addition to a focal point. Our focal plane discussion inspired a lot art connections, I hope you will enjoy solving this problem. I will share more unique geometrical optic problems tomorrow. Please post your solutions here. And of course, students solve this problem after they have constructed the concepts of focal point, focal plane and how to predict where the image in a lens would be following the ISLE process (see the textbook and the ALG/OALG Chapter 23). Here is just an example of the use of focal plane. Here it is! Who is up for the challenge?

23.6.3 Represent and reason

PIVOTAL ***Class:*** *Equipment per group:* whiteboard and markers.

In the figure below, you see the location of a thin concave lens and its focal points. You also see a narrow light beam incident on the lens. Draw the light beam after it passes through the lens.



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Eugenia Etkina
Admin
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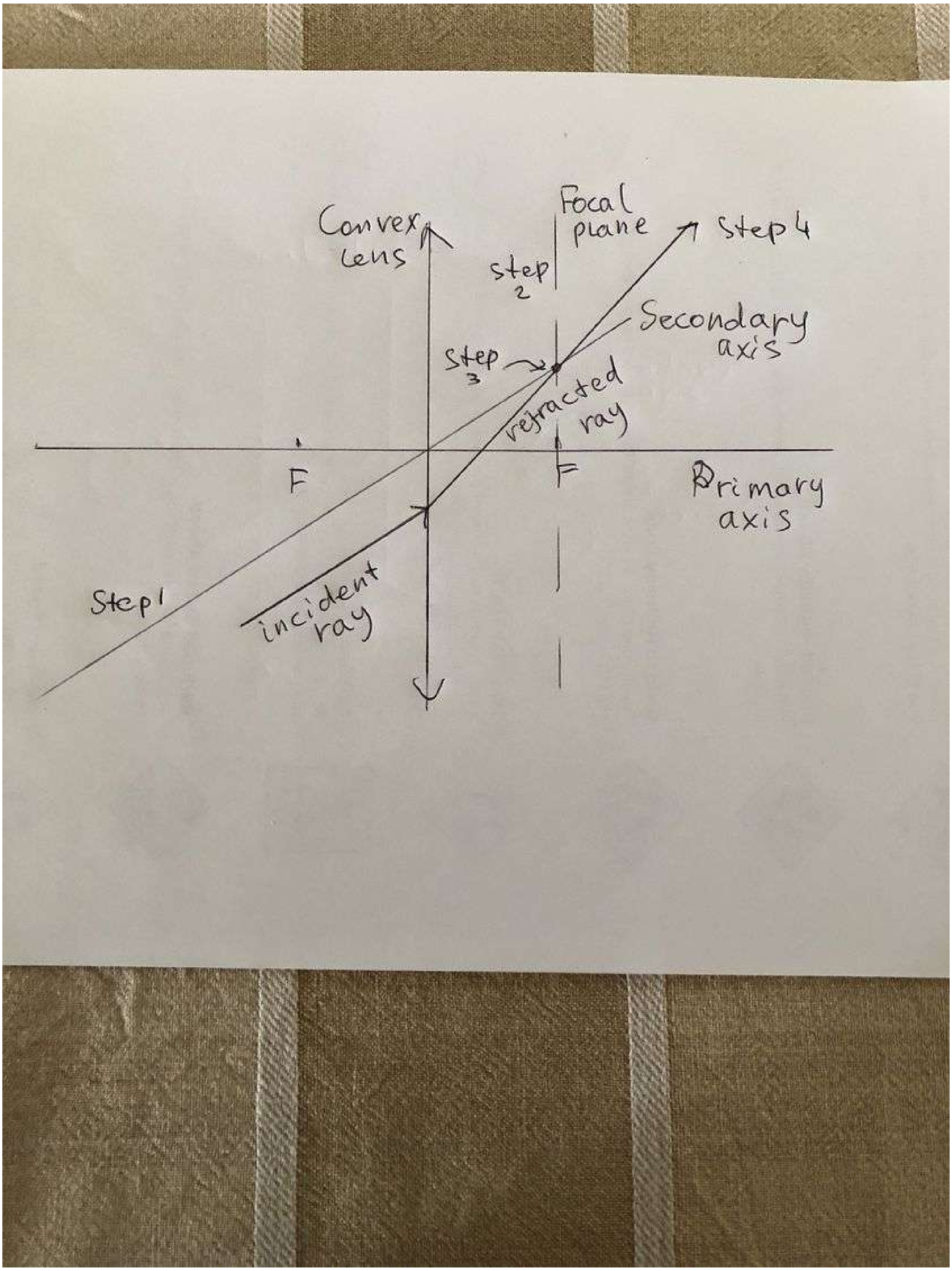
#focalplane
Hi all Exploring and Applying Physics! Thank you all for contributing your thoughts to the problem I posted yesterday. Noah Segal wrote a correct solution but as he could not attach a photo to the comment, I will illustrate what he said, but I am going to do it first with a convex lens. Then I am calling on volunteers to apply the same method to a concave lens.
Here is an important step of SECONDARY AXIS. A secondary axis is any straight line that passes through the center of the lens. It passes through it undeflected, similarly to the principal axis. And it crosses the focal plane at a location that we can call a secondary focal point. Now, all rays parallel to this secondary axis will cross the focal plane at the same point. This is the main idea of my solution. Please follow the steps and try to apply them to the concave lens. If nobody posts the ray diagram for the solution, I will post it tomorrow. We have a few other super cool activities for this chapter, I will share them in my next posts.



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Eugenia Etkina
Admin
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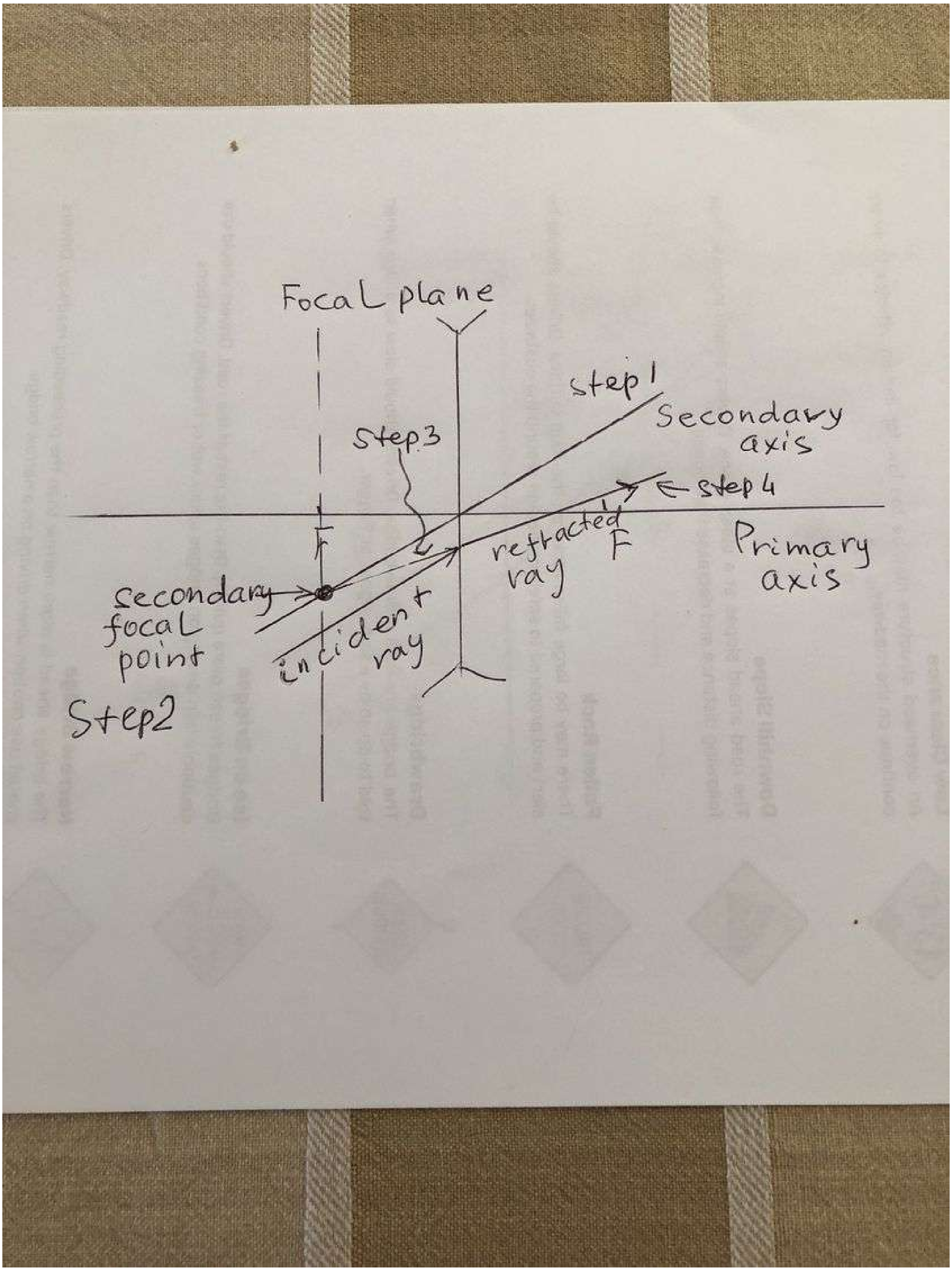
#focalplane and #WELCOMENEWMEMBERS
Hi @everyone! Two things today: first, welcome new members - we have 10 people who joined recently. As always, I remind you to benefit from the group, use islephysics.net website to learn about the ISLE approach to learning and teaching physics which is the philosophical foundation of this group, check posts every day to follow what is going on and watch out for the workshops that we run every month during the school year and in the summer - one 8-hour long in July. This one is all booked but the next one is coming in August, I will announce it after the July one is done.
Second - I am posting the solution ot the original focal plane problem with a concave lens. I wanted to emphasize that not only the idea of the focal plane is cool and useful, but also, the idea of secondary axis! See how both play their roles in the solution.
New people, we welcome you to our community!



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Eugenia Etkina
Admin
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June 30
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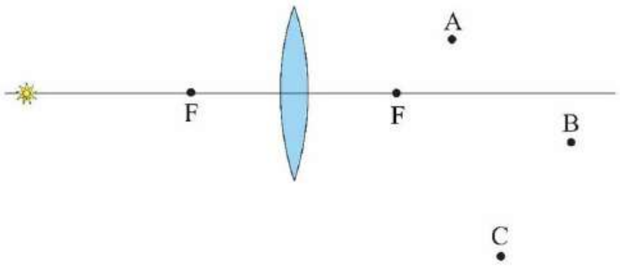
#geometricaloptics
Hi all at Exploring and Applying Physics people! I continue with "cool" geometrical optics problems. This one (designed by Gorazd Planinsic) is best done if you set up the equipment. For the light source the best thing is a small LED - as small LEDs work as point like sources beautifully. I used an optical bench, a convex lens and the LED fixed as shown in the picture. The problem stumped many of my students - all of them had an undergraduate physics degree. The beauty of the problem is that if you set it up, the students can literally SEE the source and images if they put their eyes in the areas that they predicted. Try it and you will love it! But first - solve it on paper. Oh, one more thing, the problem is in the Appendix to the Active Learning Guide. There are lots of such cute problems there, check it out if you have access to Mastering Physics. If not, send me an email. eugenia.etkina@gse.rutgers.edu

A.8 Decide

Class or lab: *Equipment per group:* whiteboard and markers, a lens, and a light source (if available).

The figure below shows a convex lens and a point-like light source on the principal axis of the lens. The figure shows the relative size of the lens.



a. Using ray diagrams, determine what each observer in locations A, B and C sees (a point-like light source, its image, none of these...).

b. Is there a location from which the observer can see the point-like light source and its image at the same time? If you think there is, draw a point at that location. If you think that such a location does not exist, explain why.

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Eugenia Etkina

Admin

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July 1

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#geometricaloptics

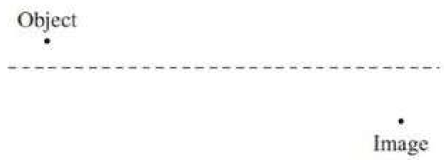
Hi @everyone! Today I am posting another one of my favorite problems in geometrical optics. While I used it when I was a high school teacher many-many years ago, after I met Alan Van Heuvelen, I found out that this is a type of problems that they called Jeopardy problems. When you are given the answer and you need to figure out what the problem was. When Alan and David Maloney wrote a paper about Jeopardy problems, they had in mind algebraic answers and some graphical answer (see Van

Heuvelen, A., & Maloney, D. P. (1999). Playing physics jeopardy. American Journal of Physics, 67(3), 252-256). We extended those problems to every unit and every representation in physics, including ray diagrams. Here is an example of such problem. Please post your answers! And please do not forget to like or comment on the post if you read it to make it more visible for other group members. Thank you!

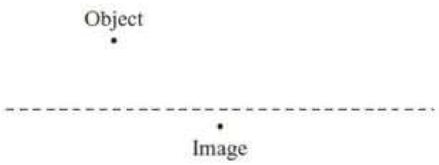
OALG 23.6.2 Diagram Jeopardy

In the figures below, you see the axis of a lens (the lens itself is not shown) and the location of a shining object and its image. Find the location and the type of the lens (convex or concave) that could produce this image, and find the focal points of the lens. When you think you have found an appropriate lens type and lens location, draw a ray diagram to help justify your choice and show the focal length on the diagram.

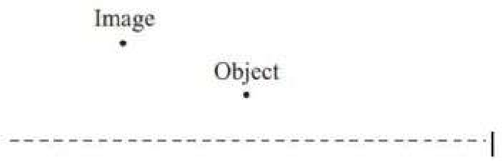
a.



b.



c.



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Eugenia Etkina

Admin

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July 3

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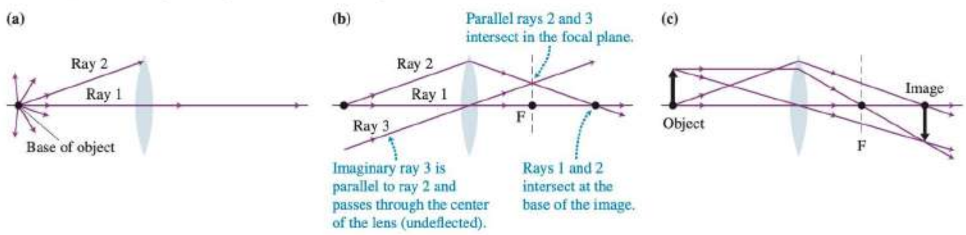
#geometricaloptics

Hi all Exploring and Applying Physics people, Jaikala Prasad and I have been having a discussion of how we know that an object perpendicular to the principal axis produces an image which is also perpendicular to the principal axis (both in curved mirrors and lenses). We always assume that it is the case, but how do we know? In other words, how do we determine where the image of the object which is located on the principal axis is? Here are step by step procedures to prove this assertion. Notice that the key steps are drawing a secondary axis and using the idea of a focal plane. Both of those ideas are largely missing from many textbooks. Enjoy!

23.4 Qualitative analysis of lenses 729

FIGURE 23.17 Locating the image of the base of an object.



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Eugenia Etkina

Admin

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July 3

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This videos provides an amazing big picture of the role of physics in our life. There is nothing about technology, just nature and its existence. I think this short video can motivate many units in physics, astronomy, chemistry, and biology. But, as always, the base foundation of every single things is PHYSICS. That's why we love it...

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Eugenia Etkina

Admin

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July 5

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#modelsoflight

Hi @everyone! I spent a lot of time sharing interesting problems involving mirrors and lenses. It looks like we are done with geometrical optics, right? Not really. Historically, people were not satisfied with being able to figure out what glasses a person needs or how to build a telescope. They were wondering how to explain the observed behavior of light. And here is where two competing models come in. I attached a screen shot of the beginning of a section describing those competing models (not the whole section) and here I am asking you to think of what testing experiments (not involving small slits) we could do to rule our the particle model of light. Specifically, how do we test the consequence of the particle model that light should travel faster in glass/water than air? Read the attached text to see where this consequence comes from.

FIGURE 22.20 Newton's particle-bullet model of light.

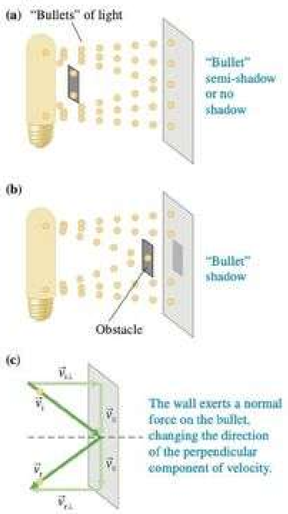


FIGURE 22.21 Explanation of light refraction using the particle-bullet model.

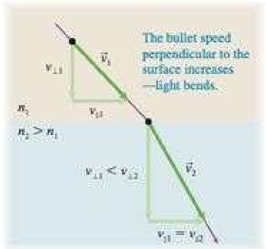
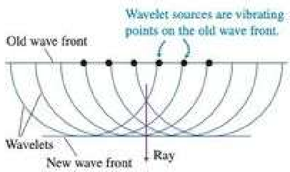


FIGURE 22.22 Wavelets produce a new wave front.



22.7 Explanation of light phenomena: two models of light

We have developed a ray model of light that describes the way light behaves. What other models can we use to explain the way light behaves?

Particle-bullet model

Isaac Newton modeled light as a stream of very small, low-mass particles moving at very high speeds, like bullets. According to this model, light bullets are affected by Earth's gravitational pull and move like projectiles, but since they move very quickly, their deflection from straight lines is not noticeable. Let us use this model to explain light phenomena familiar to us. We will start with shadows.

Imagine an extended light source such as a bulb sending light bullets in all directions from each point. If we place an obstacle close to the light source, bullets of light will still reach each part of the screen—the result will be a semi-shadow or no shadow (Figure 22.20a). If the obstacle is farther away, there will be a place on the screen where no bullets reach the screen—a shadow will form (Figure 22.20b). We can explain the reflection of light if we imagine that the bullets bounce elastically off surfaces. For the bullet model of light, the normal force exerted by a surface on the light bullets can only change the component of velocity perpendicular to the wall (because the acceleration of an object is in the same direction as the force exerted on it); the component parallel to the wall stays the same (Figure 22.20c). This is consistent with the law of reflection. Newton's particle-bullet model of light does successfully explain light propagation and reflection.

Can we explain refraction using this model of light? In order for the model to be consistent with Snell's experiments on refraction, the light bullets will have to speed up when they refract into a more optically dense medium (see Figure 22.21). The particle-bullet model suggested that the denser medium exerts an attractive force on the light particles, causing their speeds to increase. Accurate measurements of the speed of light turned out to be very challenging, and for many years the speed of light could only be determined in air or in a vacuum (it was found to be 299,792,458 m/s—about 3×10^8 m/s). In addition, the particle-bullet model requires an additional interaction between the surface and the light particles that causes them to speed up when entering the denser medium. Scientists prefer explanations that are as simple as possible. Another model of light that did not require this additional interaction was proposed.

Wave model of light

Simultaneously with Newton's development of the particle-bullet model of light, Christiaan Huygens was constructing a wave model of light. The motivation for the model could have come from the observations that light reflects off objects similar to the way sound reflects. Recall (from Chapter 11) that Huygens' wave propagation ideas involved disturbances of a medium caused by each point on a wave front producing a circular wavelet. Imagine that we have a wave with a wave front moving downward parallel to the page (see Figure 22.22). We choose six dots on this wave front, and from each dot we draw a wavelet originating from it (as shown in Figure 22.22). Each dot represents the source of a circular wavelet produced by the wave disturbance passing that point. According to Huygens' principle, each small wavelet disturbance produces its own circular disturbance that moves down the page in the direction the wave is traveling. The distance between two consecutive wavelets is equal to the wavelength. Now, note places where the wavelets add together to form bigger waves. These places are where the wave front will be once it has moved a short distance down the page. We also draw an arrow (a ray) indicating the direction the wave is traveling perpendicular to the wave fronts and consistent with the ray model of light propagation. In this model, the ray is the line perpendicular to the wave front.

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Admin

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July 6

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https://www.facebook.com/watch?v=868704810965834

#quasiparticles

Hi all Exploring and Applying Physics people! I was going to continue our discussion of models of light today but I stumbled upon this cool video that helped me visualize something that I learned about over 40 years ago in my solid state physics course. These are phonons. No, I did not make a typo. I mean PHONONS not PHOTONS. If you are not familiar with them - watch, if you are - watch too, as you will have a different image of those amazing particles that mathematically explain how thermal energy and other energies travel inside solids. Phonons are a tiny part of this short video, just one sentence, but try not to miss it. The video also has other treasures. Watch!

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Eugenia Etkina
Admin
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July 7

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#modelsoflight #WELCOMENEWMEMBERS

Hi @everyone, two things today - Welcome to our new members - see the list and guidance below and how the refraction of light cannot be explained by particle bullet model of light; that the consequences of the model are for refraction and how to test those. I will start with the second part.

In my post 2 days ago I showed how the particle bullet model of light can explain both reflection and refraction. However, one consequence of this model in the explanation of refraction is that light in a medium other than air SHOULD TRAVEL FASTER. If you do not remember how the model leads to this crazy idea, please see my post from the day before yesterday. At the time when this model was popular, there was no way to measure the speed pf light in water or glass, so this consequence went untested Armand Foucault measured it in 1849. The speed of light in air was determined by Ole Romer in 1670 using astronomical methods. As you know, the famous experiments that could only be explained by the wave model of light (Young's double slit - 1801, and Fresnel's single slits - 1820) were conducted much earlier, so nobody cared that the speed of light in water was LESS than in air when Foucault measured it - I mean for the battle of two models, as the wave model became dominant before, so no one was surprised. However, when our students are learning, they can test this consequence for the speed of light in water right away if they use a device called a laser distance meter used in construction. This simple (relatively) simple device (costs about $20) sends a laser pulse to an obstacle and using the delay of the returned pulse determines the distance to the obstacle. It is calibrated for light traveling in air. So, if you send the pulse through a transparent container with water and put an obstacle on the other end, the measurement of the size of the container will come our WRONG! Will it be more or less than the real one? What do you think the particle bullet model predicts?

Now, it is important to remember that we are talking about MODELS of light. Therefore I always caution people from talking about light as a wave. It is not a wave. Wave is one of the models of light (and a model means simplification) that can explain SOME behaviors of light in SOME circumstances but cannot explain many phenomena concerning light. So

light is not a wave. It just sometimes behaves like a wave. And sometimes - does not...
Now, let's welcome our new members! If you just joined the goup you would see a message about what to do to benefit from the group. Please follow it closely and study what ISLE is at https://www.islephysics.net/. This group is for those who wish to learn about the ISLE approach and implement it in their classrooms (high school or college). We have tons of free resources and a textbook that follows this approach. The website will help you learn about all of those. Browse it slowly. And Welcome!
https://www.facebook.com/groups/320431092109343/posts/1445408709611570/?__cft__[0]=AZXpNob_-sIJskSlJWI63MgqAAPgeGZ4FMZVpIojy53UiHO_liTMN--YPLU1a8Am4wNSShJlaz_jzoCwYT8bkyM8oB-6AXuzBJZdZ2Prsn07_hjeTl4ZQB9f8LFV0QyI9pNKVqzmuTRGsXy08kvmmL5HkSaeBr7Tit8I00LqLQsc4-ReMF6xXsRvYLZEmKZihQI&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
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July 8
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#wavemodeloflight
Hi @everyone! Yesterday I discussed the experiments of the speed of light in different media that rejected the particle bullet model of light. I also talked about the fact that the experiments that that model could not explain were conducted earlier. Those are interference and diffraction experiments. Those experiments and related mathematics are in Chapter 24 of our textbook. Today, I would like to show you how we approach this chapter in the Instructor Guide. Reminder: to prepare your lessons using our materials, you first read the relevant chapter of the textbook, then read the Instructor guide chapter, and then do the activities in the ALG. This is not the sequence for students, only for teachers.
So, here is the beginning of the Instructor Guide for chapter 24. Notice the elements of this introduction: a general summary explaining the language that we use, conceptual goals of the chapter (procedural goals are in the

Introduction to the whole book), a list of non-traditional problems and a discussion of student difficulties. These elements are in every chapter. What will follow is the discussion step by step how to help student achieve the goals and overcome the difficulties; what activities to use, what problems to assign, etc. I am also attaching the intro page to this chapter in the textbook, so that you can see possible "Needs to Know" for this chapter.

Chapter 24 Wave optics

In Chapter 22, the first chapter on optics, students learned that observable light phenomena can be explained using the ray or particle-bullet models of light and assuming that light behaves in a similar way to a wave. However, we did not resolve the issue and continued to study mirrors and lenses using a particle model of light (represented by light rays). In this chapter, students will learn about experimental evidence that cannot be explained by the particle-bullet model and start building the wave model of light.

We focus on interference and diffraction in this chapter and do not touch on the polarization of light, which is covered in the following chapter (Chapter 25, Electromagnetic Waves). Notice there is a slight change of language here—we do not use the term diffraction grating but instead call the gratings interference gratings, or sometimes just gratings. The reason for this is that in the book we are treating each slit in a grating as infinitely narrow. This simplifies the analysis to the interference (superposition) of simple circular waves, avoiding complications that result from taking into account the diffraction on finite-width slits. To emphasize this, we do not use the term diffraction grating but instead call the gratings interference gratings. We use the term diffraction to describe the pattern obtained when light is incident on a single slit. When we study diffraction, the slits are not considered infinitely narrow. We discuss the interference of light produced by different parts of the same slit. Because this model is not applicable to the grating (where light that passes through different slits interferes on the screen), we do not call it a diffraction grating.

Content-based learning goals of the chapter are listed below.

Students should be able to:

1. “Read and write” with wave fronts and rays.
2. Use Huygens’ principle to explain interference and diffraction phenomena.

3. Apply the superposition principle to explain interference effects.
4. Analyze qualitatively and quantitatively situations involving laser light passing through two slits, one slit, multiple slits, gratings, and thin films. Identify path length difference and phase difference.
5. Determine resolving power of optical instruments, including eyes.
6. Design an experiment to determine the slit separation in a double-slit experiment.
7. Design an experiment to determine the slit width in a single-slit experiment.
8. Design an experiment to determine the wavelength of different colors of light using a grating.
9. Design an experiment to determine the number of slits per mm in a grating.
10. Apply knowledge of wave optics to explain and analyze technological and biological applications.

Nontraditional end-of-chapter questions and problems

Evaluate (reasoning or solution…) (EVA): Q24.17, P24.27, P24.28, P24.62

Make judgment (MJU): Q24.12, Q24.13, P24.19

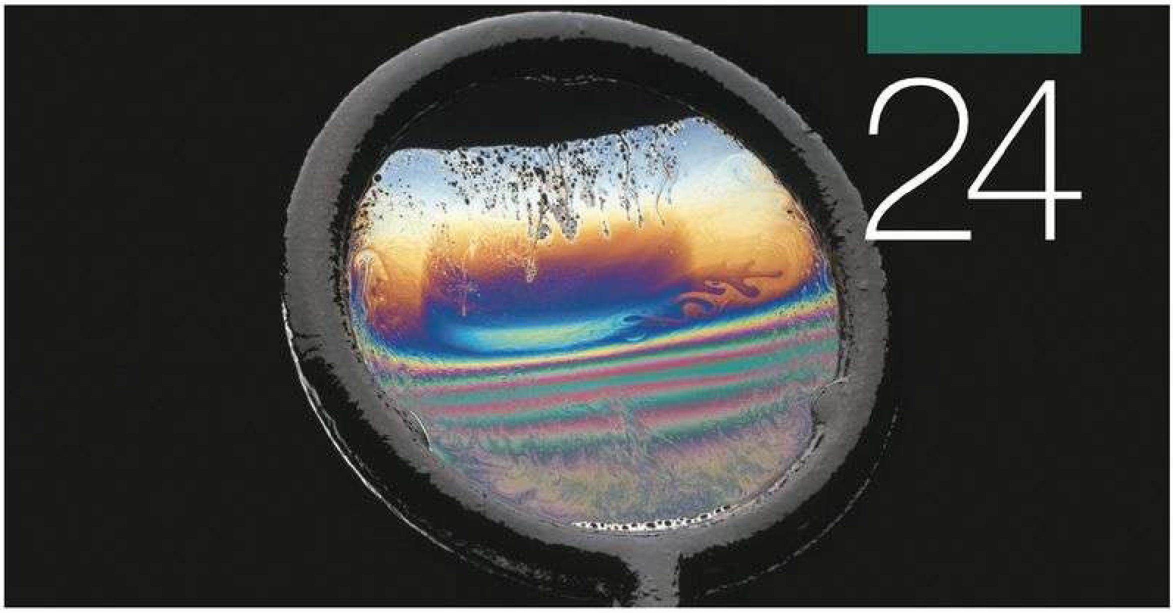
Multiple possibility and tell all (MPO): Q24.24, P24.2, P24.4, P24.18, P24.38, P24.39, P24.46, P24.47, P24.50

Design an experiment (or pose a problem) (DEX): Q24.10, P24.2, P24.14, P24.49

Problem based on real data (that students can collect by themselves) (RED): P24.17, P24.45, P24.62, P24.67

Brief summary of student difficulties with wave optics

The biggest conceptual difficulty that comes from instruction is when students think that light is a wave after working through the material in this chapter. They need to distinguish between the phenomenon and the model. A wave is just one model of light phenomenon. One of the difficulties is moving between representations such as rays and wave fronts, another one is reconciling the mathematical description of double slit interference with the qualitative analysis and not connecting the waves language with the phenomenon (how does the interference maximum or minimum look in the real world?). A question that shows how good this reconciliation is, is when students have to decide how a certain change (slit separation, wavelength) will affect the total number of maxima that appear behind the grating. A major difficulty is considering the effect of a slit on a passing wave – what will happen to the interference pattern if one of the slits is covered? If a part of both slits is covered? Remembering that the frequency of the wave is determined by the source and the speed is determined by the medium and not by wavelength is also a challenge. Visually distinguishing the effects of diffraction on a slit (bending of light around it) and interference due to multiple slits is difficult unless students have seen the interference/diffraction pattern on a screen and analyzed their observations.



Wave Optics

Soap bubbles display a remarkable array of colors. Watch a bubble hanging from a bubble wand, and you will see horizontal bands appear on its surface and repeatedly change colors. The bands of color on the top of the bubble will widen until a dark band takes their place—and then the bubble pops. In this chapter you will learn why soap bubbles display such brilliant colors and why those colors disappear just before the bubble pops.

- **Why do we see colors in soap bubbles?**
- **Which best explains the behavior of light: the particle-bullet model or the wave model?**
- **What limits our ability to perceive as separate two closely positioned objects?**

IN OUR CHAPTER on reflection and refraction (Chapter 22) we developed two models of light: a particle-bullet model and a wave model. The particle model predicted that the speed of light in water should be greater than in air; the wave model predicted the opposite. Eventually, in 1850, Hippolyte Fizeau and Léon Foucault established that light travels more slowly in water than in air, finally disproving the particle model. However, even before Fizeau and Foucault, the wave model was gaining wide acceptance because of experiments performed by Thomas Young in the early 1800s.

BE SURE YOU KNOW HOW TO:

- Draw wave fronts for circular and plane waves (Section 11.1).
- Relate wave properties such as frequency, speed, and wavelength (Section 11.2).
- Apply Huygens' principle and the superposition principle (Section 11.6).

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Eugenia Etkina
Admin
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July 10
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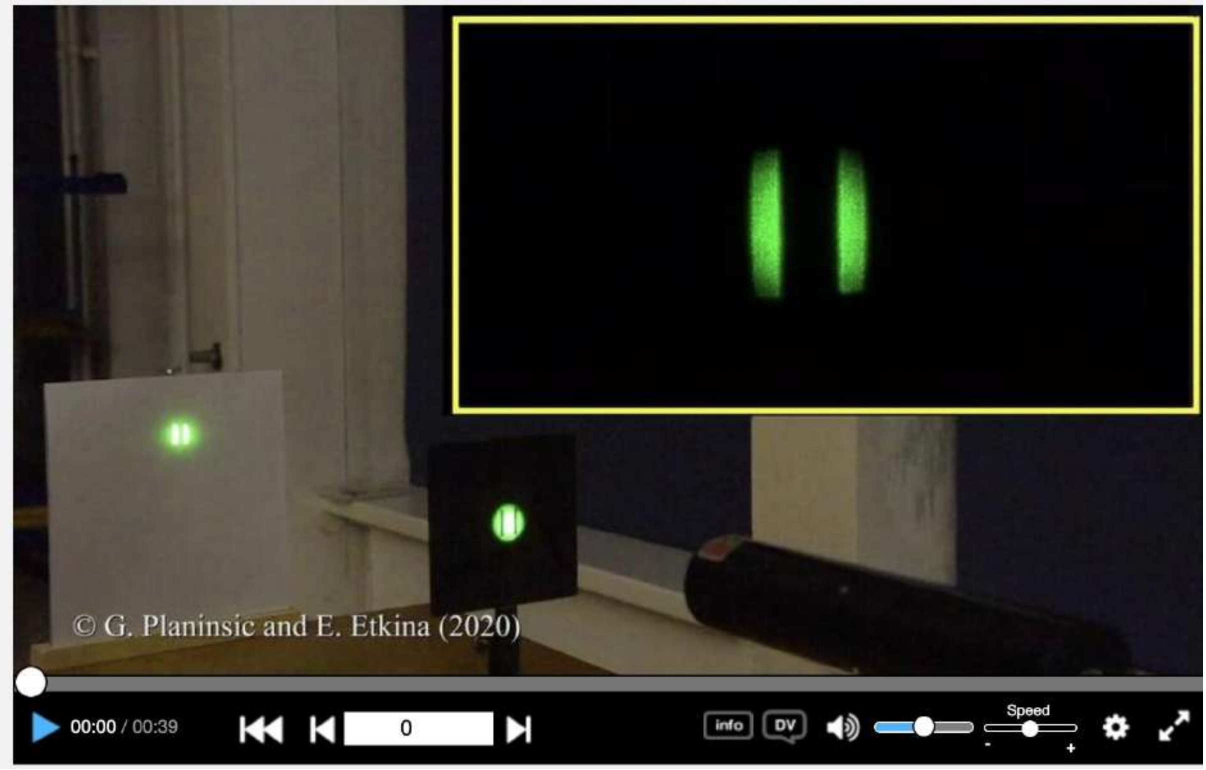
#modelsoflight
Hi @everyone, I continue with the experiments that help students devise the wave model of light. This is the famous Young's experiment but done very cleverly with a laser. To reproduce it in your classroom, you will need a beam expander to widen the laser beam so that is can go through wide slits separated by clearly visible distance. We treat is as an observational experiment for the students to come up with the idea that the behavior of light can be explained if we assume that it is similar to a wave. However, to come up with this idea, they should be familiar with the Huygens principle from mechanical waves, so do not skip it teaching mechanical waves. Here is the activity.
24.1 YOUNG'S DOUBLE SLIT EXPERIMENT
OALG 24.1.1 OBSERVE AND EXPLAIN
a. In the following video https://mediaplayer.pearsoncmg.com/.../sci-OALG-24-1-1observe laser light first shining on two wide slits and then on two narrow slits.
b. Draw a careful sketch of what you observe on the screen in both experiments. Compare and contrast the results. Can the outcomes of these two experiments be explained using the particle-bullet model of light? The wave model of light?
c. Use Huygens' principle that you learned in Chapter 11 to explain the pattern on the screen in the second experiment with narrow slits. Is it possible for bullets to arrive at the same location and cancel each other?

Is it possible for two waves to arrive at the same location and cancel each other?
d. Read and interrogate text on pages 752-753 in the textbook and compare the textbook explanations with yours.



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Eugenia Etkina
Admin
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July 11
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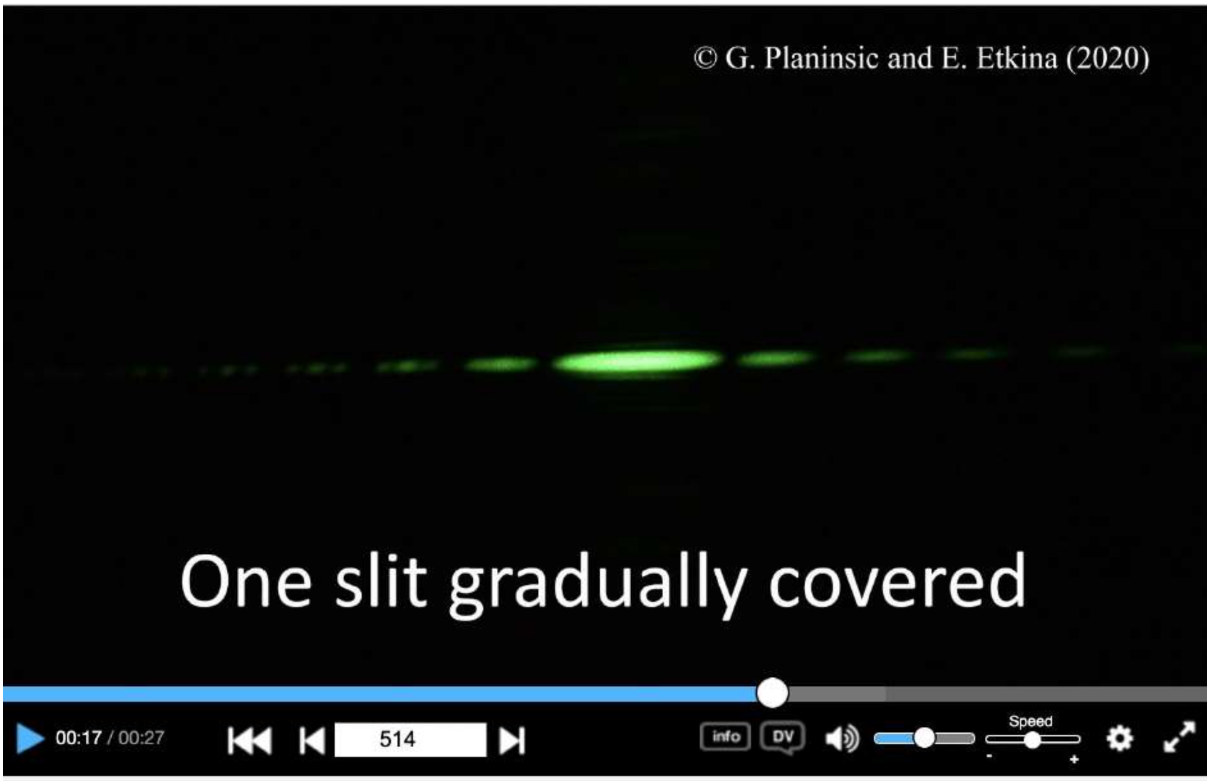
#wavemodeloflight
Hi @everyone ! I continue with the wave model of light. If you watched the video in my post yesterday or are familiar with the pattern produced by

laser light going through two narrow closely positioned slits, you remember that in addition to closely spaced bright and dark spots you see another pattern - the wider bright bands separated by dark bands. It looks like the first pattern is "inside" the second. When we ask our students to explain the double slit pattern, we ignore this "larger" second pattern. But why is it there?
You can use it as the future "need to know". To explain the narrow bands the students use the idea of interference of the waves created by the slits (Huygens principle) assuming that each slid is so narrow that is acts as a point like source. When the slits are very narrow, this assumption works and the explanation of the double slit pattern can be experimentally tested (see the OALG file for Chapter 24, Section 1, posted here)
Once the students have constructed this classic double slit explanation, they are ready to focus on the second pattern that they ignored before. I am pasting the activity and the beautiful video done by Gorazd Planinsic.
OALG 24.5.1 OBSERVE AND EXPLAIN
In previous activities involving two or more slits, we used very narrow slits and considered them to be point-like wave sources. In the following video one of the two slits in a double slit experiment is slowly covered https://mediaplayer.pearsoncmg.com/.../sci-OALG-24-5-1. Observe the changes in the patterns on the screen and suggest an explanation. Hint: what would a pattern look like if each slit were infinitely thin as we assumed in al previous experiments?



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Eugenia Etkina
Admin
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July 13
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#applicationexperiments
Hi @everyone! I usually post about the processes that help student construct and test physics ideas. This process is at the heart of ISLE. However, there is another aspect of the ISLE approach that is very important. And it is reflected in the name of our Facebook group and in the title of the textbook where the ISLE approach is implemented. You guessed right - it is the APPLICATION part. As you remember, we group

all experiments that students perform or observe into 3 groups - observational (help students develop explanations and models), testing (help students test the explanations and models that they have created) and application (help students apply developed ideas to solve practical problems) (reminder: we do not use the term DEMOS - why?). The application experiments not only provide the students connections to real world and allow them to combine several tested ideas that they have created themselves, but also provide connections to the engineering. If you are a US physics teacher, you know how important it is to provide these connections according to the NGSS (Next Generation Science Standards). Below is an example of the application experiment in wave optics. If you have done wit with your students, please share their designs! Note: in the ALG and OALG the Application experiment activities have a title Design and Experiment. You can use them for labs.
DESIGN AN EXPERIMENT
You have probably noticed that stars have different colors—some are white, some are yellowish, and some are reddish. Does this mean that stars of a red color do not emit any blue light? Astronomers use an instrument called a spectrograph to analyze the color composition of starlight. The central mechanism of a spectrograph is a grating. Work with your group mates to design a simple version of a spectrograph, an apparatus that will allow you to separate different colors of light emitted by a lamp on your desk (that emits light very similar to the light emitted by many stars) and will also allow you to measure the wavelengths of these different colors. Draw a picture of the apparatus and explain how it works. Then use equipment on your desk to build the device and use it to study the spectra of two sources provided by the instructor. After you investigated the spectra, prepare to share your designs and findings with the rest of the class.
Please do not forget to like or comment on the post to make it more visible.

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Eugenia Etkina
Admin
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July 14
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#whatmaterialstogivetostudents
Hi @everyone! Yesterday I posted an application experiment for wave optics and Divine Elbo asked an excellent question: are the students limited to the materials that we give them or can they use anything they want? I responded to his question in yesterday's post for that specific experiment, but today I want to talk about this question in general. Should we tell the students what materials they can use when they are designing an experiment with a specific goal or let them choose?
A study that we did a long time ago shows that if we tell them exactly what is available, they might try to design an experiment to use all of those materials and basically turn the activity into searching for the "right answer". So, giving the list on hand is narrowing the task but on the other hand is removing the creativity from the process. The former is good when we are short on time, but the second is problematic as one of our goals is to unleash creativity.
So, here is my suggestion: when the experiment is relatively straightforward and there is only one basic way to do it , then provide the students with the list of equipment. If the experiment allows for many different approaches, provide the most technical part and let them ask for the rest. And sometimes, do not give any lists just tell them to come and ask for whatever they need.
The paper with the study about affordances and constraints of the lists of equipment is attached.
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Eugenia Etkina
Admin
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July 15
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#youcannotprovenanythinginphysics
While the author of this video is not my favorite (as he approaches learning from a misconception view point), this video gets at the heart of the ISLE process - disproving wild ideas is science, looking for evidence to support them, is not. That is why claim-evidence-reasoning approach is not really scientific. Watch it, it's very useful.

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Eugenia Etkina
Admin
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July 16
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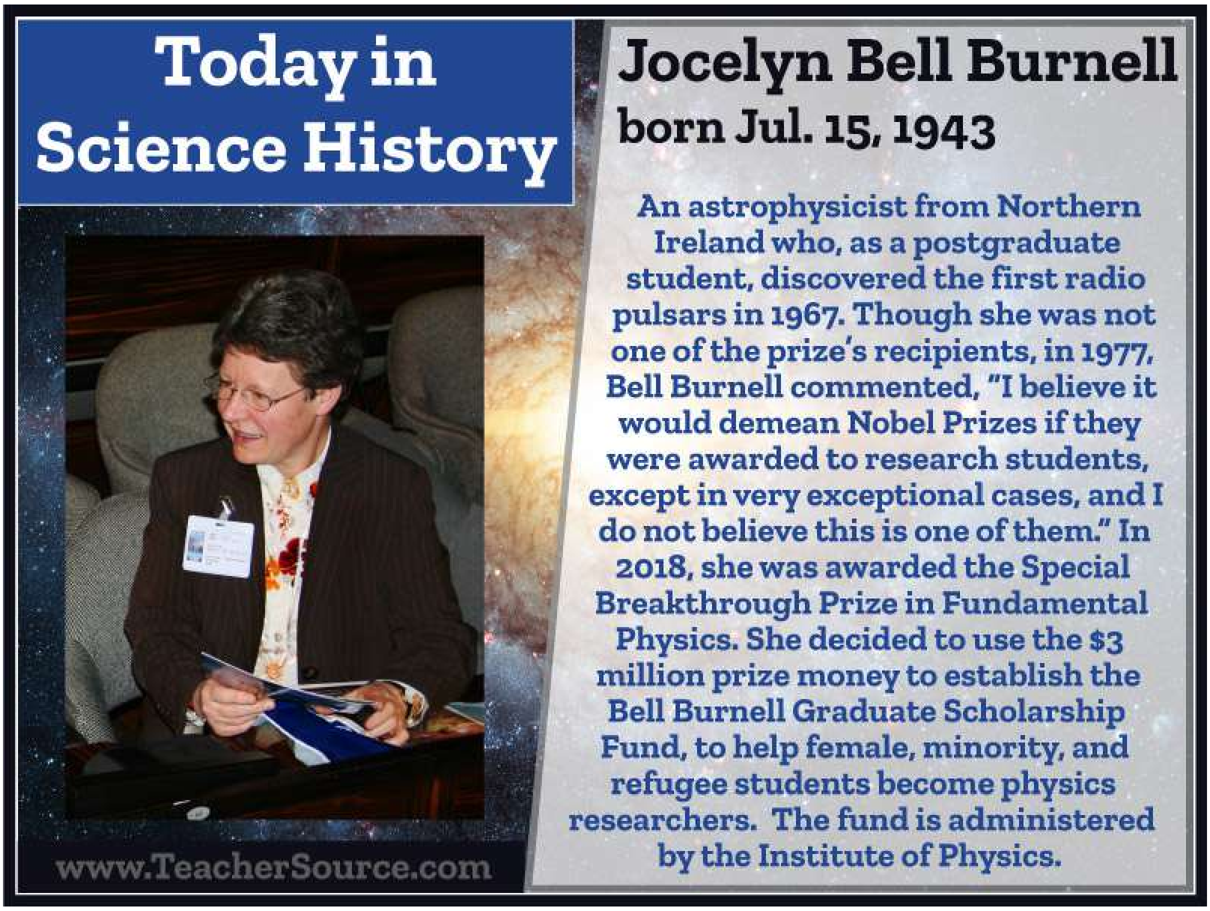
#womeninphysics
And here is another woman who did not get the Nobel prize she totally deserved. I remember the time when pulsars were discovered as my father was a radio physicist and he talked about them when I was a little girl. At that time there was no explanation and he used the term that I remember forever - little green men. The fast pulsating signals were thought to be produced by intelligent life. A lot of physics was needed to explain the mysterious oscillations but the fact that we knew that they existed was due to a graduate student - Joselyn Bell. Read more about her and you will be very impressed by this woman.



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Eugenia Etkina
Admin
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July 17
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#wavemodeloflight
Hi @everyone! We have been discussing how to help our students construct the wave model of light. Imagine, that they have learned everything in Chapter 24 and are familiar with interference, diffraction, resolving power, etc. - all of the phenomena that can be explained is we assume that light behaves like a wave. But what is waving in this wave? To answer this question, the students need to learn about another property of light - polarization. It is polarization that made people come up with some wild ideas about what is waving in the light wave. Because light turned out to be possible to be polarized. And only transverse waves can be polarized. But transversed waves can only propagate in solids as they require sheer deformation. But light propagates in a vacuum. Which means that vacuum is in fact full of a solid material which is weightless and invisible BUT behaves lie a solid. If anything is more wild than this idea, I don't know. But it is all a true story and the solid was called ETHER. So, are you ready for the exploration of polarization? Here are activities from the Active Learning Guide, Chapter 25.

Chapter 25

Electromagnetic Waves

25.1 Polarization of waves

25.1.1 Observe and find a pattern

PIVOTAL ***Class or lab:*** *Equipment per group:* a Slinky.

Several experiments involving traveling waves on a Slinky are described below.

a. Construct a sketch for each experiment. The outcome is shown in the right column.

Experiment	Sketch	The outcome
A Slinky rests on its side on a table. One end is held off the edge of the table. The Slinky is shaken left to right, parallel to the table. Make a sketch of the process.		The pulse continues across the table.
The same as above except the Slinky is shaken up and down, perpendicular to the table.		The pulse does not continue across the table.
The same as above except the Slinky is shaken forward and backward, along the direction of the Slinky.		The pulse continues across the table.
The same as above except part of the Slinky on the table passes through a tube. The Slinky is shaken forward and backward, a longitudinal pulse.		The pulse continues across the table.

b. Devise a rule or rules that describe the pattern of conditions under which the pulse can continue across the table.

25.1.2 Test an idea

PIVOTAL ***Class or lab:*** *Equipment per group:* an incandescent lightbulb that can be plugged into a socket, and two polarizers.

Light is either a transverse wave or a longitudinal wave. Several experiments that test these two hypotheses are described below. The experiments make use of a polarizer, a device made from material that prevents light waves from passing through if something in the wave is vibrating perpendicular to the axis of the polarizer.

a. Make predictions, based on each of the two hypotheses, about the brightness of the light once it has passed through the polarizer(s).

Experiment	Prediction if light is a transverse wave	Prediction if light is a longitudinal wave	Outcome
Light from a lightbulb shines on a polarizer and its brightness is detected on the other side.			The light reaching the other side of the polarizer is significantly dimmer.
The same as above except the polarizer is slowly rotated.			The light reaching the other side of the polarizer is significantly dimmer and does not change as the polarizer is rotated.
Light from a lightbulb shines on a polarizer. A second polarizer is positioned behind the first one. The second polarizer is slowly rotated relative to the first.			The light is dimmer overall but also fades in and out (depending on the angle) completely as the second polarizer is rotated.

b. Make a judgment about each of the two hypotheses. Which (if any) of them are disproved by these experiments?

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Eugenia Etkina
Admin
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July 18
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#electromagneticwaves

Hi all Exploring and Applying Physics people! Two things today - I will continue with what waving in the light wave and we welcome our new members - the list is below.

First - light and waves. Light is not a wave. We actually do not know exactly what it is but we know that sometimes it behaves like a wave. When we use the word "like" talking about something, we acknowledge that we are using an analogy, not meaning that two things are the same.

For example, when we say that electric current behaves similar to flowing water in some situations, we are very clear that electric current IS NOT water, but we can use our knowledge of water to explain and predict some of the phenomena involving electric current (and some we cannot explain). The latter part of the sentence is crucial for understanding the limitations of analogies. Notice when we say current flows, we do not use "like", we speak about current metaphorically as a fluid. From the analogy as a cognitive device we moved to a metaphor as a figure of speech. Do you see the difference?

The same is true for light. As long as we keep "LIKE" talking about it having wave-like properties, we acknowledge that in some cases the wave analogy for light might not work. It is very important to keep this in mind.

Now, let's move to what is waving in that wave model of light. We know that it is not material, or substance or any "stuff" (unless you want to bring up ether, whose existence was disproved by the experiments by Michelson and Morley in 1886) as it can b e polarized (see my post form yesterday). But even before those experiments, the work of James Maxwell in 1861 showed that there is a possibility of a transverse wave moving in a vacuum without ether. That wave was a wave of changing electric and magnetic fields. How did he do it? Where do famous Maxwell–Heaviside equations come from? To understand the story, you need to first go back to Chapter 21, last section, that summarizes what people knew about electric and magnetic fields before Maxwell. Then proceed to reading the screenshot that I posted here. And please post comments or just like this post to make it more visible. Thank you.

in a vacuum. We know from our study of electromagnetic induction (Chapter 21) that Michael Faraday introduced the concept of a field and the relationship between electric and magnetic fields. According to Faraday, *a changing magnetic field can produce an electric field*. Subsequently, in 1865 Maxwell suggested a new field relationship: *a changing electric field can produce a magnetic field*. This idea was motivated by a thought experiment devised by Maxwell in which he imagined what would happen in the space between the plates of a charging or discharging capacitor. He suggested that the changing electric field between the capacitor plates could be viewed as a special nonphysical current, but one that would still produce a magnetic field (**Figure 25.3**). This magnetic field was first detected in 1929 but not measured precisely until 1985 due to its extremely tiny magnitude. Maxwell summarized this new idea and other electric and magnetic field ideas mathematically in a set of four equations, now known as Maxwell's equations. The equations are written using calculus, but we can summarize them conceptually:

1. Stationary electric charges produce a constant electric field. The $\vec{E}$ field lines representing this electric field start on positive changes and end on negative charges.
2. There are no individual magnetic charges (magnetic monopoles).
3. A magnetic field is produced either by electric currents or by a changing electric field (Figures 25.3 and 25.4a). The $\vec{B}$ field lines that represent the magnetic field form closed loops and have no beginnings or ends.
4. A changing magnetic field produces an electric field. The $\vec{E}$ field lines representing this electric field are closed loops (Figure 25.4b).

FIGURE 25.3 A changing electric field produces a magnetic field.

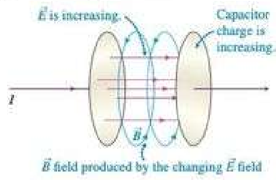
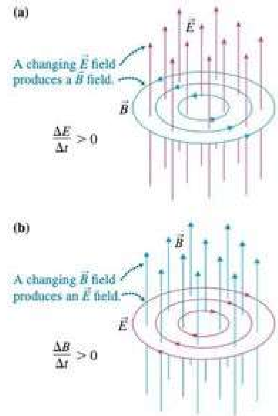


FIGURE 25.4 Changing $\vec{E}$ and $\vec{B}$ fields produce $\vec{B}$ and $\vec{E}$ fields.



Producing an electromagnetic wave

Maxwell's equations had important consequences. First, the equations led to an understanding that a changing electric field can produce a changing magnetic field, which in turn can produce a changing electric field, and on and on in a sort of feedback loop (**Figure 25.5**). This feedback loop does not require the presence of any electric charges or currents. Maxwell investigated this idea mathematically using the four equations, and to his surprise he found they led to a wave equation similar to Eq. (11.4) in which the electric and magnetic fields themselves were vibrating. The speed of propagation of these waves in a vacuum turned out to be a combination of two familiar constants: $v = (1/\sqrt{\epsilon_0\mu_0})$, where the constants $\epsilon_0 = 8.85 \times 10^{-12}\,\mathrm{C^2/N \cdot m^2}$ and $\mu_0 = 4\pi \times 10^{-7}\,\mathrm{N/A^2}$ relate to the electric and magnetic interactions of electrically charged particles in a vacuum. The constant ϵ_0 is the **vacuum permittivity** and is related to Coulomb's constant k_C through the relationship

$$\epsilon_0 = \frac{1}{4\pi k_C}$$

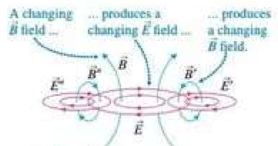
(See Chapter 17 for more on vacuum permittivity.) The constant μ_0 is the **vacuum permeability**. We discussed vacuum permeability in the chapter on magnetism (Chapter 20). When Maxwell inserted the values of the constants into the expression for the speed of electromagnetic waves, he obtained

$$v = \frac{1}{\sqrt{\epsilon_0\mu_0}} = \frac{1}{\sqrt{(8.85 \times 10^{-12}\,\mathrm{C^2/N \cdot m^2})(4\pi \times 10^{-7}\,\mathrm{N/A^2})}}$$

$$= \sqrt{9.00 \times 10^{16}\,\frac{\mathrm{N \cdot m^2 \cdot A^2}}{\mathrm{C^2 \cdot N}}} = \sqrt{9.00 \times 10^{16}\,\frac{\mathrm{m^2 \cdot A^2}}{\mathrm{A^2 \cdot s^2}}} = 3.00 \times 10^8\,\mathrm{m/s}$$

At the time Maxwell did this calculation, the speed of light in air had already been measured and was consistent with this value. Could it be that light is an electromagnetic wave? This was the second testable consequence of Maxwell's model. *If* the relationship between the changing electric and magnetic fields suggested by the model is correct, *then* a change in either of these fields could generate an electromagnetic wave

FIGURE 25.5 The changing $\vec{B}$ and $\vec{E}$ fields can spread without any charges or currents.



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Eugenia Etkina

Admin

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July 20

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#labsinISLE

Hi @everyone! I continue the discussion that was started yesterday by Kateryna Kushnir. It is important to stress that in the ISLE approach there is NO separation of student learning into "theory" and labs. Student learning is one continuous process as was said by David Brookes. It starts with them observing new phenomena (could be done in a lab), finding patterns (could be done in a lab), devising explanations, designing experiments to test those (could be done in a lab), revising and improving explanation (could be done in a lab), and applying new ideas for all kinds of problem solving (some of it could be done in a lab). Therefore, lab work is an integral part of learning physics, not an add on after students got the theory portion in lecture, class, lesson, etc. The students are the creators of models, hypotheses, explanations and thus the labs are not verification or application of something that somebody told them but a natural part of the construction of physics knowledge THE SAME WAY as physicists do it. In physics there are people who are experimentalists and people who are theorists. In old times those two kinds were usually the same person (Galileo was both). But now those two kinds of physicists work together to produce the knowledge that our students have to reconstruct. Only in the ISLE approach we want them to play both roles working in groups to experience the true nature of physics. NGSS tell us that science practices should be integrated into the learning of disciplinary core ideas and cross cutting concepts. The ISLE approach shows you HOW to do it and provides materials to help you guide your students in the classroom. The hard part is to navigate the myriad of those materials. This is exactly what the purpose of this group is. That is why I run monthly workshops for each unit of the physics course, and that is why we have introductory workshops in the summer. This summer, there are 3: the weeklong at Rutgers (happened in early July), an 8-hour long at the AAPT - just happened, and an 8-hour long that is to happen tomorrow and on Saturday. If you wish to learn how to implement the ISLE approach, please read all posts, pose questions here, attend the workshops, and if all this is not enough, send me an email at eugenia.etkina@gse.rutgers.edu

And of course, use https://www.islephysics.net/ and the FILES posted here.

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Eugenia Etkina
Admin

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July 24 at 9:21 PM

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Hi all! Two things today: First, we have a huge influx of new members and we would like to welcome them. Welcome!!! Please make sure you follow instructions in the message that you received when you first logged into the group to learn what the group is about and how to use it. Most importantly, visit https://www.islephysics.net/ and explore ALL TABS, and second, try to check messages posted here every day.
Second, I would like to ask all of you if you think that our workshops in the coming school year should again start from kinematics and go on chapter by chapter or address the chapters that we did not have time to start this year - kinetic molecular theory, thermodynamics, etc. What do you think? My intention is to start from kinematics again, but I would welcome your ideas, please comment! And again - welcome to our new members!

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Eugenia Etkina
Admin
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July 26 at 7:02 AM
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Hi all, this is the message to welcome our new members. We had a huge influx in the last couple of days and I saw that many of those who requested access and were accepted think that this is a group for Modeling Instruction. It is not. This group is for those who wish to learn and implement the Investigative Science Learning Environment approach to learning physics (short ISLE, please see islephysics.net to learn more). While ISLE is compatible with modeling instruction and many aspects are similar, it is not Modeling Instruction. It differs from MI in the process that students use to construct knowledge, in the reasoning that students develop and how they develop it, in different representations that are used and in different approaches to assessment. The MI and ISLE are complimentary but not the same. This said, we love to have you here and hope that you will combine your knowledge of MI and the new knowledge of ISLE to help your students learn to think like physicists and fall in love with physics.
Welcome, our new members!
Please investigate all table on islephysics.net website and contact your Pearson rep to get a copy of College Physics: Explore and Apply (AP Edition) to teach AP 1 and 2 and honors physics. It comes with free Active Learning Guide, Online Active Learning guide, Instructor Guide and about 400 freely available physics experiment videos at https://media.pearsoncmg.com/aw/aw_etkina_cp_2/videos/

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Eugenia Etkina
Admin
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July 29 at 3:46 PM
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#kinematicsworkshop
Hi all Exploring and Applying Physics people, I made a typo in my yesterday's post, I wrote September instead of August. It is August 12, 9 am US West coast time, 12 pm East coast time and 6 pm Central European time. If you plan to attend the workshop, there is homework to do. Starting now will give you enough time to prepare. You will need to know the foundations of the ISLE approach, how we start the first day of class, and how to teach your students interrogate scientific texts. I am attaching the shortest paper about ISLE here, and I invite you to read the Introduction chapter of the Instructor guide posted here in the FILES. In my next post (on Monday) I will provide you with more information how to prepare. Even if you cannot attend the workshop on zoom, we will post the recording and link to the slides, but to understand the reasons why we do things the way we do and how your students will benefit from them you need to know how ISLE works. Thank you. I will create an even for the workshop tomorrow and you will be able to sign up.

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Eugenia Etkina
Admin

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July 30 at 3:35 PM

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##kinematicsworkshop

Hi all Exploring and Applying Physics, I created an event for the kinematics workshop, please sign up. August 12. The start time is 9 am Pacific coast time, noon East coast time, 6 pm Central European time. The length is 1.5-2 hours depending on the questions.

As I wrote yesterday, you need to be familiar with the ISLE approach to benefit from the workshop. Yesterday, I posted the first paper to read about it, today I will post the second paper (I cannot attach it to this post). Those two will give you an idea of what we do and how ISLE is different from other approaches. It has a unique philosophy regarding two things:

1) HOW students LEARN physics (by systematically engaging in the processes that mirror scientific practice; and when I say systematically, it means for EVERY concept that they are learning with the full support of developed curriculum materials) and

2) How students FEEL about their learning (by creating conditions for the students to feel capable, developing growth mindset, the feeling of belonging in physics, developing their creativity and curiosity; and belonging to a community of learners; all this is done again through a set of carefully crafter curriculum materials and classroom settings). Please read the papers and pose questions here. We have multiple ISLE experts in the group who have been implementing ISLE for years with different audiences and they have a wealth of experience that they will share with you. Please ask questions!

The attached photo shows the community of learners in the course taught by David Brookes. Notice how everyone is participating in the discussion lead by a group of students - you can see the same engagement in scientific seminars. They all just finished working on a problem and one group is presenting their solution. Look at the tilt of bodies and gestures of the audience.

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Eugenia Etkina
Admin

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July 30 at 3:36 PM

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And here is the second paper to read about the ISLE approach.

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Eugenia Etkina
Admin
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July 31 at 7:28 PM
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#startingtheschoolyear
Hi all Exploring and Applying Physics, starting school year using the ISLE approach is an important step and we usually do a lot of it in our workshops - we just practiced the beginning of the school year in our 2 - day ISLE workshop here on line and in two workshops help in person. But I am sure there are many members who were not able to attend and did not have experience with how to start the school year using ISLE. WARNING: LONG POST. PLEASE BE PATIENT.
Make sure that your classroom from the beginning looks like collaborative space - tables for group work, white boards there, equipment if needed, etc. The students will take seats randomly, do not worry about it, the groups of 3-4 are perfect. This environment will send them the message of what learning physics looks like.
When you have the first lesson, do not start with the rules of the classroom, syllabus, or anything like that. Start with the activity that we call 10 TVs, 10 tennis rackets, 12 cameras, or whatever you might have at home that needs explaining. Do it right away after the lesson starts. Activities are described in the OALG and ALG Chapter 1 and in the textbook in Chapter 1. I am pasting both activities here and the discussion in the Instructor Guide to help you see what I mean by this activity. Note, that at the end of the discussion, the students will not know why Miha has those 10 rackets. They will only be able to rule out some reasons but never prove anything. The next activities will let them see that finding an answer is possible.
After the students have done the first activity choose either the Wet Glass activity from the ALG/OALG or the Balloon activity. DO NOT DO BOTH, AS IT TAKES A LOT OF TIME. CHOOSE ONE.

Then ask them to reflect on the process through which they figure out where the water on the glass came from or what made the loud sound of a poked balloon. Guide them through the process of observational experiments-patterns- hypotheses - designing experiments to test hypotheses-making predictions of the outcomes based on the hypotheses-running the experiments and comparing the outcomes to the predictions, and ruling out some of the hypotheses.

Finally, let them know what this process is what physicists use to create knowledge and they would use it all the time too, and thus they will experience what it is like to MAKE physics.

Please ask questions about each step! Thank you!

OALG 1.1.1 OBSERVE, EXPLAIN, AND TEST YOUR IDEAS

Watch the video at https://mediaplayer.pearsoncmg.com/.../_fr.../sci-OALG-1-1-1.

a. Come up with at least 3 explanations (crazy ideas) for why the person living in this house has 12 cameras.

b. Make a list of the explanations. How can you decide which one is correct? You can conduct additional experiments but you cannot talk to the person. Describe the experiments you plan to perform.

c. What outcomes of these experiments might convince you that certain explanations (or all of them) are not correct?

d. Read subsection “The process for devising and using new models” on pages 3-4 in the textbook and compare what you planned in parts b and c with what is described on these pages. Do you think there is a way to know with absolute certainty why the person living in the house has 12 cameras?

ALG 1.1.1 TENNIS RACKETS

Class: Equipment per group: whiteboards and markers

Imagine that a new acquaintance (Miha) invited you to his house. You walk in and notice that he has 10 tennis rackets in the hall way. You wonder WHY Miha would have those rackets. Unfortunately, Miha does not speak English and cannot answer your question directly.

Work with your group members to come up with a plan to find out why Miha had 10 tennis rackets.

Explanation in the Instructor Guide:

I. What is physics?

This section is dedicated to the first day of class. Traditionally, people start the first class meeting by going over the syllabus and course requirements, but we suggest that you dedicate the beginning of the first class meeting to activities that will show the students what the course is about. Examples of such activities are in Chapter 1 of the Active Learning Guide.

A brief description of the first activity is in Section 1.1 of the textbook, subsection “The processes for devising and using new models”. The first activity does not involve any physics. It starts with you telling the students that you invite them to your house or your friend’s house where they notice 10 tennis rackets (10 TV sets, 10 computers, 10 bicycles, anything that is atypical to have in such quantity) in the house. Noticing these rackets is what we call an observational experiment. You can also shoot a short video of your home with these things and show the video. The question is why you would have these 10 rackets? Group your students in groups of 3-4 and ask them to come up with at least three “crazy ideas” (these are actually hypotheses) that explain the data (the 10 tennis rackets) and put their ideas on whiteboards. In 2-3 minutes you will see their ideas. They are usually: you have 10 people living in the house, you repair tennis rackets, you steal them, you collect them and so forth. The students lift their boards and share their ideas.

How would they know which one of their ideas is correct? The students usually say that they would ask you. Then you answer in a language they do not understand (you can make up any language you wish). They will look surprised at you. You say: “You posed the question and you received an answer, but you do not have an instrument to interpret it. Why?” The answer is that they did not expect you to speak in this unknown language. This situation brings up the whole class discussion about testing ideas in physics. Testing means designing an experiment whose outcome you can predict using an idea under test. However, in addition to the crazy idea that is the basis of any prediction, we always make additional assumptions. In this case, the students made two assumptions (1) that they could interpret your answer and (2) that you will answer honestly. As they did not validate their assumptions, the outcome of the testing experiment was inconclusive.

How does one design a testing experiment? There are a few general requirements. First, you should be able to predict the outcome of the experiment using all the ideas under test. But the second one is that these predictions should be different for different ideas. At this moment you ask the groups to go back and think of experiments that they could run to test their ideas (explanations, hypotheses). Then they need to make clear predictions of the outcomes based on each of the "crazy ideas" that they suggested and make sure that they consider any additional assumptions. For example, let's say they wish to test the ideas that you have 10 people in the house or that you are a tennis racket thief. The table below shows the experiments that they might suggest, the predictions that they might make, and the outcomes that they might find. Note the hypothetico-deductive logical structure of the predictions: if the explanation is correct and we do such and such experiment, then such and such outcome is expected. "If" relates to the hypothesis under test, not to the experiment.

Here you again have a whole class discussion about different issues involved. Here are three key points that we suggest you could focus the discussion around:

a. Testing experiments and observational experiments are different from each other; they have different intentions/goals. The first testing experiment in the table was specifically designed to test an idea. It requires a video camera and a person to continuously film the entrance. Thus, this experiment is very different from the first one when you just happen to notice the rackets without any expectations. Understanding the different intentions of observational experiments and testing experiments is key to understanding how physicists create knowledge and is one of the cornerstones of the ISLE approach. Make sure you understand their distinct intentions yourself!

b. Try to make the hypothetico-deductive reasoning process explicit. In our experience, students try to avoid this and don't see the point of being pedantic about it. They think the reasoning process is "obvious," and yet as soon as they move from tennis rackets to a physics context, they struggle to perform the process. Try to get as many students as possible (either verbally or on a whiteboard) to articulate the reasoning explicitly: IF idea X1 is correct AND I conduct testing experiment Y THEN Z1should happen. Z1 is the predictedoutcome based on the hypothesis, not the student's personal beliefs or a hunch. Students mistakenly believe that a prediction is basically a hunch or a guess based on intuition or personal belief. While this may be true in other contexts, this is not how physicists

reason. This same statement repeats in the context of testing experiment Y for idea X2, leading to predicted outcome Z2, and so on for all the ideas under consideration.
c. Now let's look at the outcomes of the experiments. The outcome of the first experiment (many people going in and out of the house) matches the prediction based on both ideas and the outcome of the second (you find the receipts) does not match the prediction based on the second idea but matches the first. What judgment can we make about the ideas?Did we prove that the first "crazy idea" is correct? There can be many reasons for people going in and out of the house, thus the match between the prediction and the outcome is not a proof or even a confirmation that the idea is correct. However, the mismatch in the second case is a stronger reason for judgment. It is much more unlikely that you are a thief if we find receipts for the tennis rackets in your house. This simple exercise helps students see that ruling out an explanation is much easier than confirming one. And that a firm proof is not possible.
After this exercise, we suggest that you discuss the general reasoning pattern behind this exercise. It is expressed in Figure 1.3 on page 4 in the textbook. Basically, the figure shows the process they went through: from the initial (often accidental) observational experiments to creating multiple explanations, testing them in new (testing) experiments until some of the possible explanations are ruled out and proceeding forward with those that were not ruled out by many experiments.
The following activities in the ALG (1.1.2 and 1.1.3) engage the students in a similar process only now the context is physics. In Activity 1.1.2, students should arrive to a judgment that water on the outside of the glass comes from the air. In Activity 1.1.3, they should reason that the loud sound is the result of the rapid expansion of air that happened due to elastic properties of the rubber (the rubber moves away very quickly, which allows the air inside the balloon to expand quickly). Note that this activity is an example where the best explanation is a combination of two (competing) explanations while the wet glass activity is a simpler case where one of the proposed explanations is found to be the best explanation.
Finally, Activity 1.1.4 ask students to summarize the steps of the process using guidance from the textbook. It is a very important activity. You can run it as a whole class discussion or let students work in groups to prepare

presentations on small whiteboards and make their own decision about how to organize their answers – as a picture with similar elements as in Figure 1.3 or as a table or in some other way. The freedom of organizing their answers will help them take ownership of the process.

Crazy idea (explanation, hypothesis)	Testing experiment	Prediction based on each idea	Outcome
CD1: You have 10 people living in the house who all play tennis	TE1: Video the entrance to the house for several days	If CD1 is correct & we perform TE1, then we will see different people going in and out. If CD2 is correct & we perform TE1: then we might see people going into the house or we might not.	There are many people going in and out of the house on the video.
CD2: You steal tennis rackets.	TE2: Look for receipts for the tennis rackets.	If CD1 is correct & we perform TE2: then there might be receipts. If CD2 is correct & and we perform TE2: then there should be no receipts.	You find receipts.

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Eugenia Etkina
Admin
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August 1 at 3:45 PM

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#startingtheschoolyear

Hi all Exploring and Applying Physics people! Today I continue with the fist day of class, now it might be the second...

After the students figured out the process through which they and other physicists construct knowledge (not a cycle, but a process), they need to work on the meaning of the words that they will be using for the rest of the year. Some of those words are familiar to them from everyday life but have a different meaning in physics, and some are probably new. It is really important that they have the image of those words and understand their meaning BEFORE you give those words names. It is the approach that we follow through the whole textbook. Idea, image, concept FIRST and the name SECOND. So, here are the important words that the students have experienced in the activities that I described yesterday. Tomorrow, I will post the activity for them to practice the meaning of those words.

SHARED LANGUAGE

Observational experiment is an experiment where you investigate a phenomenon by collecting qualitative or quantitative data without specific expectations of the outcome.

Description is a statement of what was observed in an experiment without explaining it (qualitatively or quantitatively). It answers the question, “What happened?” You can describe with words, pictures, diagrams, etc.

Explanation is a statement of a possible reason for why something happened in the experiment. It answers the questions “why” or “how”. An explanation might contain a hypothetical mechanism of how something happened. In this case it is a mechanistic explanation. For example, the mechanistic explanation for drying of alcohol is the random motion of its particles. However, sometimes an explanation does not have a mechanism in it - it only explains the causal aspect of the phenomenon. In this case it is a causal explanation. For example, an object’s acceleration is explained by the net force exerted on it and its mass. If you are collecting data, an explanation might be an inference from the data – why the data look the way they do.

Hypothesis is a synonym for an explanation. There are multiple hypotheses that can explain what happened. A hypothesis should be experimentally testable.

Prediction is a statement of the outcome of a particular experiment (before you conduct it) based on the hypothesis being tested. Without knowing what the experiment is, one cannot make a prediction. A prediction is not equivalent to a hypothesis but should be based on the hypothesis being tested.

Testing experiment is an experiment whose outcome you should be able to predict using the hypothesis being tested. The experiment tests the hypothesis, not the prediction. A testing experiment cannot prove the hypothesis to be correct (if its outcome matches the prediction) but might disprove it (if the outcome does not match the prediction).

Assumption An assumption is some factor in the physical situation you choose to ignore or assume to be true, that simplifies a calculation or a model, or an experiment.

Model: A model is a simplified version of an object, a system, an interaction, or a process under study; a scientist creating the model decides what features to neglect.

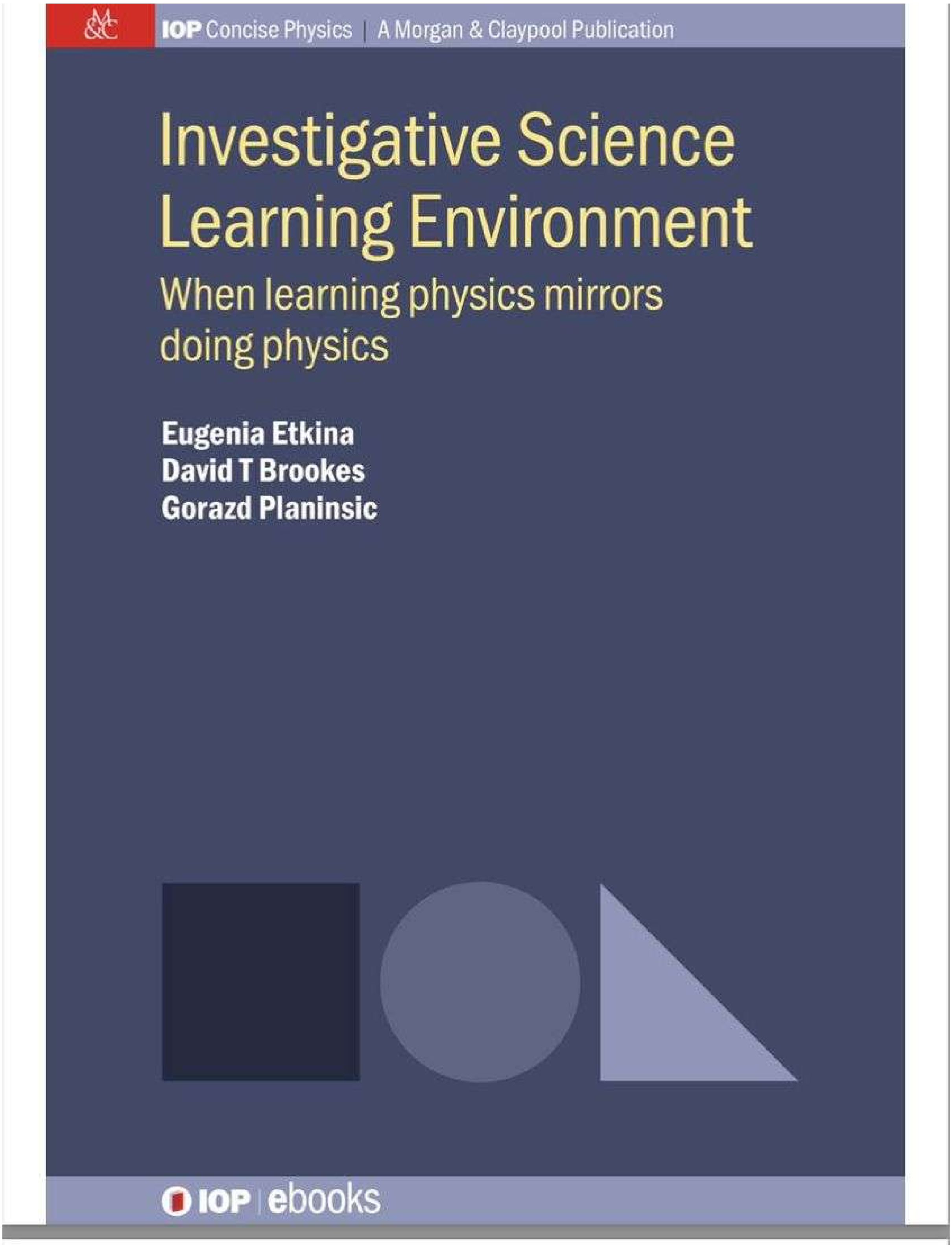
System: A system is the object (or objects) of interest that we choose to analyze. Make a sketch of the process that you are analyzing. Then, make a light, pretend boundary (a closed, dashed loop) around the system object to emphasize your choice. Everything outside the system is called the environment and consists of objects that might interact with and affect the system's motion. These are external interactions.

Physical quantity: A physical quantity is a feature or characteristic of a physical phenomenon that can be measured in some unit. A measuring instrument is used to make a quantitative comparison of this characteristic with a unit of measure. Examples of physical quantities are your height, your body temperature, the speed of your car, or the temperature of air or water.

Physical quantities that contain information about the direction of some quantity are called vector quantities and are written using symbols with an arrow on top. Force and velocity are vector quantities. Physical quantities that do not contain information about direction are called scalar quantities and are written using italic symbols (m, T). Mass is a scalar quantity, as is temperature.

Operational definition is a rule that tells you what to do (what other quantities to measure and what mathematical operations to use) if you need to determine the value of a particular quantity. For example, for

motion at constant velocity, v=delta x/delta t is an operational definition of velocity.
Cause-effect relationship is a rule that tells you what will happen to a quantity when another quantity changes. For example, for motion at constant velocity, delta x= v X delta t is a cause-effect relationship that shows if the time interval of travel is doubled, the distance traveled is doubled. However, the operational definition of velocity is not a cause-effect relationship because if you double the distance that the object travels, the velocity will not change (since the time interval for the doubled distance will be doubled too).
I forgot to write yesterday, that a complete description of the wet glass activity is in our ISLE book, chapter 1. Here is the link to it on the web. It should be in any university library and you can get the file on researchgate. https://iopscience.iop.org/book/mono/978-1-64327-780-6



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Eugenia Etkina
Admin
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August 2 at 6:15 PM
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#startingtheschoolyear
Hi all Exploring and Applying Physics people! I continue with the beginning of the school year. Once we established the vernacular for learning physics through ISLE (see my post from yesterday), it is great to let our students see how these elements apply to a scientific text. Activity 1.1.5 in the ALG or OALG does just that. It is best done in groups.
Put the table shown in the attachment on white boards for the groups before class to save time so that they can fill it out as they are discussing in groups. Then the groups share and after everyone comes to consensus, they can take pictures of the boards (or you can) and post them on class website or put them in their electronic journals (whatever works).
Oh, I forgot, it is good to laminate ISLE process diagram and put it on every desk. If you need ISLE slide for the lamination, please ask and I will post it again.
And please do not forget to like the post or comment on it to make it more visible. As I stopped tagging all in my posts, the viewership dropped dramatically. Thank you!
Activity:
1.1.5 IDENTIFYING ELEMENTS OF PHYSICS PROCESS IN A TEXT
In the text below, identify elements of a process that scientists use when they construct new knowledge (See figure 1.3 n page 4 in the textbook) and match the sentences with the elements of scientific reasoning by writing a number that you find at the beginning of the sentence into corresponding row in the table. Note: more than one sentences can match each element and not all elements are necessarily present in the text.
Youth and physical activity*
(1) The skeleton shows greatest flexibility to physical activity-related mechanical loads during youth but is more at risk for failure during aging;

yet we know that some old people adapt better to physical load than others. (2) Is it possible that the skeletal benefits of physical activity during youth persist with aging and provide some benefits even decades later? Researchers tried to find the answer to this question by studying professional baseball players (3) because these athletes all undergo the same training routines, have similar levels of activity, and most of them stop physical activity altogether upon retirement. (4) The researchers took CT scans of baseball players of all ages, early career to long retired, and compared the humeri (the bone of the upper arm) of their dominant and non-dominant arms. (5) The researchers expected that if the benefits of physical activity persist with aging, some changes in humeri would maintain later in life. (6) After comparing the CT scans, they found out that the humeri in the throwing arms of the active baseball players were much larger than those in the non-throwing arms. (7) When the researchers compared the bones of former baseball players, they found out that though some benefits of training disappeared over time, the increase in total bone size that resulted from years of throwing was maintained decades later. Even 90-year old former baseball players retained some of the benefits of their training, even though they stopped training more than half a century ago. (The authors stress that their work shows the benefit of physical activity, especially during youth.

Elements of scientific reasoning

Sentence numbers

Observations/identifying patterns

Proposing a hypothesis/explanation

Designing/planning a testing experiment

Making prediction of the outcome of the testing experiment

Making assumptions

Describing the outcome of the testing experiment

Making judgment

* Adapted from the short news by Kara Feilich in The Journal of Experimental Biology(2014) 217, 2624-2626. Original article: Warden, S. J., et al (2014), Physical activity when young provides lifelong benefits to cortical bone size and strength in men, Proc. Natl. Acad. Sci.USA 111, 5337-5342.

Elements of scientific reasoning	Sentence numbers
Observations/identifying patterns	
Proposing a hypothesis/explanation	
Designing/planning a testing experiment	
Making prediction of the outcome of the testing experiment	
Making assumptions	
Describing the outcome of the testing experiment	
Making judgment	

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Eugenia Etkina
Admin
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August 3 at 3:04 PM
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Hi all Exploring and Applying Physics people! Two things today: I am continuing with the first few days of class and I wanted to to welcome our new members.
First thing first - the last element of the beginning of the school year is working with the students to help them learn how to read scientific text. Research shows that most of the strategies that people use are not effective for our students. These include summarizing what was said, posing questions about it, etc. They work for literature, history, etc, but not

for science. The strategy that works for reading scientific text is called ELABORATIVE INTERROGATION. This means that the reader asks themselves about EVERY sentence or a couple of sentences: WHY IS THIS TRUE? HOW DO I KNOW THIS? HOW DOES THIS RELATE TO EVERYTHING I KNOW? Experts do this interrogation habitually while reading scientific papers, books, etc. But students use the strategies that they have been using in language classes for fiction texts. And as these strategies do not work for scientific texts, the students do not read textbooks. But this skill is vital for their success in STEM whatever they choose and it is a part of what physicists do when they do physics. Thus, according to the first intentionality of the ISLE approach (students learn physics by practicing it) our students need to learn how to read scientific text. Here is the activity in the ALG that helps them learn how to do it. But I recommend that YOU read any part of Chapter 1 text (one -two paragraphs) aloud in class and show how YOU would interrogate it (you model for your students). Then let them take turns for a few sentences. An example of how to do it is in the activity. I pasted it below:

1.6 HOW TO USE THIS BOOK TO LEARN PHYSICS

1.6.1 INTERROGATION STRATEGY

Below are instructions on how to work with the textbook. The method is called interrogation. Here is an example of your interrogation of the following text (Chapter 1, page eight). This is how the process works.

1.4 Making rough estimates

Sometimes it is useful to make a rough estimate of a physical quantity to help assess a situation or to make a decision. To do this, we use our personal knowledge or experience to get an approximate numerical value for an unknown quantity. Often the goal of the rough estimate is to determine the order of magnitude of the quantity—is it tens, hundreds, or thousands of the relevant units? Estimating is an extremely valuable skill.

You read the first sentence: “Sometimes it is useful to make a rough estimate of a physical quantity to help assess a situation or to make a decision.” You tell yourself: “What is an estimate? Do I even make estimates to make decisions? Hmmm… When I need to estimate how much money I need to live for one month I think about my rent, groceries, gas and other expenses. The rent is fixed but food money changes every week, so what I spend on food can only be estimated. This means they are right; I make estimates to make decisions. Now the next question is about physical quantities. What are those? Oh, let me go back to Section 1.3, it is called Physical Quantities. Aha, money can be a physical quantity as it has units – dollars. So I do make rough estimates of physical quantities. Then you read: “To do this, we use our personal knowledge or experience to get an approximate numerical value for an unknown quantity.” You tell yourself: “This is exactly what I need to use to estimate my monthly food expenses. If I never paid for my groceries, I would have no idea how much it costs a month. It looks like I completely understand what they are saying. Then you continue reading: “Often the goal of the rough estimate is to determine the order of magnitude of the quantity—is it tens, hundreds, or thousands of the relevant units?” You tell yourself: “Order of magnitude. What is this? Oh, I just read about prefixes on page 6 for the units – these are the mathematical expression for the powers of ten, for example 1 meter is 100 times bigger than 1 centimeter. So the order of magnitude is ones, tens, hundreds and so forth. For example, the length of my finger is measured in centimeters, not in meters. For my food money example, the estimate would be that I spend a few hundred dollars a month not a few thousand. This is good to know, especially if I have better idea whether it is one hundred or 8 hundred, right?”

This internal dialogue with yourself is exactly the process that scientists do when they read scientific tests. They continuously interrogate every sentence asking themselves whether it makes sense, whether it is consistent with their prior knowledge, whether what the author is writing describes an experiment or a hypothesis, and so forth. They do not move to the next sentence until they fully interrogate and understand the previous one. They also interrogate figures in the text. Above you see the figure to which the paragraph in the textbook mentions. Your task is to “interrogate it”. What questions would you ask in the process? List possible interrogation questions and answers below.

1.6.2 PRACTICE INTERROGATION STRATEGY

To practice interrogation strategy read the rest of the subsection 1.4 in the textbook and interrogate it. Reflect how this strategy helped you understand the content of the section.

WELCOME to our new members!

And now I would like to welcome our new members! When you first went to the group's page, you saw a message from me about the group. PLEASE DO NOT SKIP IT if you wish to benefit from the group. Go to

islephysics.net and learn what ISLE is and what resources we have. Kinematics workshop on August 12 is in the announcements, lots of materials is in the FILES. Try to check posts every day, to follow the flow. WELCOME!
https://www.facebook.com/groups/320431092109343/posts/1459801988172242/?__cft__[0]=AZX06SYBofLYFdEFQMjeFpQkh6mTC_c4z-1BVS4dIWNlod5rSVZXu-1Y7S4Mgo4hWi8o89THjJBW800HOzjN9DvGYvpOBuZ1ptzWlxT7KjOsEEuv9I4C0kaMR96gH2xGpnQQr41IF7W4gEltBuJ3GPSBBEhhgfW7kSZRGC0gnrca-NV1p6B8paT8ddmKcnnBOJI&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
·
August 4 at 7:47 PM
·
Hi all Exploring and Applying Physics people, I am taking 4 days off posting and encourage you to spend those days reviewing my posts about chapter 1 - all this week and a few last weekend. Please use the Instructor Guide posted here in the FILES to read the Introductory Chapter that introduces goals common to all chapters and self-assessment rubrics.
Explore the website for scientific abilities and labs as https://sites.google.com/site/scientificabilities/
and make sure you bookmark the website with the textbook videos and that ALG: https://media.pearsoncmg.com/aw/aw_etkina_cp_2/videos/
I will be back on Wednesday next week and we will start discussing kinematics in preparation for the workshop next Saturday, August 12. If you have not signed up yet, please go to EVENTS, find the workshop and sign up!

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Eugenia Etkina
Admin
·
August 9 at 11:16 PM
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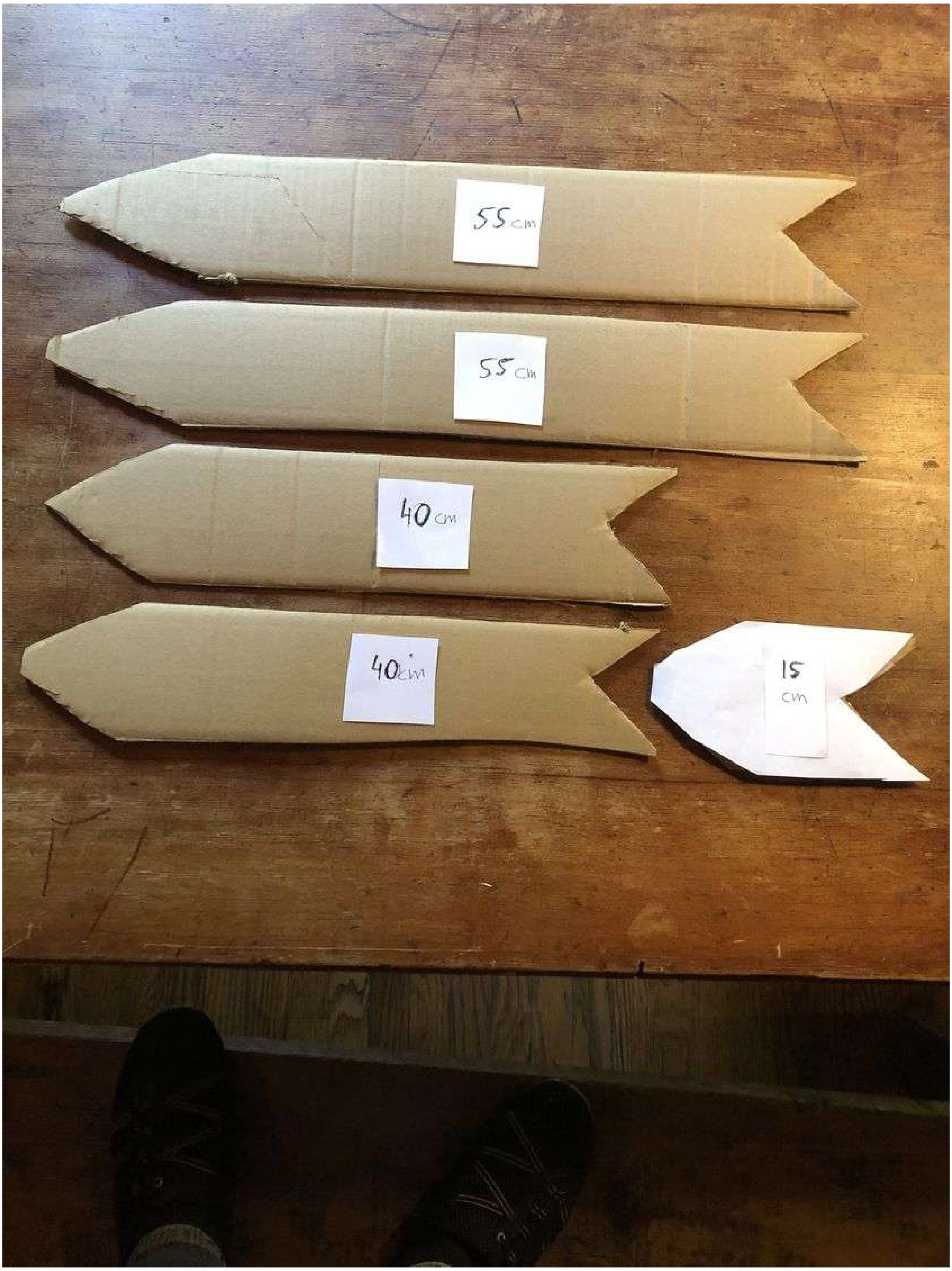
#kinematicsworkshop
Hi those Exploring and Applying Physics who are planning to attend kinematics workshop on Saturday. You will need to do some homework. Specifically, you need to cut our several arrows (I used a cardboard box) as shown in the photo. PLEASE find 10 minutes to do it. The short arrow should be of different color. These arrows will be extremely useful during kinematics. For your students you will need as many sets as the number of groups that you divide your students into. If you are going to attend the workshop but have not attended an introductory ISLE workshop, you need to familiarize yourself with the ISLE approach. You need to read the introductory chapter in the Instructor Guide posted here, or any paper about the ISLE approach posted here in the files or a brief introduction to it on islephysics.net. Whatever you choose for the preparation should help you visualize the ISLE process and help you ask questions during the workshop. Here are the arrows. The lengths are marked. Please ask questions and please do not forget to like the post or comment on it. Thank you.



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Mo&__tn__=%2CO%2CP-R]()

Eugenia Etkina
Admin
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August 13 at 4:19 PM
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#kinematicsworkshoprecording
Hi @everyone, I am posting the recording and the slides we used in the workshop. I am tagging everyone and am going to continue tagging everyone when Facebook allows me as without it, very few people are notified about new posts.
Unfortunately, we did not start recording from the first moment, so you will see the workshop about 5 min after it started. But you can see the beginning using the slides. We had record attendance yesterday, and I thank everyone who came for working extremely hard for 2 hours. Hope it was helpful for your teaching of kinematics. I will announce linear Dynamics workshop possible dates tomorrow.
Here is the link to the recording and password:
https://rutgers.zoom.us/.../Zop1P8WbWMGz67XaeKIDCs4kalYne...
Password: v25n2X$C
Here is the link to the slides and in there the links to the whole folder of workshop materials
https://docs.google.com/.../1paaDXn0T-yHMK.../edit...
Please ask questions about the materials. And please like or comment on the post to make it more visible. It only takes a second to click the "like" button. Thank you all for being a part of this amazing community.
https://www.facebook.com/groups/320431092109343/posts/1465139674305140/?__cft__[0]=AZXExJXR91axpwAXOPuvUq5cnGLYDAiZqg3NyCaB6Z0Ki87pQboIH-XjgJCd3N2DjTfRM4Ul0WcB8zspXyOED8rDu0CqCRovi8nsmc2Dughv506_vJuS9zf4f1in6_LsftSx1dJA-IRrEdYL_tVAQ-FQfuFtzJxjaOFqO6t0VdAKVtjH0CJIIEjMpvh3tefVIpM&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
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August 15 at 4:01 PM
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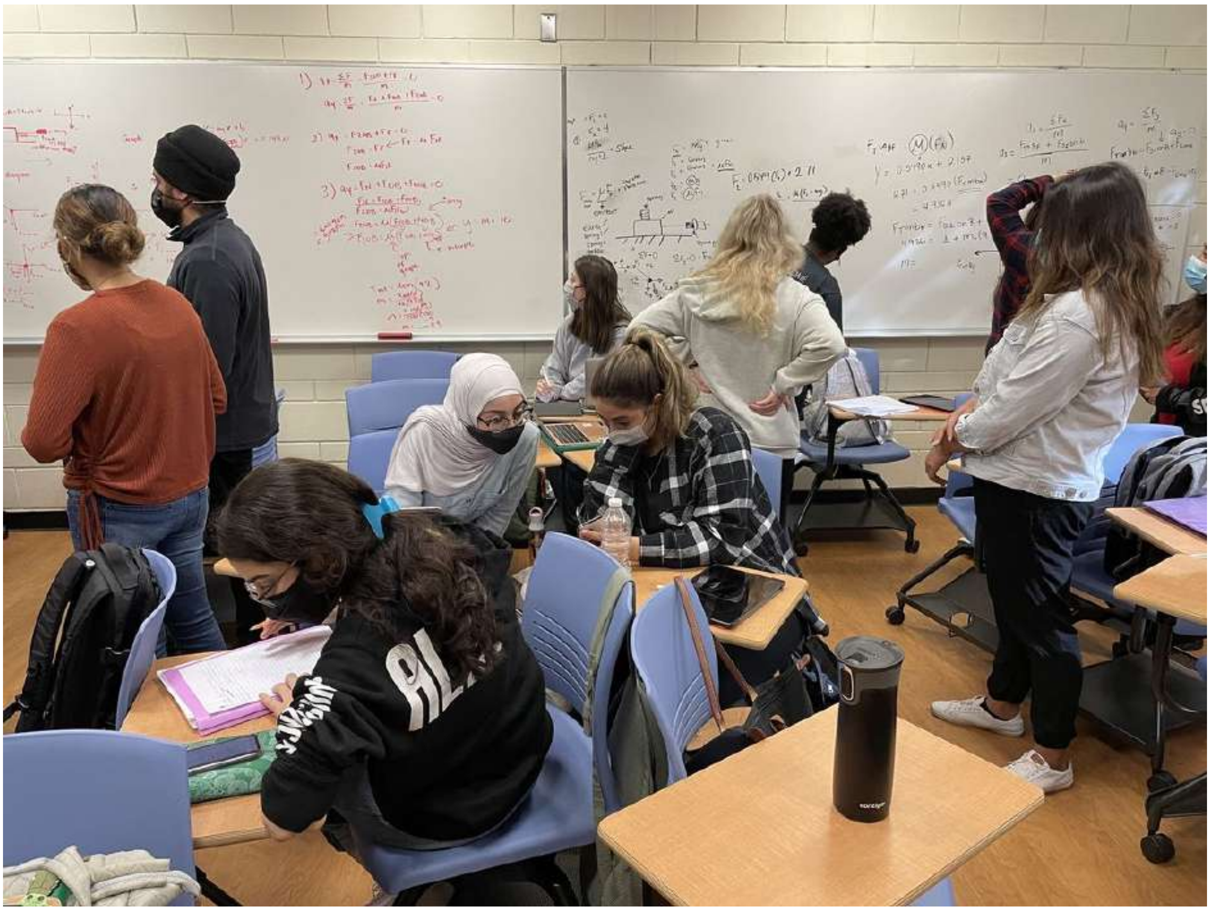
#dynamicsworkshop #kinematics
Hi all Exploring and Applying Physics people!
Two things today.
Yesterday I posted the poll about the dates for the Dynamics workshop. Lots of people responded (GREAT, thank you!)! However, it is difficult to make a decision about the date, as the votes are not clearly split 66% vs 47%. So far September 2nd wins but we need more votes. Please vote! Also, if you marked, September 16 as your preferred choice but could attend September 2nd if the workshop were held on that day, please let me know here by commenting.
2. While we are discussing Dynamics date, some people are already teaching kinematics. I am reminding you that while kinematics might potentially take months, it is useful to move quickly. Do not try to get to the point when every students can analyze kinematics graphs - it takes a whole year to learn to interpret graphs and kinematics ones are very abstract. You goal is to help them learn things that are crucial for moving forward. Here are those things: motion is relative (the observer is KEY!), motion diagrams with the velocity change arrow as the most important part, the difference between velocity and acceleration, understanding that negative acceleration does not mean slowing down, and graphical method of finding acceleration. Mathematically, it is good if the students learn to manipulate equations, but again, this is the skill that takes a whole year to develop. Science practices that are key is drawing good sketches of a problem situation, evaluating the answers and finding patterns in observational experiments.
Finally, I am a member of several Physics Teaching Facebook groups and I see that people are sharing about teaching their students through lectures and videos. I am reminding you that research showed again and again ineffectiveness of the transmission mode of instruction. The students need to be actively engaged in making meaning if we want them to learn anything. Thus, participating in carefully crafted activities and

reflecting on this experience is the way to go. No matter how well we explain things, the knowledge is in our brain connections, not theirs, so helping them to change THEIR brains is the path to learning. Nobody learned to play music, or tennis by listening to lectures or watching videos with explanations. While sometimes those are helpful (we call those "time for telling"), this step comes AFTER the students have constructed connections in their own brains by participating in research-based activities. This is what the ISLE approach is about. If you have questions, please ask. The attached photo says it all. Courtesy of David Brookes.



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Eugenia Etkina
Admin

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August 16 at 7:26 PM

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#dynamicsworkshop #whatislearning

Hi @everyone! There are 31 votes for September 2nd Dynamics workshop and 19 votes for the 16th. Only one person from the 16th group said that they could do the 2nd. I do not want to lose 18 people who can only do it on the 16th, so I am thinking of doing it both days. The only thing that worries me is that people who marked some day as their choice will not actually attend the workshop. So, I am at a loss what to do here. I think I will make an even for the 2nd and see how many people sign up. Then I will see whether to create another event for the 16th. Do you think it is a good plan?

The second thing I wanted to talk about is learning. As we all know, learning is a physical change in the mind and body of the learner. Therefore, as teachers, if we wish our students to learn anything, we need to focus on how their minds and bodies will change as the result of our actions, not how well we explain physics concepts.

Very often, when we explain something, a student would say - I got it, now it makes sense. We happily accept this as a proof of learning. But if we ask them, what is it that they actually got, it would turn out that the student did not understand what we were trying to explain and "got" something else. Additionally, this "bulb going off", "goes out" tomorrow or a few days later, when we return to the same issue. Therefore, it is really important to asses student learning using activities, not their own perception in the moment. Research shows that overconfident student tend to overestimate what they learned and less confident student (usually females) tend to underestimate. The activities in the ALG and OALG will tell you much more about student real learning than their subjective perceptions. Observe them carefully, stand behind and listen to what they are saying while they are working on group activities and you will learn a lot about your students.

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FG1CjPVFhF30ER2PoQCNA1IA90_XIW_xBoe-JdbHqOs8RoJuMKg35o&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
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August 19 at 4:22 PM
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#dynamicsworkshop #developingkinematicsquantities
Hi @everyone Two things today:
First: please sign up for the Dynamics workshop on September 2nd if you plan to attend it. The number of people who marked the 2nd as their choice is much bigger than the number of those who signed up. I would really like to avoid running two workshop twice.
Second: in the Kinematics workshop we discussed in detail how students invent the quantities of velocity and acceleration through the ISLE approach. In both cases they analyze data that they collect (or the data that somebody else collected), find patterns and find the slope of the best fit line (the slope of position vs time graph for velocity and of velocity vt time for acceleration). We do define both quantities as the slopes of respective graphs, so that the definition is correct for any time of motion and can also be used in calculus (as a derivative). Please follow activities in ALG/OALG and the textbook to see the flow. All activities are logically connected as always.
This part reflects the Explore side of our group. To show the Apply side, I am sharing one of my most favorite activities for constant motion. It relates to the total solar eclipse in 2017 (attended personally!) and is a great preparation for the total eclipse of 2024 (hope to attend too!) I am posting the screenshot, it is in the ALG and OALG (posted here in the FILES). The activity is unique as it combines constant velocity motion, geography, and astronomy. It requires students to search fro data, draw pictures and work with each other. I love it, hope you will too. Please do not forget to like the post or comment on it to make it more visible. Recently the posts became invisible again.

2.6.8 Apply

A total solar eclipse is a rare phenomenon that happens at the same location once in about 200 years. During this phenomenon, the Moon passes directly in front of the Sun as seen from Earth. Given the visible diameter of the Moon is very close to the visible diameter of the Sun, the Moon covers the Sun completely and the part of Earth in the Moon's shadow plunges into darkness during the daytime. The average shadow of the Moon on Earth is about 200 km wide and it slowly travels across Earth during the eclipse day. On August 21st 2017, this rare phenomenon occurred in the US. Below are the data about the eclipse. Work with your group members to answer the questions below. (The photo above shows the Sun in Franklin, NC, about 5 minutes before the total solar eclipse in 2017).

a. The 2017 total solar eclipse started on Monday August 21 in Madras, Oregon at about 10:20 am (Pacific daylight time) and ended in Columbia, South Carolina at 2:44 pm (Eastern daylight time). Estimate the average speed of the Moon's shadow moving across the United States and compare it to the speed of sound in air (340 m/s). Indicate any assumptions that you made.

b. During the same total solar eclipse in Franklin, North Carolina, the Moon cast on Earth a circular shadow with a diameter of about 109 km. The total solar eclipse in Franklin lasted for 2 minutes and 30 seconds. Estimate the speed of the Moon's shadow moving across Franklin. Compare this answer with the answer in part a. and try to explain any discrepancies.

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Eugenia Etkina
Admin

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August 20 at 6:40 PM

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#isleinkinematics

Hi all Exploring and Applying Physics people! I continue with kinematics today as this is probably the topic that most of you are or will be teaching soon. We discussed the intentionalities of the ISLE approach before: 1) the students learn physics by practicing it; 2) their well being (self-confidence, growth mind sent, feeling of belonging, motivation, etc.) is enhanced. How do these intentioanlities manifest themselves in EVERYTHING that happens to ISLE students? We talked a lot about the thepocees of invention of physics concepts that goes through observational experiments, finding patterns, coming up with multiple explanations/models, testing then experimentally and so forth. We talked about the development of hypothetico-deductive reasoning (key reasoning in physics) and the use of multiple representations. All of those strategies address BOTH intentionalities. Today, I wanted to challenge you to find the elements that address ISLE intentionalities in the three End-of-Chapter problems in Chapter 2 in our textbook: College Physics: Explore and Apply. When I was looking for examples, I thought that those three back-to-back problems exemplify our intentionalities. I challenge you to name the features of those three problems that address 1) and 2). Who can see the most? Please respond! I will analyze these problems after you post your ideas. Thank you!

71. * While babysitting their younger brother, Chrisso and Devin are playing with toys. They notice that the squishy Piglet slows down in a repeatable way when they push it along the smooth wooden floor. They propose a hypothesis that the toy slows down with a constant acceleration, which does not depend on the toy's initial velocity. For each of five different initial speeds, they measure the distance traveled by the toy from the time they stop pushing it to the time the toy stops moving, and they measure the corresponding time interval. Their data are presented below. Do the data support their hypothesis? Explain. If yes, determine the average acceleration of Piglet and the maximum speed with which Chrisso and Devin push Piglet.

Experiment #	Distance (m)	Time (s)
1	0.96	0.65
2	2.84	1.12
3	1.72	0.87
4	2.53	1.05
5	0.62	0.53

72. ** An object moves so that its position changes in the following way: $x(t) = -100\text{ m} + (30\text{ m/s})t + (3.0\text{ m/s}^2)t^2$. (a) What kind of motion is this (constant velocity, constant acceleration, or changing acceleration)? (b) Describe all of the known quantities for this motion. (c) Invent a story for the motion. (d) Draw a velocity-versus-time graph, and use it to determine when the object stops. (e) Use equations to determine when and where it stops. Did you get the same answer using graphs and equations?

73. * The positions of objects A and B with respect to Earth depend on time as follows: $x(t)_A = 10.0\text{ m} - (4.0\text{ m/s})t$; $x(t)_B = -12\text{ m} + (6\text{ m/s})t$. Represent their motions on a motion diagram and graphically (position-versus-time and velocity-versus-time graphs). Use the graphical representations to find where and when they will meet. Confirm the result with mathematics.

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Eugenia Etkina
Admin
·
6 days ago
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Hi @everyone! Three things today: 1) welcome new members; 2) sign up for the Dynamics workshops; 3) problems fro myesterday.
I will start with 3.
Yesterday I posted 3 problems from end of the chapter problems in our textbook College Physics: Explore and Apply. I asked you to figure out how these problems address tow intentionalities of the ISLE approach: students learn physics by practicing it and students feel good about themselves while doing it. Roby Rod responded to my question and provided some excellent answers. While everything she said is correct, there is more to the problems. I will only analyze the first problem here - the problem with the Piglet. First, the context shows that even physics professors/teachers play with stuffed animals, therefore they are human, just like the students (which is not evident for many students). Second, the problem proposes a hypothesis which is based on some observations that are not described in the problem. To solve the problem, the students need to to understand the hypothesis (this requires the understanding of the meaning of the word hypothesis) and then to decide whether the experiment that the friends conducted could be a testing experiment for this hypothesis. This step requires the students to understand how a testing experiment is different from the observational experiment and what prediction the friends made before running it. Therefore, this problem helps develop the skill of hypothetico-deductive reasoning which is a crucial type of reasoning in physics.
Now, that I analyzed the first problem, can you add more to Roby Rod's analysis of the second and third problem? (see my post from yesterday).

Second: I see that many more people registered for the Dynamics workshop on September 2nd (see the EVENTS to sign up). Thank you! If you plan to attend but have not registered yet, please do!
Third, our community grows every day. Welcome new members! It is very important that you follow instructions in my welcoming message (you received it when you first logged into the group) and study what the ISLE approach to learning physics is about. Please ask questions and try to check posts every day.
[https://www.facebook.com/groups/320431092109343/posts/1469340370551737/?__cft__[0]=AZXHs15wxcbVZY-KlJJadnOtyXwIOTQdJk2lbIl-WMn5wX6916U7e-jlANctxcjdc51RTn7Es6tyZWdV3DbKoF2hXRs2W8RWRM6wzTZvtS8viNV_KxjJPOlldk4Wx-3M024hEFIwtm6us32kP4n5lo_wNbLJ4NzxOe42NPHPxyo4IffdVseQoS24HYck85VHLhw&__tn__=%2CO%2CP-R](https://www.facebook.com/groups/320431092109343/posts/1469340370551737/?__cft__[0]=AZXHs15wxcbVZY-KlJJadnOtyXwIOTQdJk2lbIl-WMn5wX6916U7e-jlANctxcjdc51RTn7Es6tyZWdV3DbKoF2hXRs2W8RWRM6wzTZvtS8viNV_KxjJPOlldk4Wx-3M024hEFIwtm6us32kP4n5lo_wNbLJ4NzxOe42NPHPxyo4IffdVseQoS24HYck85VHLhw&__tn__=%2CO%2CP-R)

Eugenia Etkina
Admin
·
5 days ago
·
#sharingexperiences #hellomistergraph
Hi all Exploring and Applying Physics people! Two things today: 1) please share your and your students' experiences using ISLE activities - first week and kinematics. What is the most exciting? What is difficult? This way we can collectively brainstorm how to improve stuff.
Second, as you are moving through kinematics, there will be a moment when your students need to work with different kinematics graphs - x(t), v(t), and a(t). To help them not to confuse those, you need to encourage them to slow down and look carefully at the labeled axes. One of my former students when doing student teaching came up with a great idea: When you see a graph of anything in physics, you stop and say: "Hello mister graph! My name is (a person says their name, I would say - Eugenia Etkina), and your name is???" .. and here come the axes - "You are a velocity-vs-time graph!" This funny moment moves brain processing from quick to slow and allows the person to correctly identify the graph. It works

not only in kinematics but in any other area. Here are two examples of questions in Chapter 2 of the textbook College Physics: Explore and Apply where this approach will help. Disregard the orange arrow on the top of the screen shot, it is from a previous question.

18. Peter is cycling along an 800-m straight stretch of a track. His speed is 13 m/s. Choose all of the graphical representations of motion from **Figure Q2.18** that correctly describe Peter's motion.

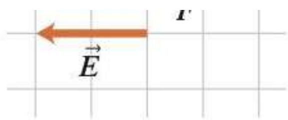
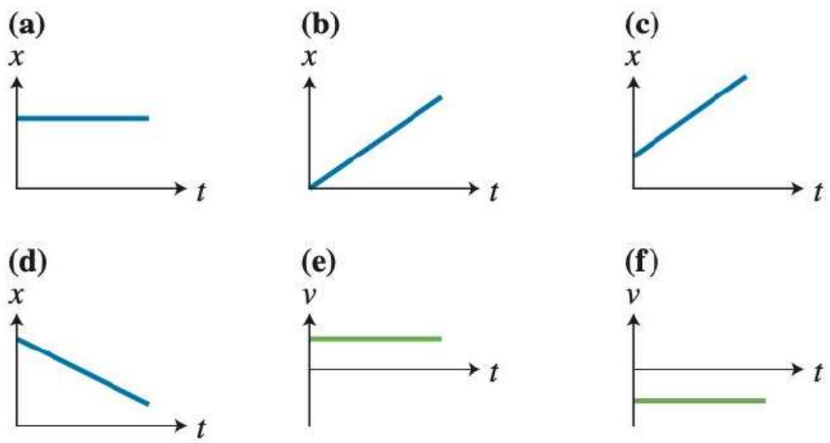


FIGURE Q2.18



19. In what reasonable ways can you represent or describe the motion of a car traveling from one stoplight to the next? Construct each representation for the moving car.

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Eugenia Etkina
Admin
·
4 days ago
·
#nontraditionalproblems

Hi all Exploring and Applying Physics people! I have been posting examples fo problems in kinematics recently, but there are many more that deserve your attention. As I wrote before, we have a whole classification of non-traditional physics problems that is used in every chapter. Many of them are absolutely unique and match the types of AP exam problems. But they are also extremely useful for those in college preparing for MCAT exams (we have special Reading Passages at the end of each chapter for these students too). How do you know that a problem is non-traditional? The answer is simple: If you look at it and think: this is different, then it is non-traditional. Here is the list for kinematics (there is a list for EVERY chapter in the Instructor Guide - posted here in the FILES):

Non-traditional end-of-chapter questions and problems

Choose answer and explanation (CAE): Q2.8

Choose measuring procedure (MEP): Q2.11

Evaluate (reasoning or solution…) (EVA): Q2.28

Make judgment (based on data) (MJU): P2.71

Multiple possibility and tell all (MPO): P2.18, P2.24, P2.25, P2.39, P2.59

Jeopardy (JEO): Q2.22, P2.17

Design an experiment (or pose a problem) (DEX): Q2.27

Problem based on real data (that students can collect by themselves) (RED): P2.71, P2.75, P2.76, RP2.

How many of those do you assign? Are you comfortable with them? Please post!

EXAMPLE 2.11 **Equation Jeopardy**

A process is represented mathematically by the following equation:

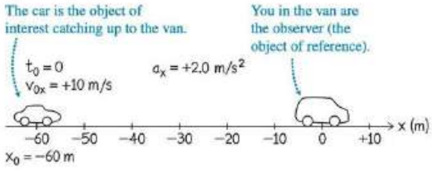
$$x = (-60\ \text{m}) + (10\ \text{m/s})t + (1.0\ \text{m/s}^2)t^2$$

Use the equation to construct an initial sketch, a motion diagram, and a verbal description of a process that is consistent with this equation.

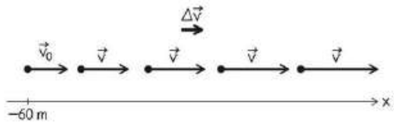
Sketch and translate The above equation appears to be an application of Eq. (2.6), which we constructed to describe linear motion with constant acceleration, if we assume that the $1.0\ \text{m/s}^2$ in front of t^2 is the result of dividing $2.0\ \text{m/s}^2$ by 2:

$$\begin{aligned} x &= x_0 + v_{0x}t + \tfrac{1}{2}a_x t^2 \\ &= (-60\ \text{m}) + (10\ \text{m/s})t + \tfrac{1}{2}(2.0\ \text{m/s}^2)t^2 \end{aligned}$$

It looks like the initial position of the object of interest is $x_0 = -60$ m, its initial velocity is $v_{0x} = +10$ m/s, and its acceleration is $a_x = +2.0\ \text{m/s}^2$. Let's imagine that this equation describes the motion of a car on a straight highway passing a van in which you, the observer, are riding. The car is 60 m behind you and moving 10 m/s faster than your van. The car speeds up at a rate of $2.0\ \text{m/s}^2$ with respect to the van. The object of reference is you in the van; the positive direction is the direction in which the car and van are moving. A sketch of the situation follows.



Simplify and diagram The car can be considered a point-like object—much smaller than the dimensions of the path it travels. The car's velocity and acceleration are both positive. Thus, the car's velocity in the positive x-direction is increasing as it moves toward the van (toward the origin). Below is a motion diagram for the car's motion as seen from the van. The successive dots in the diagram are spaced increasingly farther apart as the velocity increases; the velocity arrows are drawn increasingly longer. The velocity change arrow (and the acceleration) point in the positive x-direction, that is, in same direction as the velocity arrows.



Represent mathematically The mathematical representation of the situation appears at the start of the Equation Jeopardy example.

Solve and evaluate To evaluate what we have done, we can check the consistency (agreement) of the different representations. For example, we can check whether the initial position and velocity in the equation, the sketch, and the motion diagram are consistent. In this case, they are.

Try it yourself Describe a different scenario for the same mathematical representation.

Answer This mathematical representation could also describe the motion of a cyclist moving on a straight path as seen by a person standing on a sidewalk 60 m in front of the cyclist. The positive direction is in the direction the cyclist is traveling. When the person starts observing the cyclist, she is moving at an initial velocity of $v_{0x} = +10$ m/s and speeding up with acceleration $a_x = +2.0\ \text{m/s}^2$.

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Eugenia Etkina
Admin
·
2 days ago
·
#groupworkinISLE
Hi @everyone! Today Tom Prewitt posted a question about group work. Here are some routines that you can set up for group work. This is a long post, please be patient.
How do you form the groups? There are different approaches to this task. During the first class of a course, we let groups be formed naturally, as the students walk in to the classroom and choose seats. Once they are settled, it is good to check that there are no groups with one female and

the rest males. You can ask students to move in this case. While some females make themselves heard in a group of males, many have difficulties doing so even when they have a great grasp pf physics. Thus, at the beginning it is a good routine to avoid such situations. Later, it is necessary to monitor the groups to make sure every voice is heard.

Is there a best size of a group for group work? If the activity has one right answer, 2 people are enough, but if it is a creative activity, with multiple possible approaches, then 3 is a minimum number and 4 is probably as large as a productive group should get. As the semester progresses, it is great to change groups to make sure that everyone in the course works with everyone else.

As one of the goals of any ISLE-based course is to create a community, the first necessary condition is that people know each other well and experience working together in different contexts (more about it later). With a possible large variability in the group member's preparation, we found useful to have groups of mixed ability. Thus, as you get to know your students, try to organize the groups so that the groups in each course meeting have both high achieving, medium achieving students, and those who struggle. If the atmosphere in the course is supportive (and this depends on you), then the struggling members will grow and improve quickly.

Working in groups is important in the ISLE approach. Remember two intentionalities of the ISLE approach? They are to help students learn physics by constructing knowledge following the processes that mirror the practice of physics and to help them stay motivated, feeling that they belong in physics and develop growth mindset. Group work fosters both intentionalities as scientists work in teams creating knowledge and group work can help develop the sense of the community, belonging, and extend students' zone of proximal development. The problem is that not all groups are functional. What does it mean a functional group? A functional group is the group when group members work together, listen to each other and support each other to solve a problem. By working TOGETHER they extend each other's zone of proximal development. This sound good in theory, but how do you help them learn to work this way? And does belonging to a functional group make a difference? It turns out that it does!

From the above follows that it is important that the group work is really collaborative, not led by one dominant person while everyone else is either passively listening or is “checked out” until the answer is provided. How can we help group members collaborate? Research by David Brookes, Yuehai Yang and colleagues (Brookes et al., 2021, see the link below) found that in the groups where the more knowledgeable person “hedges” the answers (makes them sound a little uncertain, for example: “What do you think of this idea?” or “I could be wrong but these are my thoughts…”) instead of declaring them authoritatively, other group members participate and collaborate more equitably. The consequence of this more equitable engagement is that these groups make far more progress on challenging activities (the activities that require the students to leap into their zone of proximal development). If there is no equitable engagement, the other group members do not challenge the statements of the person who is perceived as more knowledgeable. It seems that hedging creates a feeling of some kind of psychological safety that is necessary for effective collaboration.

After the groups finish their activity, they will need to report it to the rest of the class. Who will do the reporting? A good practice is for each group to choose a “spokesperson” for the day. This person will deliver the groups solution to the class during that lesson. You will need to monitor the list of spokespeople so that everyone gets to play this role before the new round starts. Choosing a spokesperson for the day can be the first assignment for each group at the beginning of each class.

When the groups start working on the assignment, it is a good routine to announce the time that they will have. If you do not do it, the start will be slow and about 4-5 min at the beginning will be lost. It is good to have a timer or some other means to remind students how much time is left. This time monitoring creates “the sense of urgency” in the lesson that prevents it from dragging. How do you know how much time will be needed for a particular activity? First, time yourself doing it when you are prepping the lesson and then multiple it by 2. This would be the minimum time. You can always extend it in class (obscurely), but having the limit is crucial for a quick start of group work.

To have the accountability for student work, the students need to put everything on their whiteboards and then present what they found to the rest of the class. But while such approach helps keep the students accountable, it might lead to the drudgery of the lesson and the lack of the “sense of urgency”.

Therefore, a key step in maintaining the sense of urgency is deciding when to cut off the time for the activity and how to organize groups' presentations. It is tempting to wait until all groups finish and then let them all present their findings taking turns. There are several dangers in this routine. Those who finish first get bored waiting for the rest of the groups and when all the groups have the same solution to the problem, it is boring to listed to the same thing again and again. Here are possible routines:

1. Notice when the first group finishes and if their work is correct, stop the rest of the groups, let this group present and then ask representatives of the groups that did not finish to ask questions or repeat what the first group said and then give them a few minutes to finish their boards using the work of the finished group.
2. Invite the members of the finished group to visit the groups that are not done and help them. Then the first group presents.
3. Give an additional activity to the finished group and let the rest of the class finish. Then if the solutions are the same, any group can present, and if the solutions are different, invite the groups visit each other, talk and then share the differences that they found without repeating the things that all groups did the same.

It is important not to be the first to validate the results and solutions yourself but let students discuss them. However, at the end it is a good practice to summarize the results of the group activity and clearly state why the students did it and what they were expected to learn from it. A good routine is to keep these summaries short on the class board and let the students take photos for their journals at the end of the lesson.

There are a few other important routines to keep in mind specifically for the group work in the ISLE environment:

1. Before each group activity, ask the students where it belongs in the ISLE process – are they working on an observational experiment, on the patterns, on the testing experiment, etc. For example, if it is a testing experiments, it is helpful to put the hypothesis that the students will be testing on the class board for clarity.
2. After every group activity, summarize what the students found so that they can proceed to the next one being "on the same page". For example, if it is an observational experiment, it is helpful to put on the class board the patterns that students found; if it is an application experiment, it is helpful to put the results on the board and ask how we know that they

make sense. The bottom line, is that developing epistemological aspect of reasoning is as important as doing the activities.

The “group work” routines described above work for the lessons when students learn new material and when they do long labs (if you are teaching in college and the course is run in a traditional mode, having the labs separate from other activities).

If you are teaching a large enrollment physic course using the ISLE approach and have “lecture time” (we call it “large room meeting”) when all 200-300 students or more are in a theatre-sitting environment, it might feel that no group work is possible. But team work is always possible. A student needs to turn to their neighbor to discuss the activity. Their consensus can either come from direct sharing with the rest of the class, or by choosing an answer among the choices that you provide using student-response system. Even if you cannot organize team work in a large room meeting, the students can still work in groups in the labs or in problem-solving activities. Then the routines described above are relevant.

Brookes, D. T., Yang, Y., & Nainabasti, B. (2021). Social positioning in small group interactions in an investigative science learning environment physics class. Physical Review Physics Education Research, 17(1), 010103. https://doi.org/10.1103/PhysRevPhysEducRes.17.010103

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Eugenia Etkina
Admin
·
a day ago
·
#groupwork

Hi all Exploring and Applying Physics, I continue with group work today as Gorazd Planinsic sent me a very interesting paper - a meta study of the

role of group work in different aspects of student learning. And guess what aspect group work affects the most? MOTIVATION! As motivation is probably the most important factor in one's learning, this means that we should consider group work as an item on the list of what to do to improve student motivation. This is, of course, if group work is organized well (see my previous post and Jane Jackson's comments on it). And there is so much more in the paper! Read the paper posted here and comment!
https://www.facebook.com/groups/320431092109343/posts/1471962883622819/?__cft__[0]=AZVf2zn6RrssTQ12A7OyCp2RXRtiG2KMdBQZEI861nmW5JQrNyU9Qjv49GTdTRSKz-YhGw73a7mlxnNPcbUKIZi9o8SkyXGupAoIB-SqJSqTLhnGGURJr-zG-4gRBFCBaCo18krZcXYDsnQ74VejIK3diCMkm9RIXF69UJlb7D_cmrIsmDU5PZBhebqYzNTTFAgIHK424gPkqdjJ6-MYQmTa&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
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August 29
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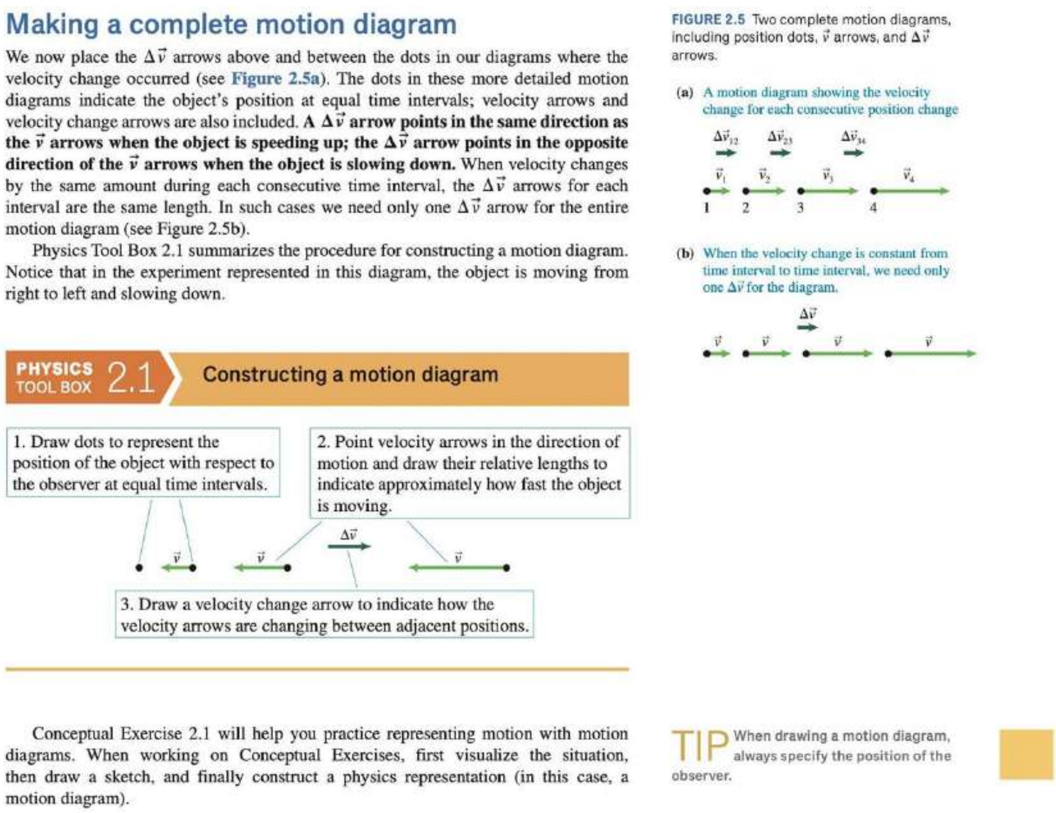
#motiondiagrams
Hi @everyone, this coming Saturday we have a workshop for Dynamics. In order to start dynamics, your students need to be fluent with motion diagrams and the concept of an observer when they describe motion. I am reminding you to use cardboard arrows for velocity and velocity change and they help the students visualize HOW the velocity change vector is constructed from initial and final velocities for one time interval.
There is one little detail that is not discussed in this chapter but is needed in chapter 5 - Circular motion. When we draw velocity change vector, where the point of this velocity change is. It is between the points of the initial and final velocity. This nuance does not matter for constant acceleration motion but will matter later. I would discuss this issue with the students.
Another important thing is the direction - positive or negative direction of velocity change vector tell us nothing about whether the object is speeding up or slowing. Only the RELATIVE orientation of velocity vectors and the

velocity change vector does. Same direction (even if both are negative) - the object is speeding up, opposite direction - the objct is slowing down. If your students are fluent with motion diagrams, it will be much easier for them to draw force diagrams in dynamics as the direction of the velocity change vector is the same as the direction of the sum of the forces vector. Needless to say that understanding how vectors add is important too. Finally, the role of the observer is very important (see the TIP on the screenshot). Without this understanding, Newton's first law is just a consequence of the second and it is not clear why it is needed. But this part we will discuss in the workshop. If you have not signed up yet, please do. We also record the workshops, so you will be able to watch the video, but it is not the same as participating. Please sign up and find time on Saturday to attend. Thank you all.



Making a complete motion diagram

We now place the $\Delta\vec{v}$ arrows above and between the dots in our diagrams where the velocity change occurred (see Figure 2.5a). The dots in these more detailed motion diagrams indicate the object's position at equal time intervals; velocity arrows and velocity change arrows are also included. **A $\Delta\vec{v}$ arrow points in the same direction as the $\vec{v}$ arrows when the object is speeding up; the $\Delta\vec{v}$ arrow points in the opposite direction of the $\vec{v}$ arrows when the object is slowing down.** When velocity changes by the same amount during each consecutive time interval, the $\Delta\vec{v}$ arrows for each interval are the same length. In such cases we need only one $\Delta\vec{v}$ arrow for the entire motion diagram (see Figure 2.5b).

Physics Tool Box 2.1 summarizes the procedure for constructing a motion diagram. Notice that in the experiment represented in this diagram, the object is moving from right to left and slowing down.

FIGURE 2.5 Two complete motion diagrams, including position dots, $\vec{v}$ arrows, and $\Delta\vec{v}$ arrows.

(a) A motion diagram showing the velocity change for each consecutive position change

(b) When the velocity change is constant from time interval to time interval, we need only one $\Delta\vec{v}$ for the diagram.

PHYSICS TOOL BOX 2.1 Constructing a motion diagram

Conceptual Exercise 2.1 will help you practice representing motion with motion diagrams. When working on Conceptual Exercises, first visualize the situation, then draw a sketch, and finally construct a physics representation (in this case, a motion diagram).

TIP When drawing a motion diagram, always specify the position of the observer.

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Eugenia Etkina
Admin
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September 4 at 4:10 PM
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#2Ddynamicsworkshop
#ForceAndMotion
Hi @everyone! Two things today. First, I posted a poll for the 2D dynamics workshop yesterday, please see the poll and vote, so far one date is a clear winner, but not enough people voted. It is important to attend all of the workshops for the school year to see the progression of the material. Every idea builds on the previous ones.
Second, Roby Rod posted about the lack of bowling balls for the experiments. The video that we (David Brookes and I) created a long time ago might help. The purpose of the video for the students to construct two important ideas: An object cannot change its motion by itself, an interaction with anotehr object is needed. Once this interaction is over the object continues to move at constant velocity (as seen by the observer on the ground). Please watch it and if rollerblade, use it? Note that the push should be strong enough, only rolling at high speed leads to constant velocity motion on rollerblades (complex interactions with the floor are to blame). You need to have a tile floor or linoleum floor. Wood will work too, but not a carpet.

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Eugenia Etkina
Admin
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September 5 at 3:29 PM
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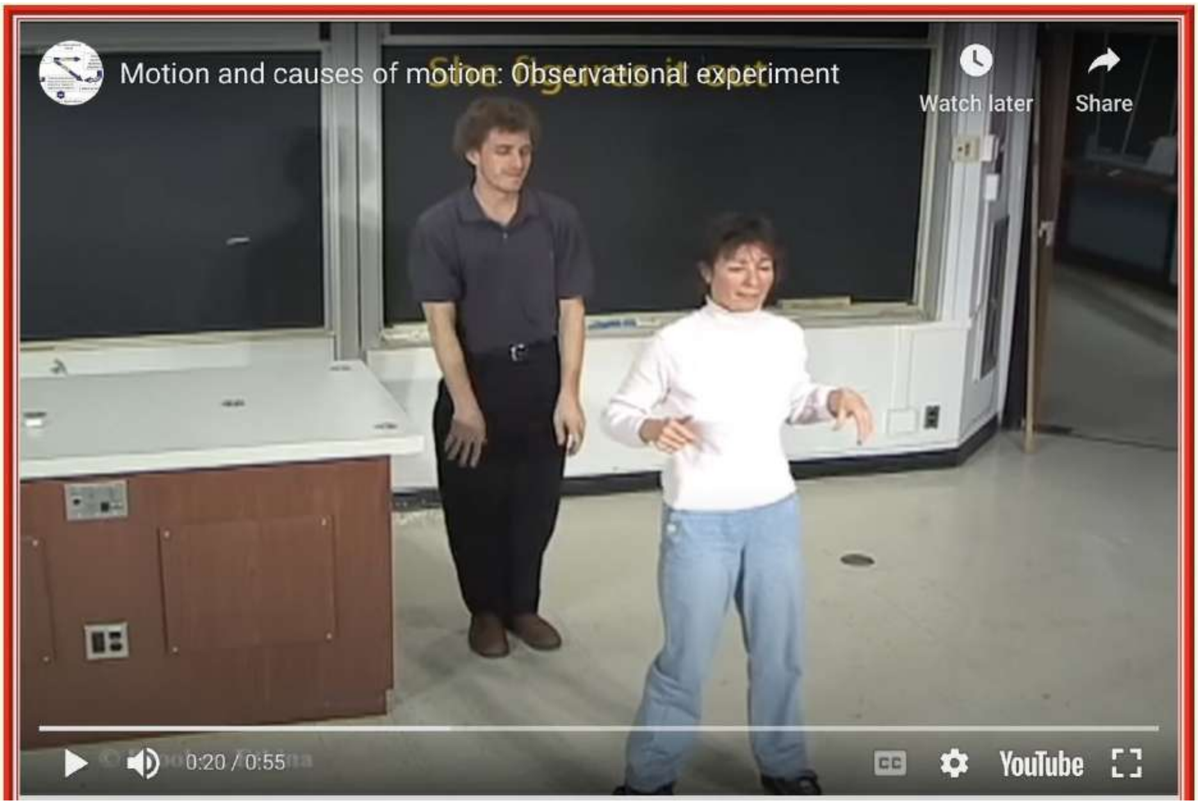
#Newtonslaws
Hi all Exploring and Applying Physics people! Now that we had the workshop on Newton's laws, I will start commenting on the most important issues in this chapter, Chapter 3.
In the workshop we discussed possible "needs to know" to start this unit, you can see them in the slides for the workshop, the link to those was posted on Saturday. Today, I am sharing another way to start the unit to emphasize that for any object to CHANGE its state of motion, it needs another object. You do not need to ask your students to explain what they see in the video (the best of course, if you do it yourself), just to wonder why the two things in the video happened: Eugenia could not get moving by herself and once she was moving, she moved in a very specific way.
Many people thing that we can start moving by ourselves. But this means the change of velocity, and such thing cannot be accomplished without another object interacting with us and exerting a force. Here in the video, David (David Brookes) is that object. The video was made and posted on our website over 20 years ago. This is how long we have been working on the materials that you are using now. Time flies!
http://islevideos.net/experiment.php?topicid=3&exptid=27



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Eugenia Etkina
Admin
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September 7 at 4:04 PM
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#2ddynamicsworkshop
#experimentvideos
Hi @everyone! Several things today:
Please vote for the date of the 2D Dynamics workshop. So far, September 30th is a clear winner, but it would be great to see more votes. The post with the poll was 3 days ago.

Pearson finally updated the video website for our textbook by including links to the OALG videos in addition to the textbook and ALG. We created a ton of new videos for the OALG, and in posted here files the links are to the youtube versions of each video as I was posting the files as soon as we were making them in pandemic times. Now Pearson added the links to those videos that are not hosted on youtube (previously they were only available through Mastering Physics), so that the schools that do not allow youtube access can safely use those. please check them out! https://media.pearsoncmg.com/aw/aw_etkina_cp_2/videos/

I encourage you to read Chapter 3 Newton's laws before you start teaching it. Many thing there will be new for you. Focus on how we talk about forces, how we introduce force diagrams (we do not call them free body diagrams), how we develop the relationship between forces and motion, how we formulate each of Newton's laws and their relationship with each other, how we talk about operational definitions and cause-effect relationships, how do we teach students to linearize data. All those issues are addressed in Chapter 3 but to find them you need to read the textbook as if you never studied physics, this means reading using Elaborative Interrogation technique that we have discussed before. I know it is very difficult, but please try! You will discover many new ideas and approaches to the familiar material.

If you read the post, please do not forget to like it or comment on it. Recently the number of views of each post dropped dramatically. It is either the posts are invisible or people are too busy to monitor group activity. I cannot do anything about the latter, but the former can be helped if you like or comment on the post. Thank you.

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Eugenia Etkina

Admin

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September 8 at 3:41 PM

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#referenceframes

Hi all Exploring and Applying Physics people! Today my post is about the importance of the observer. Chapter 2 Kinematics starts with the discussion of how the motion depends on the observer and the role of a reference frame. While the concept that motion is relative is common to kinematics, many forget about it when teaching Newton's laws. But the fact is that the laws only work for observers in inertial reference frames (this is the essence of Newton's first law), for whom the forces are the results of interactions between objects, not their acceleration. Thus, when we draw force diagrams, we ONLY draw them as observers standing on Earth.

Think about the following situation. You are standing in an elevator on a bathroom scale. The scale reads 150 lb. All of a sudden, the scale starts reading 160 lbs, then goes back to 150 and then drops to 140. Nobody exerted an additional force on you and nobody reduced any forces. You, as the observer, cannot explain what happened. However, a person the ground can do it easily. The elevator accelerated upward, then moved at constant velocity and then slowed down going upward.

It seems like a small detail, but it becomes huge when studying circular motion. We feel thrown out in a turning car and yet we teach our students that the sum of the forces exerted on a revolving object points towards the center. But this is only true for the person standing on the ground and NOT for the person sitting in a turining car. The same is true for an accelerating car, an airplane experiencing turbulence and so forth.

Thus it is crucially important to remind the students again and again who the observer is that is drawing the force diagram. This is the observer for whom the forces are the results of interactions and if they cannot find two subscripts for a force, there is no force. This funny video by Gorazd Planinsic which is in Chapter 3 of the textbook is a good illustration of the importance of this idea. https://mediaplayer.pearsoncmg.com/.../secs-egv2e-strange...

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Eugenia Etkina
Admin

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September 9 at 3:56 PM

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Check this out: this great story shows the role of observational experiments in physics. That is why in ISLE we start with students observing carefully selected experiments and trying to explain them instead of asking them to predict what will happen when they have no idea. The article does not take us through the whole ISLE process, but the beginning is is described wonderfully. https://www.nytimes.com/.../astronomy-holmdel-antenna…

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Eugenia Etkina
Admin
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September 12 at 3:56 PM
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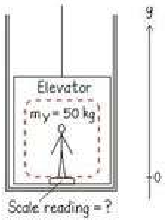
Hi all Exploring and Applying Physics people! Two things today:
I posted the event for our next workshop, please sign up! Go to your EVENTS and you will see it there.
When your students start solving Newton's second law problems, it is crucial, that they start with representing the problem situation with a motion diagram first, drawing the delta v arrow, and then move to the force diagram. The delta v arrow will cue them to the direction fo the sum of the forces and thus will help them decide what force arrow is longer. Here is an example.

Elevator ride

You stand on a bathroom scale in an elevator as it makes a trip from the first floor to the tenth floor of a hotel. Your mass is 50 kg. When you stand on the scale in the stationary elevator, it reads 490 N (110 lb). What will the scale read (a) early in the trip while the elevator's upward acceleration is $1.0\ \text{m/s}^2$, (b) while the elevator moves up at a constant speed of $4.0\ \text{m/s}$, and (c) when the elevator slows to a stop with a downward acceleration of $1.0\ \text{m/s}^2$ magnitude?



Sketch and translate We sketch the situation as shown at right, choosing you as the system. The coordinate axis points upward with its origin at the first floor of the elevator shaft. Your mass is $m_Y = 50\ \text{kg}$, the magnitude of the force that Earth exerts on you is $F_{\text{E on Y}} = m_Y g = 490\ \text{N}$, and your acceleration is (a) $a_y = +1.0\ \text{m/s}^2$ (the upward velocity is increasing); (b) $a_y = 0$ (v is a constant $4.0\ \text{m/s}$ upward); and (c) $a_y = -1.0\ \text{m/s}^2$ (the upward velocity is decreasing, so the acceleration points in the opposite, negative direction).

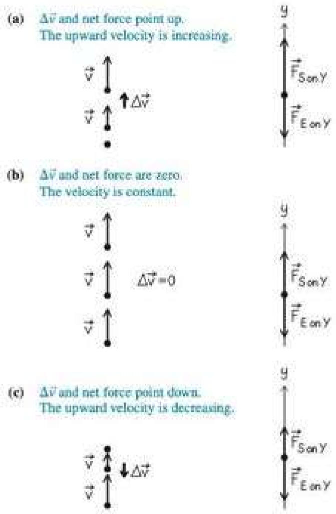
Simplify and diagram We model you as a point-like object and represent you as a dot in both the motion and force diagrams, shown for each part of the trip in Figures a, b, and c. On the diagrams, E represents Earth, Y is you, and S is the scale. The magnitude of the downward force that Earth exerts does not change (it equals $m_Y\vec{g}$, and neither m_Y nor $\vec{g}$ changes). Notice that the force diagrams and motion diagrams are consistent with each other for each part of the trip. The length of the arrows representing the force that the scale exerts on you changes from one case to the next so that the sum of the forces points in the same direction as your velocity change arrow.

Represent mathematically The motion and the forces are entirely along the vertical y-axis. Thus, we use the vertical y-component form of Newton's second law [Eq. (3.7y)] to analyze the process. There are two forces exerted on you (the system) so there will be two vertical y-component forces on the right side of the equation: the y-component of the force that Earth exerts on you, $F_{\text{E on Y}\,y} = -m_Y g$, and the y-component of the force that the scale exerts on you, $F_{\text{S on Y}\,y} = +F_{\text{S on Y}}$:

$$a_{Yy} = \frac{\Sigma F_y}{m_Y} = \frac{F_{\text{E on Y}\,y} + F_{\text{S on Y}\,y}}{m_Y} = \frac{-m_Y g + F_{\text{S on Y}}}{m_Y}$$

Multiplying both sides by m_Y, we get $a_{Yy} m_Y = -m_Y g + F_{\text{S on Y}}$. We can now move $-m_Y g$ to the left side: $m_Y a_{Yy} + m_Y g = F_{\text{S on Y}}$, or

$$F_{\text{S on Y}} = m_Y a_{Yy} + m_Y g = m_Y a_{Yy} + 490\ \text{N}$$



Remember that $m_Y g = 490\ \text{N}$ is the magnitude of the force that Earth exerts on you. The expression for $F_{\text{S on Y}}$ gives the magnitude of the force that the scale exerts on you.

Solve and evaluate We can now use the last equation to predict the scale reading for the three parts of the trip.

(a) Early in the trip, the elevator is speeding up, and its acceleration is $a_{Yy} = +1.0\ \text{m/s}^2$. During that time interval, the force exerted by the scale on you should be

$$F_{\text{S on Y}} = m_Y a_{Yy} + 490\ \text{N}$$
$$= (50\ \text{kg})(+1.0\ \text{m/s}^2) + 490\ \text{N} = 540\ \text{N}$$

(b) In the middle of the trip, when the elevator moves at constant velocity, your acceleration is zero and the scale should read

$$F_{\text{S on Y}} = m_Y a_{Yy} + 490\ \text{N}$$
$$= (50\ \text{kg})(0\ \text{m/s}^2) + 490\ \text{N} = 490\ \text{N}$$

(CONTINUED)

(c) When the elevator is slowing down near the end of the trip, its acceleration points downward and is $a_y = -1.0\ \text{m/s}^2$. Then the force exerted by the scale on you should be

are consistent with each other and the force diagrams are consistent with the predicted scale readings—an important consistency check of the motion diagrams, force diagrams, and math.

Eugenia Etkina
Admin
·
September 13 at 11:22 PM
·
#WELCOMENEWMEMBERS
#forcediagrams
Hi all Exploring and Applying Physics people! Three things today:
If you plan to attend our 2D dynamics workshop on September 30th, please sign up on the EVENTS webpage for it.
In our materials we have several ISLE based sequences of activities helping students construct the relationship between the sum fo the forces exerted on a system and the system's acceleration. They are different in the textbook, ALG, and OALG. My favorite is in the OALG and I am attaching it here. It is probably the most fundamental relationship in Newtonian mechanics and if a student does not get it, then it is almost impossible for them to apply Newton's laws. So, please examine and see which sequence speaks to you! The sequences are complete - observational experiments-patterns-hypotheses-testing experiments.

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Eugenia Etkina
Admin
·
September 16 at 7:44 PM

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Thank you all for responding to my previous post. Despite the record number of comments, a relatively few members of the group viewed the post. I guess everyone is busy. Or the Faceboook is getting less attention in general. In any case, I will continue with the posts for linear dynamics. I wonder who moved from kinematics to dynamics already. Please reply here!

Today my post is about the word we use a lot. The word is WEIGHT. We use it for the force that Earth (or another planet) exerts on an object or for an object itself (a weight is attached ot a string). Both ways of using this word are confusing. The first one stands for a force, but the forces do not belong to objects. They characterize interactions and one object CANNOT have a force. And yet we say: "My weight is XX lbs". This clearly communicates the idea that weight is a property of an object. Thus using the term weight for a force goes agains what we want our students to learn about forces. What should we do? Use the term: The force exerted by Earth (no article, as it is a planet) on the system (or on the object) and always write it with two subscripts F^E on O.

When I googled the word weight, the definition seemed strange but it is actually correct using the ideas of general relativity (screenshot attached). However, I doubt that many students would be able to understand it. Additionally, the images attached to the definition communicate the wrong message, as the scales do not measure "weight".

The second use of the word to denote an object (hanging weight), is also confusing. Therefore, it is better to say: an object, a bob, a ball, whatever it is, but NOT a weight.

Learning physics is similar to learning a new language. Therefore we should try to make this language be consistent with its meaning.

But then, what to do if curriculum materials use the word weight for the force exerted by Earth on an object? My suggestion is NOT to use it at all at the beginning, but closer to the end of dynamics tell the students that sometimes this force is called weight. And to continue double subscript notation of this force forever.

Weight

In science and engineering, the weight of an object is the force acting on the object due to acceleration or gravity. Some standard textbooks define weight as a vector quantity, the gravitational force acting on the object. Others define weight as a scalar quantity, the magnitude of the gravitational force. Wikipedia

Other units: pound-force (lbf)

SI unit: newton (N)

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Eugenia Etkina
Admin
·
September 18 at 4:03 PM
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Hi all, one more comment about language. The first one is mass. Similar to weight we use it for both the physical quantity and for the object. We say "a mass was attached to a string" or something like that. It increases already heavy cognitive load for our students, who have to decide what is involve - an object, or a physical quantity. Thus, I recommend again using the term object or bob, but not "mass" to refer to an object.
Next, the scale... Some scales in US are calibrated in kg, some on pounds. In Europe, they are all in kg. Pound is a unit of force, so we would like to think that American scales measure weight. Do European scales measure mass? The truth is that none of the scales measures what most people think they do. All scales measure the force exerted on them by the object that we place on it. This force depends on the acceleration of the object with respect to Earth. Thus it is equal to weight (mg) only when the object is not accelerating. We have lots of activities that help students construct this important idea and even "feel" it themselves when they stand on a bathroom scale in an elevator.
Additionally, there are two masses as physical quantities - inertial and gravitational. How much time should we spend on this difference? When I was teaching high school physics, I would go into a lot of detail about the difference, but in retrospect, I think not too many of my students remembered anything I said (people do not learn from listening, right?)

Bottom line: avoid calling objects masses and help students learn that a scale does not measure mass or weight. Here is what Wikipedia says about mass.

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Eugenia Etkina
Admin
·
September 20 at 3:53 PM
·
#highschoolteachers
Hi all Exploring and Applying Physics people! Two things today:
First: as you know, Gorazd Planinsic and I have been working developing new materials, activities and problems to continuously improve ISLE. In order to know what existing materials you are using and how to move forward, we designed a survey. This is survey is for high school teachers (we are working on a version for college teachers and I will post it in a few days). Thus, if you are a high school physics teacher and you are using any of our materials (AP Edition of College Physics: Explore and Apply,

ALG, OALG, Instructor Guide, etc.) please respond to the survey! It takes about 5 minutes and the results will be extremely valuable for us. Thank you! Here is the link to the survey:
https://www.surveymonkey.com/r/Etkina2eAP
Second. We have 20 people registered for 2D Dynamics workshop on September 30. Please, if you plan to attend, sign up. For new members: workshops are free, they happen once every month (this is our third year of running those), they last for 2 hours and they help you implement the ISLE approach for a particular unit. The units come in the order of chapters in the textbook College Physics: Explore and Apply. To sign up, please go to EVENTS - this is where the workshops are announced. In the announcement there is the link to the zoom meeting for the workshop.

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Eugenia Etkina
Admin
·
6 days ago
·
#Newton's laws
Hi all Exploring and Applying Physics people! I continue my posts about Newton's laws. We already discussed that Newton's first law is in fact a statement of the existence of inertial reference frames as without defining the observer, the statement written in most textbooks and found online as " An object at rest remains at rest, and an object in motion remains in motion at constant speed and in a straight line unless acted on by an unbalanced force" is not true for any accelerated observer.

The same is true for the second law if written as familiar to us F=ma. An F does not equal to ma, it is the sum of the forces that are. And written in this way, the definition confuses cause and effect. It is not acceleration that produces the net force, but it is the sum of the forces that lead to the acceleration of an object. That is why we write it as acceleration of a system is equal to the sum of the forces exerted on it divided by its mass. The important part here is that the forces need to be EXTERNAL to the system.
Similar to this change, the traditional formulation of the third law as action-reaction is also not helpful, we use the following: When two objects interact, they exerte forces on each other that are equal in magnitude and opposite in direction. Labeling forces with two subscripts helps identify those forces. The key here is that those two forces describe the SAME interaction. We have a great end of the chapter question that assesses this very understanding. Check it out and discuss the right answer. Thank you!
Two more things: please do not forget to sign up for 2D dynamics workshop on September 30th and fill out the survey that I posted two days ago if you are a high school physics teacher using our materials.

8. A book sits on a tabletop. What force is the Newton's third law pair to the force that Earth exerts on the book? Choose the correct answer with the best explanation.
   (a) The force that the table exerts on the book because it is equal and opposite in direction to the force that Earth exerts on the book
   (b) The force that the table exerts on the book because the table and the book are touching each other
   (c) The force that the table exerts on the book because it describes the same interaction
   (d) The force that the book exerts on Earth because it describes the same interaction
   (e) The force that the book exerts on Earth because it is equal and opposite in direction to the force that Earth exerts on the book

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Eugenia Etkina
Admin
·
6 days ago
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#2ddynamicsworkshop
This is the post for those who signed up to attend 2D Dynamics workshop on September 30th. Here is the homework (it is good to do it this weekend):
You need to conduct an experiment and to ask somebody to record you. The goal of the experiment is for you to run at constant speed and throw the ball upward while running so that the ball lands in your hands when it comes back down. You need to figure out how to throw the ball so it lands in your hands. If you have a friend at home, they can take a video of the experiment (as soon as you do it successfully.) Then, carefully analyze the motion of the ball. It is best to do the experiment outside. Good luck!

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Eugenia Etkina
Admin
·
4 days ago
·
#equitygaps

Hi all Exploring and Applying Physics today is my post about two aspects of the ISLE approach that are really important: starting each unit with qualitative development of concepts and allowing and encouraging students to resubmit their work for improvement without taking points off for repeated retakes. We talk about those approaches helping all students succeed and feel that they belong in physics. A recent study (not of ISLE) shows that those two approaches allow to close equity gaps in our classes. Please read the paper, it is very important! There are many other aspects of the ISLE approach that are designed to help our students. One of them is using multiple representations.

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Eugenia Etkina
Admin

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#newtonslaws
#nontraditionalproblems
Hi all, two things today:
A reminder about our 2D Dynamics workshop tomorrow, 9 am Pacific coast time, noon East coast time and 6 pm Central European time. Length 2 hours. If you need a PD certificate after, please email me at eugenia.etkina@gse.rutgers.edu. The zoom link is in the event - see in your EVENTS. It is the same link for all workshops.
Non-traditional problems. I am posting a screen shot of a few of non-traditional problems in Chapter 3. Those who teahc AP 1 and 2 will recognize familiar formats. Your students should be able to solve those

problems before proceeding to Chapter 4, the subject of the workshop tomorrow.
See you tomorrow at the workshop!

processes

22. * **Equation Jeopardy 2** Describe in words a problem for which the following equation is a solution and draw a force diagram that is consistent with the equation (specify the direction of the axis):

$$3.0\ \mathrm{m/s^2} \times 3.0\ \mathrm{kg} = +29.4\ \mathrm{N} - F_{\mathrm{R\ on\ O}}$$

23. **Equation Jeopardy 3** Describe in words a problem for which the following equation is a solution and draw a force diagram that is consistent with the equation (specify the direction of the axis):

$$\frac{0.8\,\mathrm{m/s} - 1.2\,\mathrm{m/s}}{1.6\,\mathrm{s}} = \frac{\Sigma F_x}{50\,\mathrm{kg}}$$

24. * **Equation Jeopardy 4** Describe in words a problem for which the following equation is a solution and draw a force diagram that is consistent with the equation (specify the direction of the axis):

$$2.0\ \mathrm{m/s^2} = \frac{196\ \mathrm{N} - F_{\mathrm{P\ on\ O}}}{20\ \mathrm{kg}}$$

25. * **Spider-Man** Spider-Man holds the bottom of an elevator with one hand. With his other hand, he holds a spider cord attached to a 50-kg box of explosives at the bottom of the cord. Determine the force that the cord exerts on the box if (a) the elevator is at rest; (b) the elevator accelerates up at $2.0\ \mathrm{m/s^2}$; (c) the upward-moving elevator's speed decreases at a rate of $2.0\ \mathrm{m/s^2}$; and (d) the elevator falls freely.

26. ** Matt is wearing Rollerblades. Beth pushes him along a hallway with a large spring, keeping the spring compressed and consequently the force that the spring exerts on Matt constant at all times. They conduct several experiments in which Matt starts from rest and travels 12.0 m while carrying objects of different mass in his backpack, recording the time interval for each trip. Their data are shown in the table at right.

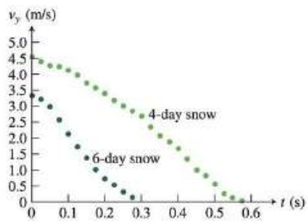
Added mass (kg)	Time interval (s)
0	19.0
3.0	19.4
6.0	19.9
9.0	20.3
12.0	20.8
15.0	21.2

(a) Draw a force diagram for Matt and use it to explain why he is moving with a constant acceleration. (b) Two physical quantities that are not listed in the table also affect Matt's motion. Determine these two quantities using the data above. (Hint: This problem requires linearization. See Example 3.8 for help.)

31. Aisha throws a 0.3-kg ball upward. Frances, standing on a balcony above Aisha, catches the ball by exerting a 1-N downward force on the ball. (a) Draw a motion diagram and a force diagram for the ball during the time interval when Frances is catching it. (b) Determine the acceleration of the ball.

32. * Students Lucia, Isabel, and Austin are investigating how snow stops a dropped 500-g lemon juice bottle. In particular, they are interested in how the force exerted by the snow depends on the age of the snow. They take high-speed videos of the bottle while it sinks into the snow, taking their first set of measurements 4 days after fresh snowfall and the second set of measurements 2 days later. After analyzing the videos frame by frame (see photo), they plot a graph that shows how the velocity of the bottle from the moment the bottle touches the snow changes for both types of snow (Figure P3.32).

FIGURE P3.32



They each explain their results as follows:

Lucia: The 6-day snow exerts a larger force on the bottle because it stops the bottle in a shorter time.

Isabel: The time taken to stop the bottle does not say much about the force. The 6-day snow exerts a larger force on the bottle because the slope of its $v_y(t)$ graph is steeper.

Austin: We cannot compare the forces exerted by the snow because the initial velocities are different. We need to repeat the experiments and make sure we always drop the bottle from the same height.

Explain how each student reached her/his conclusion and decide who (if anyone) is correct. Indicate any assumptions that you have made.

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Eugenia Etkina
Admin
·
2 days ago
·
#fission
I posted a few times about how Lise Meitner was never awarded a Nobel prize for hers and Otto Frisch's discovery of the mechanism of fission.

Here is another article with yet a different explanation of the reason. If you are teaching fission or are sharing women's in physics stories with your students, it is a good short read.

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Eugenia Etkina
Admin

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#archiveofposts #circularmotionworkshopdate #projectilemotion
Hi all Exploring and Applying Physics people! Three things today (see the hashtags).
During our last workshop Amin Rainy suggested that I pin the post with the link to the archive of all the posts to the top of the group. This is what I am going to do. Here is the link: https://drive.google.com/.../10qn... This archive was created and is being maintained by Hrvoje Miloloža. Eugenio Tufino worked with him on saving the zoom recordings.
Yesterday I posted the poll for the circular motion workshop. 13 people responded choosing the dates. Please find my yesterday's post and vote. So far the later date wins. The circular motion is one of the topics where

student kinestetic experience is at odds with the physics that they need to learn as they themselves experience circular motion being in non-inertial reference frames (turning car, bicycle, merry-go-round) while we teach them how to analyze it using Newton's laws that are only valid in inertial reference frames.

In our workshop on 2D Dynamics we had a great discussion of WHY in ISLE we teach projectile motion in 2D dynamics and not in kinematics. I explained three most important reasons: a) in kinematics the students do not have the tools to explain why the horizontal component of velocity remains the same (or almost the same) and the vertical component changes. b) quantitative analysis of projectile motion involves complex mathematics and the longer we delay it in our curriculum, the more mature mathematically they are. As we teach components thoroughly in 2D dynamics, the students are "mathematically" ready to analyze projectile motion. c) This quantitative analysis prolongs already long unit of kinematics. The sooner we get out of kinematics and move to forces where we have more exciting situations, the better.

Hope I convinced you! Please do not forget to vote for the date of circular motion workshop and please like this post or comment on it to make it more visible.

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Eugenia Etkina

Admin

Top contributor

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October 6

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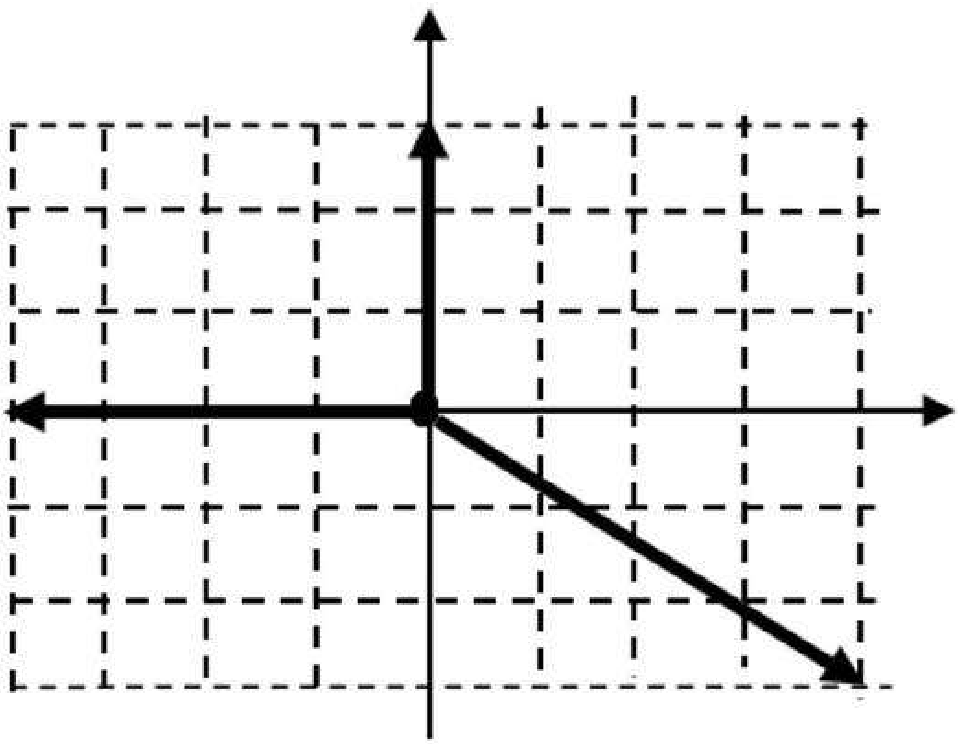
#2dDynamicslearninggoals

Hi all, three things today:

A. One more reminder to vote for the date of the Circular motion workshop. It looks like both dates that I posted are gathering similar numbers of votes. If this pattern persists, I will either need to toss a coin or run two workshops.
B. By now all those who started the school year with kinematics, should be finished with kinematics and finishing up Newton's laws. 2d Dynamics for which we had a workshop a week ago is next. If you have not attended the workshop, I encourage you to examine content-based learning goals for 2dDynamics that are in the Instructor Guide. Do you have similar goals? How are your goals different? Please comment! Here is our list:
Students should be able to:
1. Explain the difference between a vector, vector component, and scalar components.
2. Find the scalar components of vectors in two dimensions.
3. Resolve the force that a surface exerts on an object into two vector components: parallel (the friction force) and perpendicular (the normal force) to the surface.
4. Apply Newton’s second law to situations with multiple connected objects, objects on inclined planes, and objects on rough surfaces (problems involving friction).
5. Test Newton’s second law experimentally.
6. Apply the independence of horizontal and vertical motions to analyze projectile motion situations.
7. Determine the coefficient of friction (static or kinetic) experimentally.
8. Apply Newton’s laws to explain complex real-life situations.
9. Give examples of situations that cannot be explained using Newton’s laws.
C. In the same chapter in the Instructor Guide there is a list of non-traditional problems that can be found in this chapter. Remember, non-traditional problems are the problems that help your students develop real physics reasoning (unlike traditional end-of-the-chapter problems that have one right answer and only call for a numerical calculation) and, as the same time, they types match the types of problems on AP 1 and 2 exams. If you are teaching AP, never skip assigning these problems. There is a similar list in every chapter of the IG.
Nontraditional end-of-chapter questions and problems
Ranking tasks (RAT): P4.55, P4.56

Choose answer and explanation (CAE): Q4.4
Choose measuring procedure (MEP): P4.25
Evaluate (reasoning or solution…) (EVA): P4.39, P4.74
Make judgment (based on data) (MJU): P4.63
Linearization (LIN): P4.86
Multiple possibility and tell all (MPO): P4.18, P4.48, P4.93
Jeopardy (JEO): P4.14, P4.38, P4.59
Design an experiment (or pose a problem) (DEX): P4.92
Problem based on real data (that students can collect by themselves) (RED): P4.19, P4.75

Finally, I am posting the idea of how to help students learn vector and scalar components of a vector. To learn it, you need to go through the activities in the ALG/OALG chapter 4 - 4.1.1 and 4.1.2, but the grid posted here will give you the idea.



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Eugenia Etkina
Admin
Top contributor
·
October 7
·
#2ddynamics
Hi all, challenge for your students:
Eugenia says that the maximum static friction force component of the force exerted by the surface on the object is equal to the product of the force that Earth exerts of the object and the coefficient of static friction. Design an experiment to test Eugenia's idea.
The students need to design an experiment to rule out Eugenia's idea. What are possible designs that they will come up with? Please share what your students do. Ruling out ideas experimentally is an important aspect of scientific inquiry which is missing from traditional physics instruction.
Also, the Wikipedia page the link to which I am putting here gives a lot of historical perspective on the development of ideas of friction. Enjoy!

https://www.facebook.com/groups/320431092109343/posts/1494340884718352/?__cft__[0]=AZWpfx5G3sX-fxj5UUT_xBE_KnL4PstqozlCk6NdGYVzH4_Wpfxot3ZePPV6gV3C-wSsvo7INF0Ec4aIrSiO2qsRTmV3aO8GCb43mM1n1LcLJBY5CUL5breNl3PZi4P9ojXgNnhb-yUNdlSm7V1kepPyNriyC5K8GqgPHY-FIsw2MqewMGgNiiKLSo1Y0wbpzVE&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
Top contributor
·
October 10
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Hi all, some time ago Mattie Baker asked me for the equipment list to implement all of the ALG activities in all chapters. I shared it but I do not remember if I posted it here. Today Dedra Demaree asked me for the list and I thought it would be good to post it.

Here it is - I pasted the list here and attached the file for you to save. Please ask questions!
Also two more things: nobody posted their students responses to the friction problem from 3 days ago and we still do not have enough people for the October 14th workshop for circular motion. I will run it regardless, but when there are not enough groups the learning process is compromised. So, PLEASE, if you voted for the 14th, sign up! Here is the list:
Preparing equipment for your physics classroom
1. White boards (as many as you have groups)
2. LCD projector
3. A watch with a second hand (for you)
4. Metersticks, measuring tape (IKEA has them for free), cardboard to cut out arrows for motion diagrams, cotton balls – all this is for group work
5. Marbles – for group work
6. A triple beam balance scale, electronic balances (sensitive), analogue bathroom scales (not digital), rubbing alcohol – for group work
7. Ring stands with different clamps - for group work
8. Constant motion cars that can move at different speeds (have two per group, different speeds)
9. Simple tracks and metal balls, Hot Wheels tracks and cars work well -– for group work
10. Wooden blocks with different surfaces (see chapter 4 for friction) – for group work
11. Washers– for group work
12. Medicine ball, heavy bowling ball (make one out a cheap ball and sand), tennis balls, basketball, bean bags (you can make them yourself or we use sugar packets) – for group work
13. Vacuum jar and a pump (this is optional, we have videos) – one for class
14. Protractors– for group work
15. Pulleys (low friction), string for the pulleys, objects with known masses – for group work
16. Mechanical toys that need to be winded or pulled/pushed to move (pull back cars, jumpers, etc.) – for group work
17. Projectile launchers – for group work
18. Elastic cord – have one for class

19. Springs (check that they obey Hooke's law) and spring scales – for group work
20. Basket-type scales– for group work
21. Flour or sand, balloons, dental floss, collect tissue boxes– for group work
22. Bricks or heavy rectangular objects
23. Slinkies (the longer the better) – for group work
24. Thermometers (in addition to conventional try to get contactless IR if possible – one for class), regular - – for group work
25. Styrofoam cups and calorimeters– for group work
26. Heater one per class
27. Tuning forks (get a set for resonance if possible) – for group work
28. Plastic bottles of different sizes, can be filled with water, sand, poked through, cut, etc. – for group work
29. Empty metal soda cans to roll, cut, etc. – for group work
30. Wimshurst generator – one for class
31. Electroscopes (can be hand made) – for group work
32. Insulation pipes, stuff to rub them with, include plastic wrap, check the charges, balloons, use Styrofoam plates to cut out sticks, felt, wool, balloons, or whatever material you need for electrostatics– for group work
33. Batteries, bulbs and resistors of different values, LEDs - red, green, blue and white, do not buy colored– for group work
34. Multimeters– for group work
35. Adjustable DC voltage source – could be just one for class
36. Analogue galvanometers, good to have analogue ammeters and voltmeters too
37. Magnets (strong), coils– for group work
38. Compasses (take good care of them)
39. Lots of wire– for group work
40. Wire that does not change resistance with temperature (constantan) – for group work
41. Glass wear – beakers, test tubes, whatever you can find– for group work
42. Candles– for group work
43. Small plane mirrors, one large mirror from Home Depot, curved mirrors of different curvature, flat pieces of glass with parallel sides and lenses

(make sure you have convex and concave of different focal distances) – for group work

44. Laser pointers (green is more visible than red) (check with your school) – for group work

45. Double slits – choose the slits as narrow as possible, gratings, and single slits of different width

46. Spectral tubes (if you do atom) – can get just one set up

47. Handheld spectroscopes– for group work

48. Vernier or Pasco – interfaces and motion detectors, thermometers (including surface) and force probes are a must, everything else is extra, Verneir's Labquest is the best instead of the interface. Smart carts. – for group work

49. Low friction track and carts– for group work

50. Small solar cells– for group work

51. Big transparent water tank – one for class

In addition to this try to get also some basic tools such as screw drivers, hammers, pliers, soldering iron, and a glue gun. Have lots of Scotch tape and different kinds of dental floss (some are conductive and some are not), aluminum foil.

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Eugenia Etkina

Admin

Top contributor

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October 11

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Hi all! I have been posting about women in physics and I wanted to share the article posted by Jane Jackson on her Facebook page about a woman

who just received the Nobel Prize in physics. Please read and share with your students. Thank you, Jane Jackson for posting!
I also wanted to remind those who are interested in the workshop on Circular motion (the first one, this coming Saturday) to please sign up. Go to your EVENTS and do it! Tomorrow, I will post the homework for those who plan to attend.

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Eugenia Etkina
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October 15

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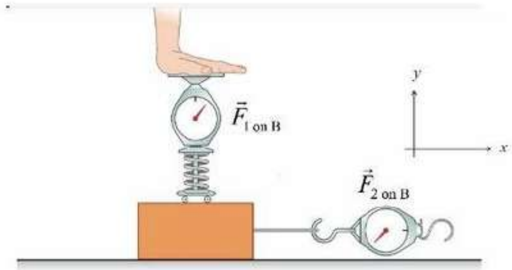
Hi all Exploring and Applying Physics people! A few things today.
Yesterday we had our first workshop on circular motion and one of the participants said that it was very helpful to learn how to teach circular motion using the ISLE materials during the workshop. She also said that her students already learned circular motion and she based their learning on the our textbook material but it did not go very well. Why wasn't the textbook enough for teacher preparation? My response was that if as a teacher you do not do all of the activities in the ALG/OALG yourself, you cannot know what exactly the students are going to learn from those, what difficulties they will have, etc. Therefore, to implement our approach with success the teacher who is familiar with the ISLE approach needs not only to read the textbook as if they never studied physics but also do personally all of the ALG/OALG activities that they plan to assign to their students. It is even better if they have a partner - just like the students- to do those activities. This is what we do in our workshops and that is why they feel so helpful.
As only a few people attended yesterday's workshop, I will proceed with Chapter 4 - Applications of Newton's laws. One of the skills that we want our students to develop is to be able to linearize data. The screen shot of one of the activities that helps them learn how to do it is pasted below. Have you tried it with your students? Please report. And please post your solutions! Thank you!
If you read the post, please like or comment on it to make it more visible. Lately the posts are mostly invisible.

OALG 4.6.4 Linearize

We use a string attached to a spring scale to pull a wooden block. The mass of the block is unknown and it does not change during the experiment. We push down on the block with a spring that exerts a series of downward forces $\vec{F}_{1 \text{ on B}}$ on it. For each of these downward forces, we use the pulling string and spring scale to determine the magnitude of the maximum force $\vec{F}_{2 \text{ on B}}$ that we can exert on the block in the horizontal direction before the block starts sliding. The downward pushing spring is on wheels to prevent it from exerting horizontal forces on the block.



Using the measurements in the table below, determine the coefficient of static friction between the block and the table, and the mass of the block.

$F_{1 \text{ on B}}$ (N)	$F_{2 \text{ on B}}$ (N)
0.0	1.2
1.0	1.8
2.0	2.2
3.0	2.6

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Eugenia Etkina
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Top contributor
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October 16
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Hi all Exploring and Applying Physics people! I stumbled across this TED talk today and I was struck how it relates to the ISLE approach. One of the main ideas of the ISLE approach is that it teaches students to come up with multiple explanations of the observed phenomenon (as much as possible) and then rule those out by designing new experiments whose outcomes the students predict using those explanations. In this process ruling out becomes a good thing not a personal failure. Generating multiple explanations develops curiosity and the willingness to test them for rejection develops openness. If you watch this short TED talk you will see how curiosity and openness are necessary for us to to be able to make decisions based on evidence, not our beliefs. Watch when you have a minute and think of our ISLE-based activities in the ALG (for example in section 1 chapter 1 or section 1 in chapter 12, or many others).

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Eugenia Etkina
Admin
Top contributor
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October 17
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Hi all, let's welcome our new members! I hope you all read the message when you first logged into the group. This group is based on the ISLE (Investigative Science Learning Environment) approach to learning physics and uses curriculum materials consistent with this approach. See islephysics.net for the details of the approach and all the resources that we offer. We also have monthly free online workshops. The next one is on October 28th at noon EDT. It is dedicated to learning how to teach circular motion and gravitation through the ISLE approach. Check your EVENTS page to sign up. To benefit from the group try to check posts as often as you can and either like them or comment to make them more visible for other members and to make sure that he next post comes to your feed.
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Eugenia Etkina
Admin
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October 18 at 11:09 AM
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Hi all Exploring and Applying Physics people! I posted a long time ago about the importance of contrasting cases for learning. This means not only knowing what something is but also knowing something that it is not. To help our students to learn to contrast, think of the following questions:

Give an example when the velocity of an object is zero, but acceleration is not zero (this can be an object thrown vertically upward at the top of its flight, or an object that just starts moving).
Give an example when an object moves at constant speed but is accelerating (circular motion at constant speed).
Think of an example when the sum of the forces exerted on an object is zero but its acceleration is not zero (the observer is in a non-inertial reference frame, i.e. has acceleration).
I came back to the importance of contrasting cases when reading John Dewey's thought on critical thinking. He defined it as He defined it as "active, persistent and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it, and the further conclusions to which it tends. (Dewey 1910)". Not only he defined critical thinking and gave examples of what it looked like, but he also gave examples of what critical thinking was not. He wrote: Immediate acceptance of an idea that suggests itself as a solution to a problem (e.g., a possible explanation of an event or phenomenon, an action that seems likely to produce a desired result) is “uncritical thinking, the minimum of reflection” (Dewey 1910).
This is exactly what we are trying to battle when we ask our students to come up with multiple explanations of an observed phenomenon.
Here is an example from Chapter 12: Gases. We observe a piece of wet paper dry slowly. The wet spot disappears gradually. To explain the slowness of the disappearance students hypothesize that the liquid is made of smaller parts. But what is the mechanism of disappearance? This is where our students develop critical thinking - they come up with many explanations of HOW the small parts of the liquid disappeared. And then we ask them to come up with the experiments to rule out their wild ideas. This is an example of the development of critical thinking. Those are in almost every chapter of our textbook, you just need to see them for what they are. Have you tried this activity with your students? Please share here!

12.1 Structure of matter

12.1.1 Observe and explain

***PIVOTAL* Lab or class:** *Equipment per group:* 90% isopropyl alcohol, strips of paper, whiteboard, markers.

Dip a piece of paper in rubbing alcohol (or rub the paper with alcohol) and place it on a table. Observe what happens. Describe your observations in simple words. [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-12-1-1]

One of your friends described the observation in the following way: "The alcohol disappeared gradually". What do you need to assume about the internal composition of alcohol to explain that the alcohol disappeared gradually rather than all at once?

12.1.2 Develop multiple explanations

***PIVOTAL* Lab or class:** *Equipment per group:* whiteboard, markers.

Mindy, Marc, Alex, and Nina are working on Activity 12.1.1. They agree that alcohol must be made of small parts to enable the paper to *gradually* dry. However, they disagree on the mechanism that allows these small parts to disappear. Work with your group to brainstorm possible reasons for how and why the alcohol disappeared from the paper. Come up with at least four different mechanisms and put them on your whiteboard. Share your ideas with another group.

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Eugenia Etkina
Admin
Top contributor
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October 24 at 9:31 AM
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Hi all, I am back from traveling and will resume posting. First I wanted to remind you to sign up for the Circular motion (includes ISLE approach to teaching the law of universal gravitation). This is the second time I will be running this workshop because of the split vote on the date. Our approach to circular motion is very different from traditional, especially when it comes to the derivation of v^2/R and to figuring our where the law of

universal gravitation came from. If you wish to experience the learning progression yourself, please sign up for the workshop, this is the link:
https://www.facebook.com/events/290962210531518?acontext=%7B%22event_action_history%22%3A[%7B%22surface%22%3A%22group%22%7D]%7D
Another thing that I wanted to mention is that please post your questions here. If you have a question about any aspect of ISLE or teaching physics and post it here, 2400 people will benefit from an answer. Please do not worry that your questions or comments are not important to be posted here because of the size of the group. Every question and post are welcome! And if you see a post with the question that you can answer, please do not hesitate!
Finally, if you are on Chapter 4 and are teaching friction, an activity in OALG helps students understand how friction helps in walking - the friction force component of the force that the ground exerts on the foot is pointed in the same direction as you are walking and in the opposite direction when you are stopping. It is a very simple video that your students can take an anlyze. Here is the activity:
OALG 4.3.6 OBSERVE AND EXPLAIN
a. Watch the video of Eugenia walking on sand (from Activity 2.9.2) https://mediaplayer.pearsoncmg.com/.../_fr.../sci-OALG-2-9-2.
b. Draw force diagrams for Eugenia (consider the person to be a point like object) when she starts a step and when she finishes the step. What object is exerting a force that makes her accelerate?
c. How does the shape of the sand help us determine the direction of the force that the sand exerts on the person?
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Eugenia Etkina
Admin

Top contributor

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October 25 at 2:56 PM

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Hi all, today I will remind you of some routines that are useful when you your students work in groups.

When the groups start working on the assignment, it is a good routine to announce the time that they will have. If you do not do it, the start will be slow and about 4-5 min at the beginning will be lost. It is good to have a timer or some other means to remind students how much time is left. This time monitoring creates "the sense of urgency" in the lesson that prevents it from dragging. How do you know how much time will be needed for a particular activity? First, time yourself doing it when you are prepping the lesson and then multiple it by 2. This would be the minimum time. You can always extend it in class (obscurely), but having the limit is crucial for a quick start of group work.

To have the accountability for student work, the students need to put everything on their whiteboards and then present what they found to the rest of the class. But while such an approach helps keep the students accountable, it might lead to the drudgery of the lesson and the lack of the "sense of urgency".

Therefore, a key step in maintaining the sense of urgency is deciding when to cut off the time for the activity and how to organize groups' presentations. It is tempting to wait until all groups finish and then let them all present their findings by taking turns. There are several dangers in this routine. Those who finish first get bored waiting for the rest of the groups and when all the groups have the same solution to the problem, it is boring to listen to the same thing again and again. Here are possible alternative routines:

1. Notice when the first group finishes and if their work is correct, stop the rest of the groups. Let this group present and then ask representatives of the groups that did not finish to ask questions or repeat what the first group said and then give them a few minutes to finish their boards using the work of the finished group.
2. Invite the members of the finished group to visit the groups that are not done and help them. Then the first group presents.

3. Give an additional activity to the finished group and let the rest of the class finish. Then, if the solutions are the same, any group can present. However, if the solutions are different, invite the groups to visit each other, talk and then share the differences that they found without repeating the things that all groups did the same.

It is important to not be the first to validate the results and solutions yourself, but, rather, let students discuss them. However, at the end it is a good practice to summarize the results of the group activity and clearly state why the students did it and what they were expected to learn from it. A good routine is to keep these summaries short on the class board and let the students take photos for their journals at the end of the lesson.

There are a few other important routines to keep in mind specifically for group work in the ISLE environment:

1. Before each group activity, ask the students where it belongs in the ISLE process – are they working on an observational experiment, on the patterns, on the testing experiment, etc. For example, if it is a testing experiments, it is helpful to put the hypothesis that the students will be testing on the class board for clarity.

2. After every group activity, summarize what the students found so that they can proceed to the next one being “on the same page”. For example, if it is an observational experiment, it is helpful to put the patterns that students found on the class board; if it is an application experiment, it is helpful to put the results on the board and ask how we know that they make sense. The bottom line is that developing an epistemological aspect of reasoning is as important as doing the activities.

The “group work” routines described above work for the lessons when students learn new material and when they do long labs (if you are teaching in college and the course is run in a traditional mode the labs are separate from other activities).

If you are teaching a large enrollment physic course using the ISLE approach and have “lecture time” (we call it a “large room meeting”) when all 200-300 students or more are in a theatre-sitting environment, it might feel that no group work is possible. But team work is always possible. A student needs to turn to their neighbor to discuss the activity. Their consensus can either come from direct sharing with the rest of the class, or by choosing an answer among the choices that you provide using a student-response system. Even if you cannot organize team work in a large room meeting, the students can still work in groups in the labs or when doing problem-solving activities. Then the routines described above are relevant.

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Eugenia Etkina
Admin
Top contributor
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October 26 at 10:57 AM
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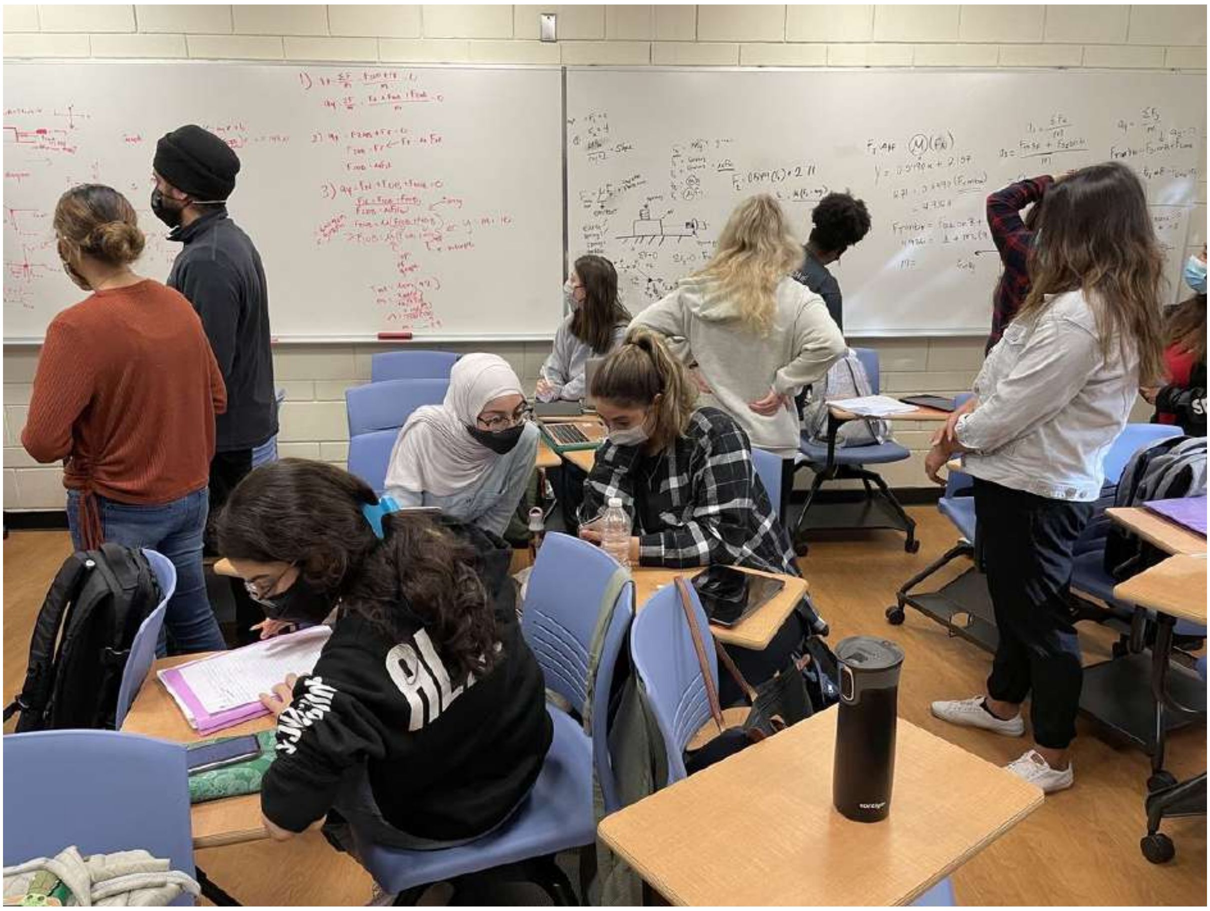
Hi all! Two things today: first is the reminder that we have a circular motion and gravitation workshop on Saturday. 9 am Pacific coast time, noon EDT

and 6 pm Central European Time. Here is the zoom link: https://rutgers.zoom.us/my/etkina...
password 164680
ID 529 521 6705
Second, I want to continue my yesterday's post. We talked before about how to make group work effective. In other words, how to create effective teams. I recently listened to The Hidden Brain Podcast (this is my favorite podcast, by the way) dedicated to effective teamwork. The person who was being interviewed was the psychologist Anita Wooley, Professor of Organizational Behavior at Carnegie Mellon University. Professor Wooley has been studying teamwork for years and after tons of research they found three major contributors to effective team work (they did not study students in the classrooms, but their findings are very applicable to our work). But before I tell you these three elements, I will say what they did not find. They did not find that the teams where individual members had higher IQ were better teams. So putting high achieving students in one group does not guarantee that the group will function.
To describe the effective teams they coined the term of collective intelligence (which is not the sum of the intelligencies of the individuals in the group) and they found that collective intelligence of a group is affected by three things.
Women on teams. The best teams were where women were in the majority but not all members were female.
2. High level of social perceptiveness. Social perceptiveness among the members of the team means picking up on the cues that other people are sending, being attentive to the needs of other people, give the floor or give help, realizing that I speak too long, ensuring equal collaboration in a way, noticing when somebody did not speak at all, whether somebody is offended, whether people are scared to ask questions, etc.. What is really interesting here is that the level of social perceptiveness is determined by the person with the lowest level of social perceptiveness in the group, it is kind of one bad apple spoiling everything. You can have several members with high social perceptiveness in the group but if one member has a low level, this level becomes the level of perceptiveness of the whole group. This is familiar to all teachers, I bet...
3. Having different members to focus on different aspects of the task (having different talents) and having the rest trust them that they can do it.

Having members question what is going on in the group: What are we doing? Why are we doing it? Is there a better way to do it?

As the ISLE process relies heavily on students working in groups designing experiments, solving problems that do not have one right answer and so forth, it is crucial that the groups function effectively. You probably remember research by David Brookes and Yuehai Yang in the ISLE classrooms (I posted their paper in the FILES) that when group members hedge their comments, the groups function better. This is the finding consistent with the social perceptiveness found by Wooley.

The next question is HOW we help our students develop social perceptiveness? I welcome your thoughts here.



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Eugenia Etkina
Admin
Top contributor
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October 27 at 11:44 AM
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Hi all, two thing today: preparation for the workshop and my comments on the article that Bor Gregorčič posted. First, the workshop tomorrow: please review the general logical flow of the ISLE process, how to draw motion and force diagrams and how to use double subscript notation for the forces. If you do not know how to find information on those, please comment here and I will put the links to the relevant workshops.
Second - an amazing article that Bor Gregorčič posted. Thank you, Bor!
This article is a great piece of evidence that supports our argument that students learn physics in the ISLE approach by engaging in the activities that mirror the practice of physics. Here are two examples from the ISLE approach and a parallel story in the article.
In ISLE, among other things, we (1) encourage the students to come up with multiple explanations fo the observed phenomenon and then (2) to test them using hypothetico deductive reasoning that goes as IF the hypothesis is correct AND we do such and such, THEN such and such should happen, BUT it does not happen THEREFORE we can reject the hypothesis.
Look at two paragraphs in the article that I pasted below - they match perfectly ISLE approach:
"In simpler terms, if light had a non-zero rest mass, and that mass were heavy enough to explain why gravitational waves arrived 1.7 seconds earlier than light after traveling 130 million light-years across the Universe, then we'd observe radio waves traveling significantly slower than the speed of light: too slow to be consistent with what we've already observed.
But that's okay. In physics, we don't have any problem considering all possible explanations for an observed puzzle. If we're doing our jobs correctly, then we'll be able to consider every fathomable explanation, hold the data up against each one of them, and all of them will be ruled out except for one. The challenge is to find the correct explanation that fits all facets of our observations, and is still powerfully predictive for what signals should appear versus the ones that actually showed up.

And we think we have!"
You have to read the whole article to see what "THEY HAVE". What an amazing story!
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Eugenia Etkina
Admin
Top contributor
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October 30 at 4:28 PM
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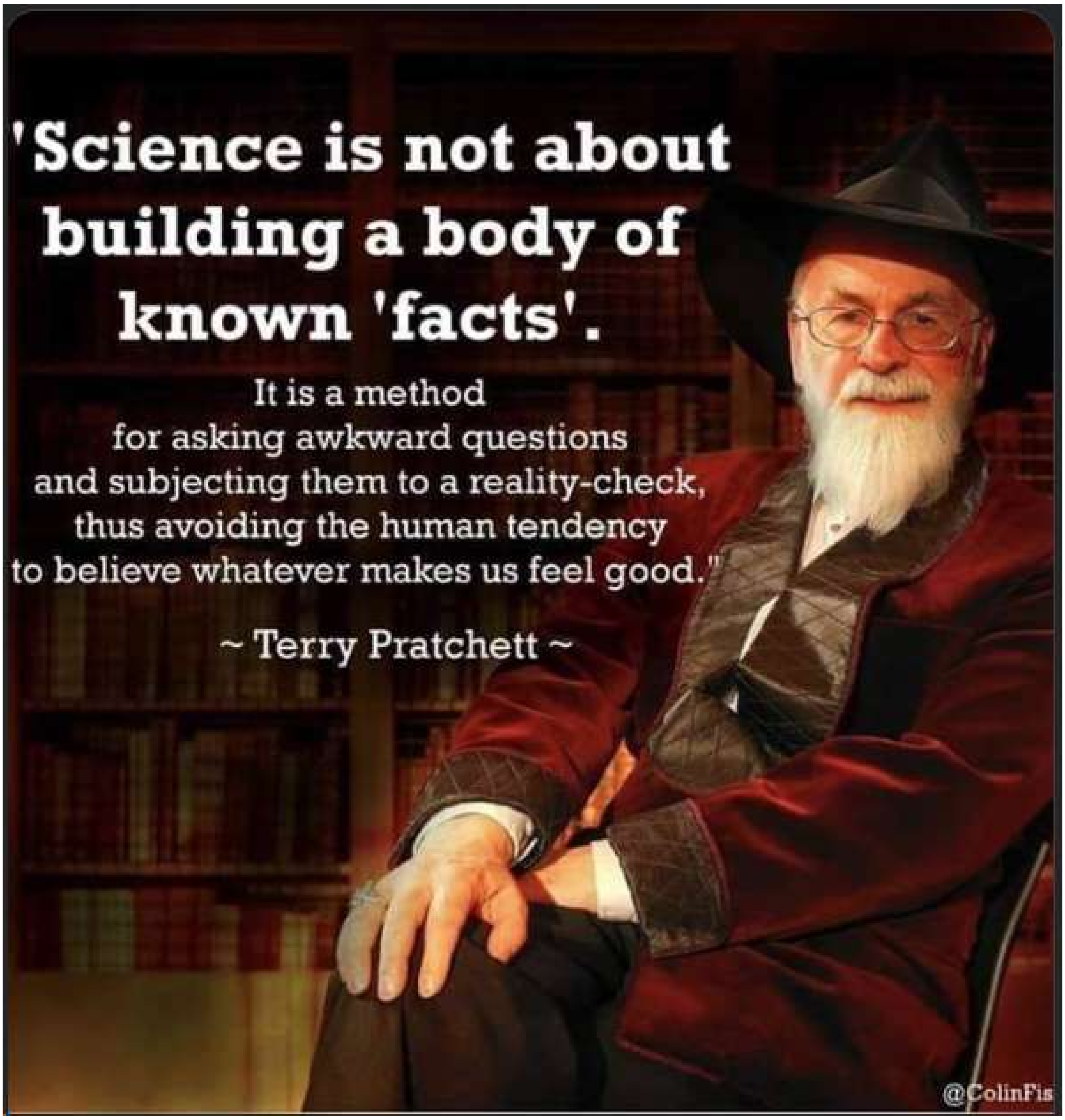
And this summarizes our method of teaching....



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Eugenia Etkina
Admin
Top contributor

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October 31 at 2:50 PM

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Hi all, yesterday I posted Terry Pratchett's quote about science. Many people saw the post and liked it.

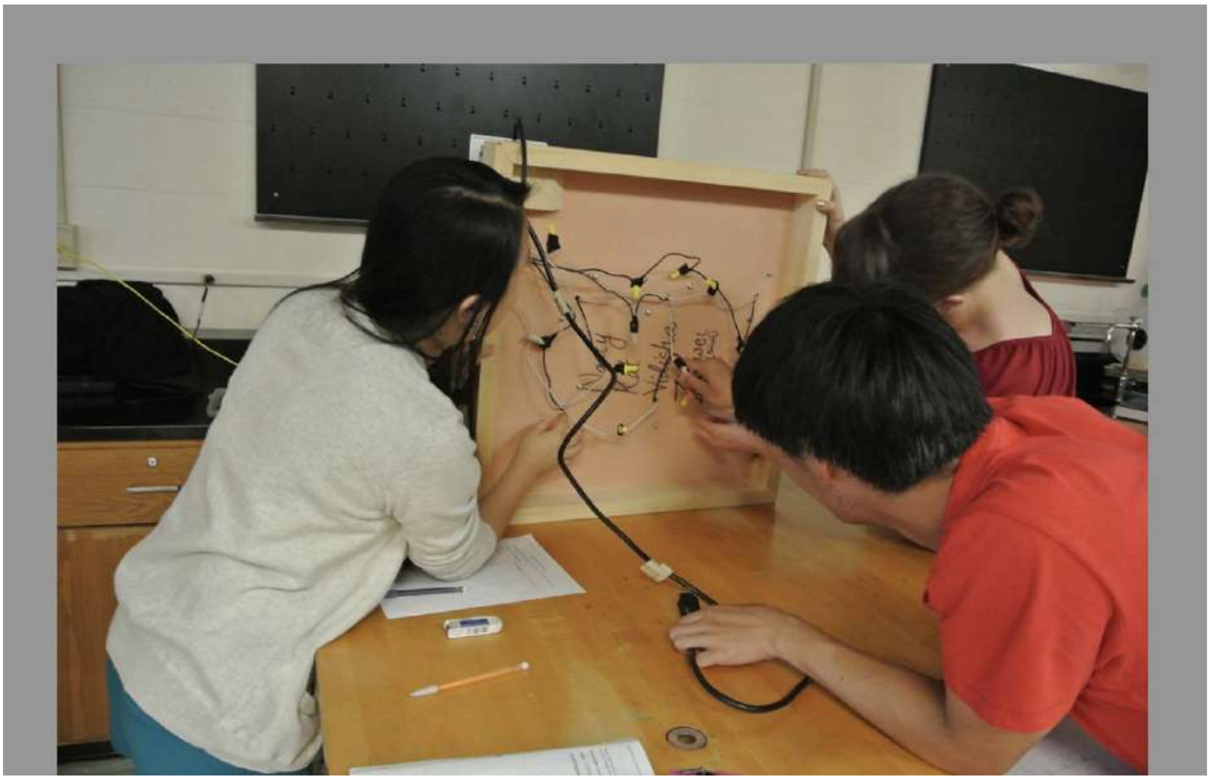
While we all might agree with what Terry said, many teachers struggle with HOW to implement his advice. The ISLE approach is not just a direct response to the quote (I mean the logical progression of activities for every concept) but more. Terry says that science starts with "asking awkward questions". But where do the questions come from?

It is this tricky moment that messes up our efforts. If you think of an old "scientific method" presented in textbooks (not anymore thanks to the NGSS), it went like this: question-hypothesis-experiment-conclusion. As you understand, this is total nonsense as it it impossible to come with a hypothesis if you have nothing to explain as the word hypothesis means an explanation, a conjecutre. And of course running one experiment (not clear how it relates to the hypothesis) and making a conclusion based on one experiment completely contradicts the nature of science. But this is not the only problem.

The problem is WHERE DOES THE QUESTION COME FROM? The same is true for the NGSS: the first science practice listed there is ASKING QUESTIONS. Where do they come from?

The ISLE approach addressed this issue: the questions come from observations or observational experiments. That is why these experiments are THE FIRST STEP in the ISLE procees. Only by observing something, collecting data and finding patterns, one can START ASKING QUESTIONS ABOUT THIS PHENOMENON. You might think that for example to ask a question of why clouds, that are made of water, float in the air which is made of air, one does not need to conduct any experiments. But this is not true. We have been conducting observational experiments all our lives by looking at the sky and noticing rain clouds up there. If we have never seen the clouds we would not have had the question. Therefore it is crucial to teach our students to observe the world around them and wonder about most common observations: why is the tap with cold water always wet and the tap with hot water dry? why do we slip and fall backward but when we stumble we always fall forward? Why do we feel thrown out of a circle when a car makes a turn?

There are lots of questions like these and by carefully observing the world our students become true physicists. As the difference between physicists and non-physicists (scientists and non-scientists to be honest) is that scientists observe and question (wonder) and non-scientists see and do not wonder. Let's turn all our students into real scientists by making them reflect on WHERE THE QUESTIONS COME FROM.
In the attached photo you see a group of students of Danielle Buggé who worked with a puzzle board, figured out how the bulbs are connected by conducting observations and asking productive questions and now they are checking their solution by looking at the wiring.



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Eugenia Etkina
Admin
Top contributor

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November 1 at 1:08 PM

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Hi all, two things today: first, if you are participating in our monthly workshops, please vote for the date of the workshop for Linear momentum (I posted the poll 2 days ago). Not too many people voted. Does it mean that the workshop is not needed and we can move straight to energy?
Second, for circular motion, I am sharing one of the OALG activities that your students can do with cell phones. Phyphox app is free and allows you to measure many things, including acceleration. Try this activity and you will see how great it is! The figure is attached as I cannot paste it in the text. The OALG file for Chapter 5 is in the FILES.
OALG 5.3.4 APPLY
This activity uses the Phyphox app on your phone and you will also need a measuring tape or a meterstick (any device that allows you to measure length). Hold the phone in front of you with both hands, so that the screen is horizontal and the y-axis points away from you. Start recording the acceleration (choose acceleration without g). Then start rotating with approximately constant speed around your body axis, keeping both hands extended (see figure below).
a. Obtain the a sub y(t) graph. Use the graph to estimate the speed with which the phone was moving (you can measure the length of your arms).
b. What should you do in the previous experiment so that the average magnitude of the reading increases/decreases (the phone should remain in the horizontal position)? Write down your ideas and test them. Do the outcomes agree with your predictions?

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Dear new members, this group is for those who use or wish to learn the Investigative Science Learning Environment approach to learning and teaching physics. To benefit from the work of the group, please go to islephysics.net and learn about the ISLE approach. Go to FILES here and check out everything that has been posted - chapters of the Online Active Learning Guide, and research papers.Then, try to check posts every day as ISLE-based professional development happens daily here and when you read a post, like it or comment on it to make it more visible and to ensure that the next post will show in your feed.
We not only have conversations but also monthly online workshops (free) about applying the ISLE approach to specific physics topics. The next one

is for Momentum. The date is November 18. Starting time noon EDT, length - 2 hours. Video records of previous workshops and records of posts are also available, I will post the link in the comments. Welcome!
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Eugenia Etkina
Admin
Top contributor
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November 6 at 10:49 AM
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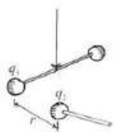
Hi all, three things today (please do not forget to like the post or comment on it to make it more visible): first I wanted to thank Amin Rainy and Marianna Anthea Bannon for their posts which invited so much discussion! And also Bor Gregorčič, Christopher Robin and Eugenio Tufino for all their comments!
Second, I wanted to thank all those who responded to my post about registration for the momentum workshop and signed up. We need about 10 more people to sign up to run a good workshop. The point of those workshops is not just me sharing our materials, but you working together and sharing your ideas! If there are no people to run group work, the benefit of the workshop is greatly diminished.
Third, I wanted to address the concern of "slow moving" though curriculum while using ISLE. There are two issues here. One, is that students take time to re-learn how to think (they knew how to do it before they started formal schooling but our traditional education beats it out of them very effectively), and once they do it, the pace picks up dramatically. So, if you feel that you are moving slowly while doing everything that I recommended (sense or urgency, prescribed time for completing an activity, etc.), be patient, the pace will pick up.

But there is also a very good way to speed things up. As you remember, one of the main goals of the ISLE approach is that students KNOW HOW THEY KNOW THINGS. The best way for them to do it is to do experiments themselves, collect their own data, reason about them, design new experiments to test their ideas, etc. This takes time. But you can achieve the same goal if the students only observe/do the observational experiments but DO NOT COLLECT DATA FROM THEM, you give them the data to analyze, do graphs, etc. Or, they can watch a video of the experiment and use the data that you provided. Or they can watch the experiment and analyze the GRAPHS OF THE DATA that you provided. Or they do not watch the experiment at all but read/learn about the set up and analyze the data collected from it. All these steps cut time significantly. As long as you do not use them all the time, and you continue to ask students how they learned what they did and they can describe the process, it is fine. We have lots of activities in the book and ALG/OALG that use this approach. One of them is helping students construct Coulomb's law for example. I am attaching the screen shot of the activity for it. Here they need to find patterns in the data and linearize the data too!

Activity for the students:

The figure at right shows a schematic of the experimental setup that Charles Coulomb used to determine the force that one charged ball exerts on another charged ball. He wished to find how the force that two electrically charged objects exert on each other depends on the magnitudes of the charges and on their separation. Coulomb did not have tools to measure the absolute magnitude of the electric charge on the metal balls. He used an ingenious method that helped him estimate the relative charges. He divided charges on the balls in half by touching a charged metal ball to an identical uncharged ball. The table that follows provides data that resembles what Coulomb might have collected. Represent the data graphically by collaborating with your group members on a whiteboard. Discuss with your group: which are the independent variables and what is the dependent variable in Coulomb's experiment? Then, analyze the changes in the dependent variable as you change only *one* independent variable at a time. Use this analysis technique (controlling variables) to find patterns in the data and devise a mathematical relationship based on these observations. Put your final mathematical representation on a whiteboard and share it with another group.



Charges (q_1, q_2)	**Distance** r	**Force** F
1, 1 (unit)	1 (unit)	1 (unit)
1/2, 1	1	1/2
1/4, 1	1	1/4
1, 1/2	1	1/2
1, 1/4	1	1/4
1/2, 1/2	1	1/4
1/4, 1/4	1	1/16
1, 1	2	1/4
1, 1	3	1/9
1, 1	4	1/16

Table Inductive reasoning to develop Coulomb's law (adapted from **College Physics: Explore and Apply**, p.152).

Notice that the students need to graph the data separately for each variable (see Figure below) to infer the pattern of the force being directly proportional to the product of the electric charges and inversely proportional to the square of the distance between their centers. If the students do this activity, they would determine exactly from WHERE Coulomb's law originates.

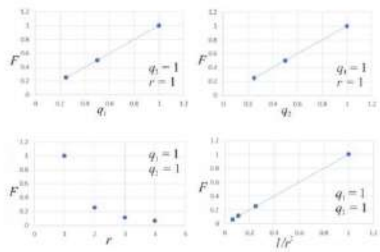


Figure Graphical representations of Coulomb's data to help students find a quantitative pattern using inductive reasoning.

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Eugenia Etkina
Admin
Top contributor
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November 8 at 10:49 AM
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Hi all, I did not post anything yesterday as I wanted everyone to have time to read the discussions that occurred on November 6. If you missed them, scroll back and read them. They are very illuminating. I thank everyone who contributed to those discussions. I have a few things today.
First, please sign up for the Momentum workshop in your EVENTS if you are interested in learning not only about momentum but about the nature of conserved quantities. A misunderstanding of this concept leads to all kinds of issues not only in momentum, but most importantly, in energy. That is why we do momentum first and energy next. In fact, we do not even start with momentum as a conserved quantity, we start with mass. Understanding the difference between conserved and constant allows you to represent conserved quantities with bar charts - an invaluable tool when analyzing processes involving momentum and energy. Note, that even NGSS uses the wrong language when talking about conserved quantities, this shows how difficult this concept is.
Second, I know that in the AP curriculum Energy comes before momentum and I happen to disagree with this approach. I do not see anything wrong with actually switching to momentum first even if you are teaching AP. Nobody said that we need to do all topics in the order prescribed. Why do I recommend doing momentum first? It is because momentum is OBSERVABLE! The students can see things moving or not moving. With energy is is more difficult - you cannot see internal energy (unless you have an infrared camera). And momentum is just one thing, while energy comes in different forms. And there are other reasons.
I also want to warn you about many textbooks providing confusing narratives related to energy. We addressed this issue in several papers,

one of which is our editorial in the American Jounral of Physics. Before you start energy, and read our textbook, please read the editorial! I am attaching it again, although I posted it earlier too.
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Eugenia Etkina
Admin
Top contributor
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6 days ago
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Hi all, as you remember, the ISLE approach has two intentionalities. If you are not familiar with this word, in education intentionality in education "emphasizes purposeful and strategic actions by teachers (or curriculum designers) to create a meaningful and effective learning experience for students. It involves careful consideration of instructional choices, ongoing assessment and reflection, and a commitment to meeting the needs of diverse learners." (the response of ChatGPT when I asked it what the word intentionality means in education).
This sounds too general, right? What it really means is that what ever you plan or do to help students learn or your students do to learn takes into consideration your major big goals (memorizing Newton's laws is not one of those).
What are those big goals that we set? There are two of them. The first one is that our students learn physics by engaging in the activities that mirror the practice of physics. This not only includes observing, finding patterns, coming up with multiple explanations, designing experiments to test those, etc., etc. It also involves, working collaboratively, sharing, arguing, presenting and most importantly redoing your work, resubmitting your assignments for improvement without losing points for multiple trials. This

is what physicists do when they learn about the world and this is how we want out students to learn. But this is just the first intentionality.
The second one is that while doing all this, our students feel that they love physics, that they CAN do it, that they belong in physics, that they are motivated to push themselves to work harder and move further. This seems like a very difficult goal, right? And yet, by changing the environment in which our students learn, it is achievable!
I am asking all of those who have been implementing the ISLE approach for a while to share how they achieve this second intentionality in their classes. I will only share one quote from a series of interviews that Yuhfen Lin and David Brookes did with their students (more is published in our paper about ISLE linked here). Here is the quote:
“I definitely do enjoy Physics. I enjoy Biology for other reasons but it’s just because I love animals so it’s a different reason. But in terms of interaction and stuff like that, I like Physics a lot, a lot. And it really does—at first I come to class and I’m like, "Oh what crazy thing are we gonna do today? Let’s see what happens."
And then when we’re actually doing it I’m just so hyped and I’m so excited and magnets, you know I love magnets. My magnets, oh those are my babies, I love my magnets.
But with magnets and with mirrors and with lenses it was exciting, it was cool and it was like I knew I was gonna leave with something that was gonna blow my mind.”
Please share your students' experiences!
And here is the link:

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Eugenia Etkina
Admin
Top contributor
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5 days ago
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Hi all, it looks like people are busy and they did not share yet how they address the second intentionality of ISLE in their teaching. I will start then and hope that Danielle Buggé, Debbie Stephanie, Yuhfen Lin, Andrew Yolleck, David Brookes, Valentina Bologna Longo, Bor Gregorčič, Gregor Brumec, Kristina Pahor, June Lee, Yuehai Yang, Sheehan H Ahmed and many others will add their comments.
So, how do we inspire and motivate our students? How do we make them feel that they CAN DO physics? How do we help them develop growth mind set? Here is my experience:
Encourage them to resubmit their work for improvement. Do not take points off for revisions. Publicly say many times that revising is a positive thing, not a sign of weakness.
Share your struggles with physics and how you overcame them. I always share my problems with magnetic field for example. I am a lefty taught to be a righty (where I grew up they would not let you eat or write with your left hand), and my brain has difficulty with right and left (I never know how to turn a lid to open a can, I need trial and error), so learning all these right hand rules was hard. But since I started actually using my hand instead of thinking about it, everything got better.
Always use a good "need to know" before you start a new unit and "dangle" it in front of your students continuously, so that they see the purpose of their learning. Make sure you come back to it at the end and let THEM figure it out.
Respect and encourage their questions. Praise good questions and opinions that are different from yours! The latter is difficult and sometimes annoying but listening to opposite opinions is the strength of science!

Have VERY HIGH expectations. In my experience, students always rise to your expectations. You expect them to be not interested and lazy - they will be. You expect them to be motivated and hard working - they will be. You just need to communicate your expectations not through words but through your behavior. If you are excited about a physics experiment - they will be too. If you return their work graded the next day and let them know what to work on, they will! (if you return it a week later, they will not care as you showed that you did not care either). Think carefully how your behavior and responses to them might inspire and motivate them, and try to do it more.

Set up infrastructure for help. Office hours, makeup times, pairing students who struggle with those who excel, there are so many ways to help them, find as many as you can.

And always, always reward persistence, not speed.

Finally, reward good work with more work, not less. WHAT??? You are probably thinking that I am crazy. I am not. I would tell my students - you did a great job on this problem, now I will give you the coolest experiment ever to explain! This way an opportunity to work on some challenging stuff is a desirable thing.

There are so many other things you can do to motivate your students and make them word harder and believe in themselves. Please share! Two years ago we had a meeting on how to do resubmissions and not overwork yourself, I am attaching the link to the slides from that meeting.
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Eugenia Etkina
Admin
Top contributor
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2 days ago
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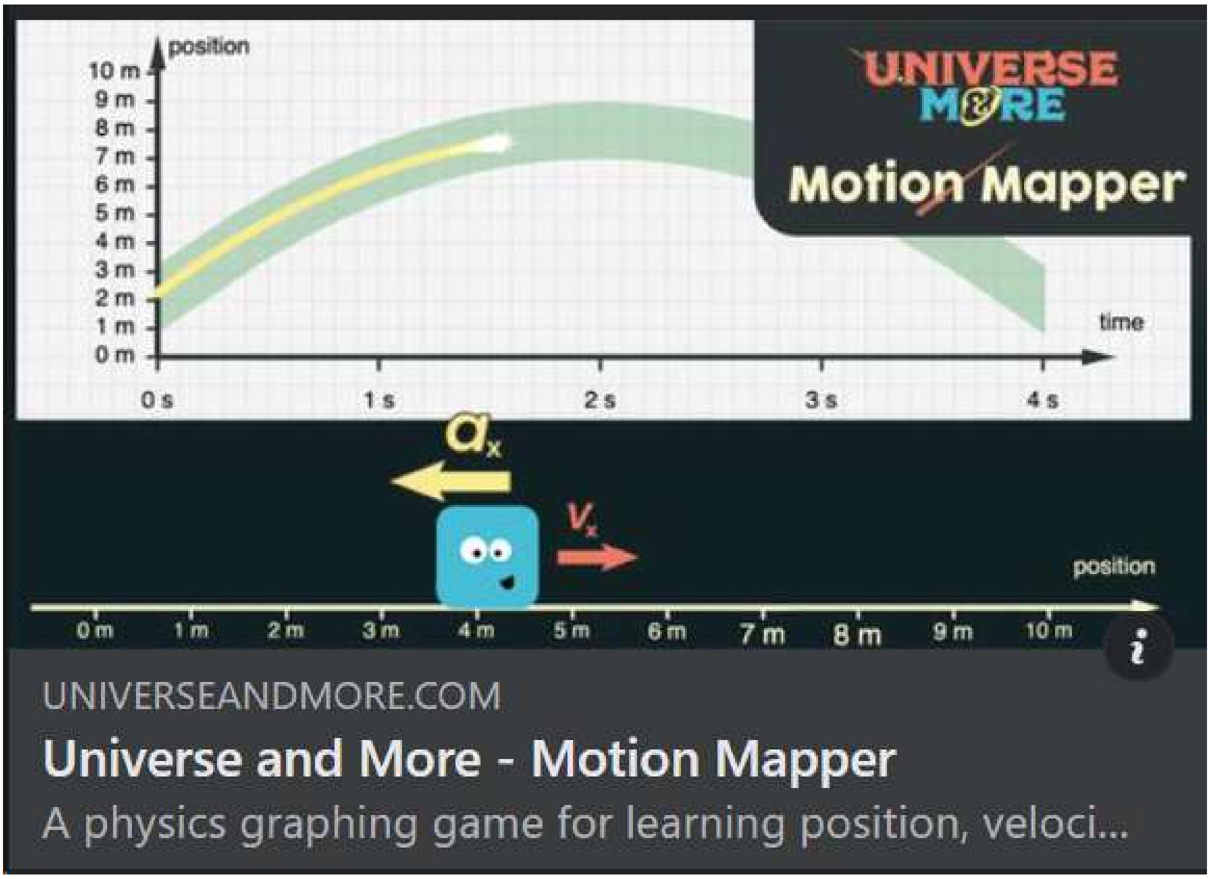
Hi all Exploring and Applying Physics people! A few things today. First, I noticed that recent posts have fewer views than average. Are the notifications aboit posts coming to your feed? If not, try to check every day for a few days and will come back.

Second, I am reminding you that we have Momentum workshop on Saturday, if you have not signed up yet, please do by going your EVENTS page.
Third, I stumbled upon a very good article by Joe Redish in the Physics Teacher about graphs "Using math in physics 6: Reading the physics in a graph." I can't attach it here, I will do it in the next post , but I am also reminding you that if your students are still having trouble interpreting graphs, one of the best ways to help them is through the games designed by Matt Blackman at universeandmore.com. The game is called Motion mapper. Go to https://www.universeandmore.com/motion-mapper/ and try yourself first. Then assign to your students!



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Eugenia Etkina

Admin
Top contributor
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2 days ago
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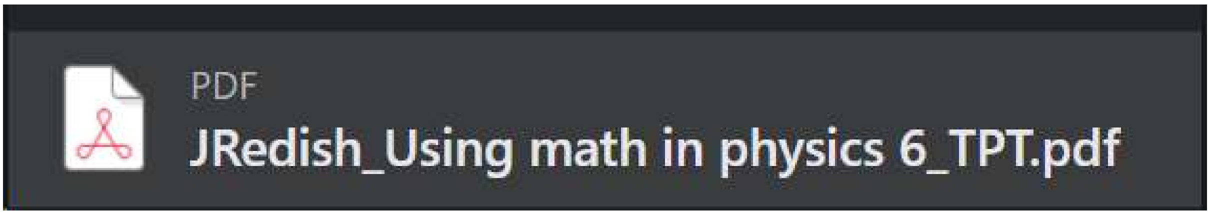
And here is the paper from the previous post. PLEASE do not forget to like the post or comment on it to make it more visible for other group members. Thank you!



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Eugenia Etkina
Admin
Top contributor
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a day ago
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Hi all, today I will talk about language (again :))
You probably noticed that we do not use the term "centripetal force" in our circular motion chapter (or in the workshop, or on the ALG/OALG). Why? The thing is that we found through observations of students that once we give a force a special name, the students start thinking that it is an additional force exerted on an object. If we use the term centripetal force, they think that they need to put this force on the force diagram. The same is true for the net force.
We do not use this term or try to avoid it. Same reason. There are forces exerted on an object, and then there is a net force - and the students try to put this net force on the force diagram. So, we decided that the only

way to avoid these extra forces is to use the term sum of the forces all the time.
Now, about a sticky point - the term centrifugal force that students hear. What is that? This term actually might stand for two completely different forces.
One meaning of a centrifugal force is the force exerted by a revolving object on a string that pulls it towards the center. As it is not exerted on an object of interest, we do not put it on a force diagram but it is a "real" force in a Newtonian sense - it is a quantity that describes a real interaction but this force is not exerted on an object of interest. It is the force that the object of interest exerts on an object that causes it to accelerate towards the center of the circle. For example, when you are in a car making a turn, the seat belt pushes you towards the center, but you, in turn push the seatbelt outward, and the force you exert on the seatbelt is the centrifugal force. This is the force that Damien Walters in our "need to know" video exerts on the loop-the-loop track that he is trying to run on upside down.
https://www.youtube.com/watch?v=dSDb9oKMCRc&t=20s
But there is another meaning of this force: non-Newtonian meaning. It is used when you analyze circular motion being in an non-inertial reference frame of the observer who is moving in a circle themselves. In this turning car, you are at rest with respect to the car. If you were to draw a force diagram for yourself, you should not have any acceleration, so the sum of the forces exerted on you should be equal to zero. To achieve this, you add an imaginary force equal to negative ma. This is this "virtual" non-Newtonian centrifugal force not associated with any interacting object. That is why we never put on a real force diagram as the real force diagrams are drawn for an observer in an inertial reference frame and this person is standing on the ground. Hope this makes sense.
I know that we do not use this term ever, but why we do not use it is a good question. I tried to answer it above. If it does not make sense, please ask questions.
Recently, I noticed that the number of views of the posts dropped dramatically. The number of comments increases and the number of views drops. Very strange. In any case, please keep liking and commenting posts to make them more visible. Thank you.

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Eugenia Etkina
Admin
Top contributor
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12 hours ago
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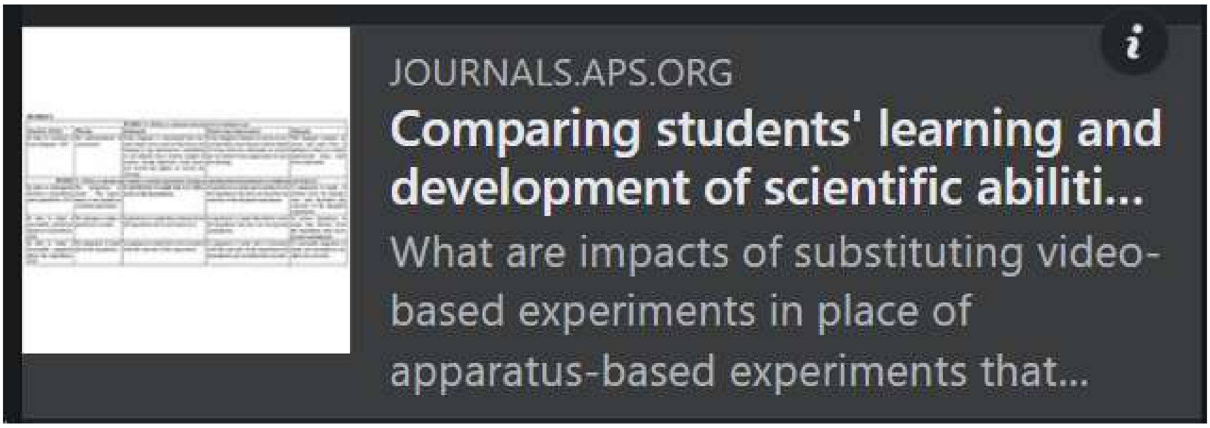
Hi all, our new paper just came out in Physical Review Physics Education Research journal. It is about learning through the ISLE approach using real experiments or ISLE-Based videos created through the PIVOT platform. As the jounral is open access, you can download free. Enjoy!



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Eugenia Etkina
Admin
Top Contributor
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November 20 at 9:47 AM
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Hi all Exploring and Applying Physics people! Two things today. First, I am thinking of running our first work and Energy workshop either December 9 at noon EDT or December 16 at 1 pm EDT (notice different time on the 16th). During the momentum workshop last Saturday I said that only the 9th is possible but then I figured that I can do the 16th too, but an hour later.

The second thing I wanted to talk about is again the difference between conserved and constant. The confusion between these two words does not come from the students. It comes from us! For years we confused these two words in the context of momentum and energy (most textbooks do and even NGSS do!). But our students who have never heard the word "conserved" in physics prior to studying these, only heard "constant" with respect to velocity or acceleration. So if you would not confuse those two words, they don't.

Constant means that the quantity does not change with time (like momentum in an isolated system). Conserved does not mean constant at all! It means that if a quantity changes in a particular system, we can ALWAYS find where it went (or came from) and find a system in which it is constant. The word ALWAYS is important here. Acceleration, velocity, temperature can be sometimes constant in a system, but when they change it is not possible to redefine the system to keep them constant. They are not conserved quantities. We also know that mechanical eenergy is not a conserved quantity, as well as kinetic energy. So the term conserved cannot be used when talking about those energies, but the term constant can, as sometimes those quantities can be constant.
I don't know the history of this confusion, who was the first to teach mechanical energy by itself and say when it is conserved and when it is not. Mechanical energy is not a conserved quantity and is NEVER conserved, but it can be constant sometimes. So, if you have trouble distinguishing these two words, please come to our workshops or pose questions here, it is time to clear this confusion and make sure that we do not confuse our students.
I messed up the dates in the first version of this post, so I will post the poll separately.
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Eugenia Etkina
Admin
Top Contributor
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November 21 at 9:06 AM
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Hi all Exploring and Applying Physics people! Two things today: first I am asking you to vote for the date of the first Work-Energy Workshop. If you

voted yesterday, it could have been for my mistaken dates. So please see the poll again and vote. So far December 9 is the winner (December 16 is another possibility)
Second, during our Momentum workshop we did not have time to do a very important activity - I pasted it below. Please read it and comment about what fundamental ideas about Momentum does this activity address? Why is it so important?
a. Watch Eugenia wearing rollerblades and holding a ball https://mediaplayer.pearsoncmg.com/.../sci-OALG-6-4-6a. She pushes off the floor once and continues rolling at constant speed across the floor. Then she drops the ball. Describe everything you can about momentum in this process using words, bar charts, and mathematics. Choose Eugenia and the ball as the system and initial state is when Eugenia is rolling while holding the ball and the final state is right after she lets go of the ball. Does dropping the ball change Eugenia's speed? What if, instead of the basketball, she dropped an object that is 1/10 of her mass in the same manner as before? Would her speed change?

Eugenia Etkina
Admin
Top Contributor

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November 23 at 10:13 AM

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Hi all Exploring and Applying Physics people! Today is the Thanksgiving holiday in the US and the day of giving thanks to the world for everything that you are grateful for.

People usually do it at the Thanksgiving dinner table with all its traditions, but as we are not having dinner together today and many of you live in countries outside the US, I wanted to take this opportunity to extend my deepest thanks to all of you.

You all work very hard and finding time to follow what is happening in our community requires persistence and dedication. You have it and I thank you for it. You come to our workshops that last for 2 hours on Saturdays disrupting your weekend with your family and friends. I thank you for it. You immediately respond to anyone who is asking for help or advice no matter what time of day it is. I thank you for that.

Hrvoje Mililoža saves all the posts and allows you to go back and read them. I thank him for that.

Hrvoje Mililoža and Eugenio Tufino save all the videos of the workshops allowing you to watch them if you missed. I thank them for it.

Dedra Demaree, Sheehan H Ahmed ,and Paul Wolf are always the first to read and like the posts. Thank you!

Jane Jackson, thank you for your thoughtful commentaries and detailed reading of the papers. Thank you for all the help you have given to this group!

Bor Gregorčič finds incredible materials to post here. Thank you!

Anne L. Caraley has been attending ALL workshops for the last 2 years. Thank you!

Hisashi Kuriki has been attending all workshops this year despite the fact that they start at 2 am in Japan - his home country, and so has Deepa Jain! Thank you both!

Yulia Turchaninova was the one who started those workshops 3 years ago. Thank you!

There are literally hundreds of other people who regularly contribute to the posts: Christine Russell, Phyllis Rogg, Allison Daubert, Amin Rainy, Ann-Marie Pendrill, Gopa Mukherjee, Matthew Mac, Marianna Anthea Bannon, Matthew L. Jacobs, Nathan Spear, Yuehai Yang, Yuhfen Lin, Roby Rod,

Kristina Pahor, Scott Garbacz, Stephanie Hunt, Charles Mamolo, Amy Paris Bancroft, Diane Crenshaw Jammula and many others - too many to name - THANK YOU!
Thanks to David Brookes, my life time collaborator and the person who is responsible for the very first ISLE video website. Not to mention his research that we use every day.
And finally, many thanks to Gorazd Planinsic who creates these amazing videos and experiments that we use in every workshop and that are in the ALG, OALG and in the textbook.
Have a wonderful day! I will post the invite to the Energy meeting tomorrow.

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Eugenia Etkina
Admin
Top Contributor
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November 26 at 8:38 AM
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Hi all Exploring and Applying Physics people! two things today:
Please sign up for the Energy workshop if you are planning to go. So far 10 people signed up. My experience is that about 2/3 of those who sign up actually come and when the group is too small, the group work is not possible. Without group work there will be very little learning. So, please, if you are planning to go, sign up. The link is in my yesterday's post.
I am reminding all of you of all the resources that are available for those who wish to implement the ISLE approach.
The textbook free examination copy is available through your Pearson rep, if you are having trouble with them, just email me at eugenia.etkina@gse.rutgers.edu and I will help. The ALG, OALG, and the

instructor Guide are all free on Mastering Physics. To find your rep and to get on mastering physics, follow instructions on https://www.islephysics.net/?page_id=159
Free resources:
PUM – Physics Union Mathematics) for middle school, Physics First and high school
http://pum.islephysics.net/;
A complete ISLE-based Laboratory Program (for algebra- and calculus-based physics)The website below contains ISLE-based labs and the rubrics that can be used for student self-assessment https://sites.google.com/site/scientificabilities/
A set of ISLE Video Experiments http://www.islevideos.net
ISLE-based physics video games https://universeandmore.com/
All this information is always available at https://www.islephysics.net/?page_id=51

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Eugenia Etkina
Admin
Top Contributor
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November 27 at 10:10 AM
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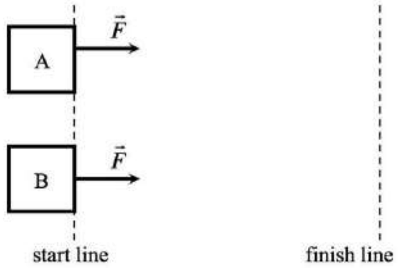
Hi all, two things today. First, please sign up for the Work-Energy workshop if you plan to attend it. It is in your EVENTS.
Second, the problem I post here always causes a lot of discussion in class among students. Why do you think it is? What are the right answers? How can we help students reason productively about this problem?

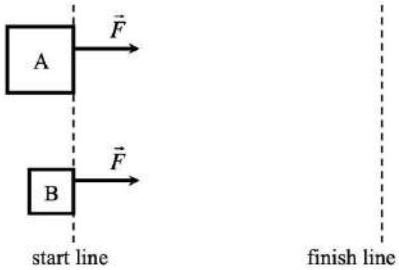
OALG 6.3.3. Reason

Answer the following questions.

a. You continuously push equally hard on identical blocks A and B from the start line to the finish line. Block B is initially at rest whereas block A is initially moving right. Which block has the greater change in momentum in moving from the start to the finish line? Explain your answer.



b. Suppose that both blocks in the previous problem start at rest, but that block A has four times as much mass as block B. Which block has the greater change in momentum in going from the start to the finish line? The blocks are pushed with equal-magnitude forces.



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Eugenia Etkina
Admin
Top Contributor
·
November 29 at 4:30 PM
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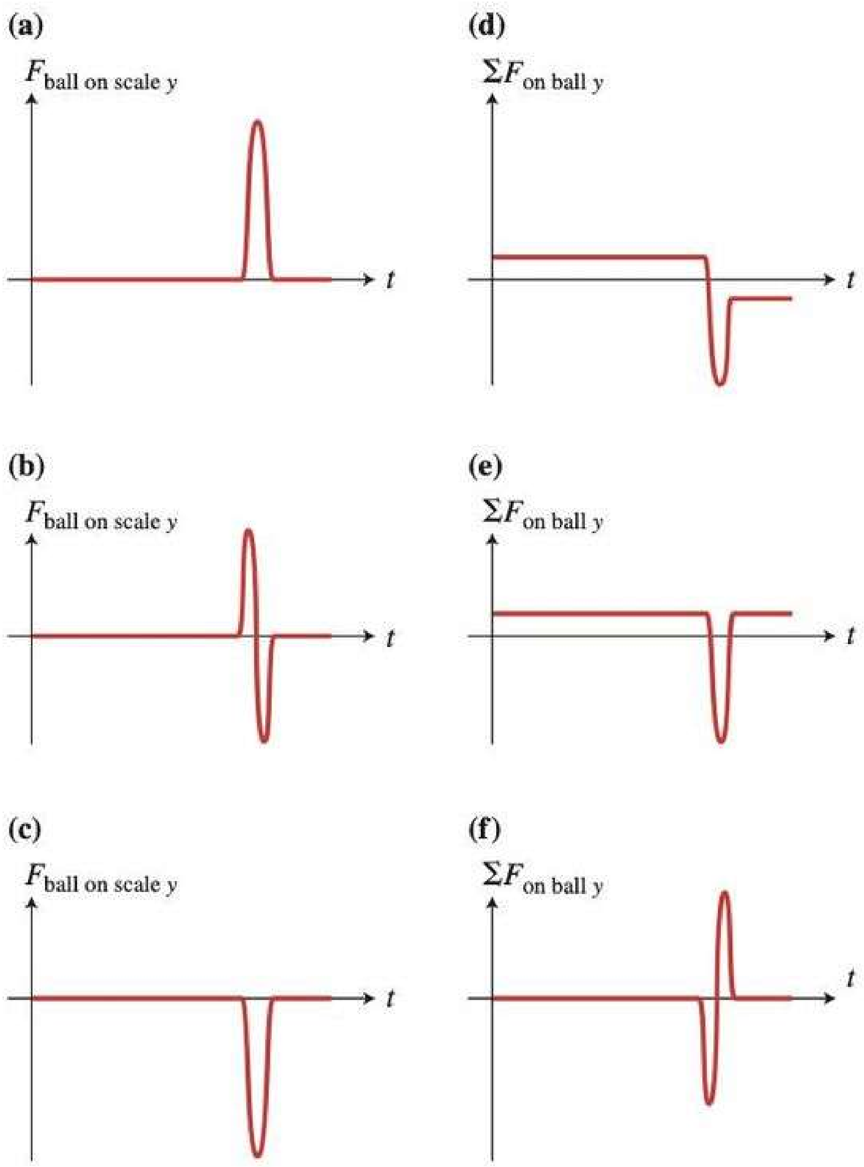
Hi all, I did not post anything yesterday to avoid distracting you from several excellent posts - by Amin Rainy and Dorota Sawicka. Thank you both for sharing your ideas and posing questions. And thank you all who responded - this is what our community is all about.
Today I wanted to remind you to sign up for the Work energy workshop (in your EVENTS) if you have not done it yet.

I also wanted to share another momentum-related question that leads to a great discussion with the students (it is from our textbook). It involves a non-traditional set of graphs which is a common thing for AP type questions. Please discuss why this question might provoke a good discussion? and please do not forget to like the post or comment on it to make it more visible. Thank you!

13. You hold a rubber ball above a scale and then drop it. After hitting the scale, the ball bounces up. In Figure Q6.13, which of the graphs (a) to (c) correctly shows the qualitative time dependence of the force exerted by the ball on the scale, and which of the graphs (d) to (f) correctly shows the qualitative time dependence of sum of the forces exerted on the ball? Assume the y-axis points vertically down.

FIGURE Q6.13



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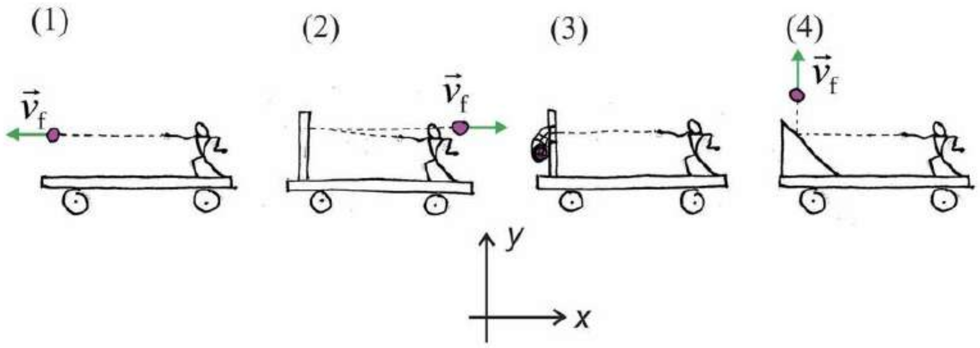
Eugenia Etkina
Admin
Top Contributor
·
November 30 at 12:41 PM
·

Hi all Exploring and Applying Physics people! A few weeks ago, Allison Daubert asked me why in our textbook we do not have any problems that require students to derive mathematical expressions. I answered, that we do in fact have a lot of them, only they do not start with the word Derive, but with the word Determine. The reason is that when we started working on the first edition of our textbook (way back in 2000), there was no revised AP physics courses that would ask students to derive anything and the word "derive" mostly meant the dread that the students felt when their teacher would start deriving equations on the board. So, we removed the term Derive from all our End of the Chapter problems. But, the truth is we ask students to derive general expressions a lot not only in the textbook but in the ALG/OALG too. An example from the ALG Chapter 7 (momentum) represents a novel approach to the concept of derivations. Please try and share your results! Thank you!

6.7.3 Apply

Shawn (mass M) performs four experiments on four carts. All carts have equal masses $2M$. The carts are on a frictionless track and initially at rest. In all experiments, Shawn is standing on the cart and throws a ball of mass m horizontally in the negative x-direction, always with the same initial velocity $\vec{v}_i$ (initial state). The final states are shown in the figures below. Assume $|v_i| = |v_f|$ in the experiments 1, 2, and 4, and the final velocity of ball 3 is zero.



a. Draw an impulse-momentum bar chart for each experiment. The system is Shawn, the cart, and the ball. Show separate bars for each object of the system.

b. For each experiment, derive an expression for the final speed of the cart in terms of relevant parameters. Discuss the direction of the final velocity.

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Eugenia Etkina
Admin
Top Contributor
·
December 1 at 10:49 AM
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I posted many times about women-physicists. This one is different. This ia about a woman due to whom we have the word "scientist". Please share with your students!

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Eugenia Etkina
Admin
Top Contributor
·
December 2 at 2:34 PM
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Hi all those Exploring and Applying Physics people who signed up for the workshop on Work and Energy a week from now. There is some homework that you need to do before the workshop.
1. Look around your house, your school/university prep room, your friends' houses and find all mechanical toys. We will need them for the workshop. The more the better. Wind-up toys, wind-up cars, pop-up toys, nerf guns, anything goes! I attached some screen shots to help.
2. Get your students (5-10) to run together up a few flights of stairs. Then ask them to run down the same number of flights (together). As them to describe how they felt on the way up and down and also if they heard any difference in the sound that they made going up and down. Record their observations. Then repeat the experiment yourself (if running is an option). Record your observations.
3. Find a brick (lots of them are outside), a few pieces of real chalk and a prepare a few sheets of printing paper. You will need this equipment for the workshop.
If you plan to attend the workshop but did not sign up yet, please do it by going to your EVENTS.
If you read this message, please do not forget to like it or comment on it to make it more visible for other group members. Thank you!

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Eugenia Etkina
Admin
Top Contributor
·
December 4 at 11:58 AM

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Hi all, recently Tom Prewitt and Andres Akamine shared their thoughts about student engagement in our lessons. I agree that it is nearly impossible to have a 100% of the students to be engaged, motivated, and working with gusto during our lessons/labs/classes. Not that we should not strive to achieve this, but life is life.

However, how do we maximize their engagement and increase motivation? Here are possible things to do:

"Need to know"

Make sure that you not only have a cool "need to know" for every big unit but also for every lesson, and do not forget to remind your students about it as they struggle along.

2. Tools to tackle borderline difficult activities

Avoid boring, repetitive activities (use what we have in the ALG/OALG, those are never repetitive) and make sure that activities are just borderline difficult for your students - they have the tools and knowledge to do them and they know what tools to use, but they still need to think and be creative while trying to solve those. So, the activities should not be too easy, and shot be impossibly difficult. You need to decide the level as you are the only one who knows your students.

3. Feeling of success

Make sure that during each lesson your students have an opportunity to experience the feeling of success. Predicting the outcome fo a testing experiment based on a hypothesis that they have just created themselves is the best way to achieve it, but there are many other ways to make your students feel successful. It is crucial that these positive emotions occur on every lesson. They release dopamine in the brains of your students and dopamine is addictive. So, basically, you need to get them addicted to learning by letting them experience success.

4. Minimize sitting time

Let them move around the classroom or stand while they are working on activities. Sitting creates boredom. It is as dangerous for our mental lives as it is dangerous for physical lives. Make them visit other groups, come to the table where you have one experimental set up, go to the hallway to run experiments, ride an elevator standing on bathroom scales, etc. Let them MOVE!

5. You learned a lot!

Make your students aware of how much they have learned TODAY. (every day). Do not skip end-of-the-lesson reflections and make sure that they need to give you a sign when they think that they also have learned something that another person mentioned. This collective "reflection" makes them see how much they learn every day, makes them proud of themselves and this is what will motivate them tomorrow. Often our students cannot self assess their progress, so you need to tell them. for example: "Last week very few of you could draw correct force diagrams, and today every single person did, this is a huge achievement!"
Remember the second intentionality of the ISLE approach - help students feel that they CAN learn physics, that they belong in physics, and that physics is an exciting subject to learn. Thinking of how this intentionality shapes everything that you do in your classroom is superbly important if you wish to implement the ISLE approach.
Attached are the photos of Danielle Buggé's students that show that real active engagement and excitement are possible.
Thank you for reading.

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Eugenia Etkina
Admin
Top Contributor
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December 5 at 10:40 AM
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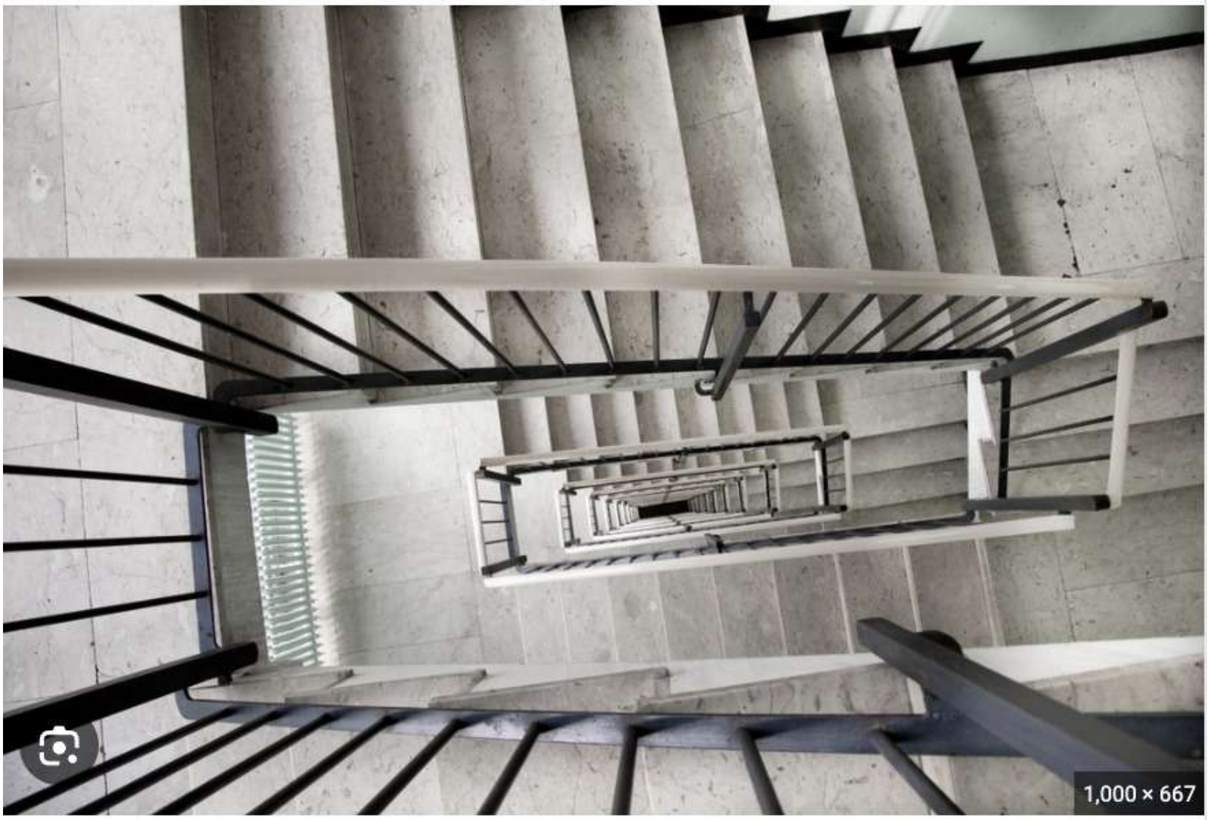
Hi all, I am not posting much today as I want people to have time to read previous posts, but I am reminding those who signed up for the Energy workshop on Saturday that they need to prepare the bricks, the chalk, the toys, and to do the experiment that I described in my post 2 days ago on Saturday (please find it and read it if you missed it). It involves your students and yourselves running up and down the stairs.



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Eugenia Etkina
Admin
Top Contributor
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December 6 at 10:12 AM
·

Hi all Exploring and Applying Physics people! today is about derivations (again!)
We often think of derivations as a process of showing students where the equations that they need to use came from. While it might seem like a worthy way to spend learning time, us deriving equations for the students

has the same effect as us explaining to them something - a zero effect, as people do not learn from listening or watching somebody. To learn they need to do something to change their own brains, and this only happens when they connect what they are experiencing to their existing neuronal connections and actively test new ideas engaging motor function of the brain (the brain cycle, to learn more read J.Zull's The art of changing the brain). So, how do we engage our students in learning how to derive mathematical expressions in a physics context?
I am sharing one of the problems in the Momentum chapter (as we are focusing on Momentum this month) that engages students in such process. Please share your thoughts and solutions. Thank you. And please do not forget to like or comment on the post to make is more visible.

47. ** You are investigating a newly discovered particle X that has an unknown mass M and moves with a constant but unknown speed u. In your experiments you observe collisions between particle X and different test particles with known masses m that are initially at rest. You let the particles collide head-on and stick together, and you measure the speed v of the combined-particle object. From other observations you know that in all experiments the objects move along the same straight line before and after the collision. Your data are shown in the table at right. Note that the masses are expressed in units of reference mass m_0 and the speed in units of reference speed v_0.
(a) Derive an expression for v in terms of M, m, and u. Indicate any assumptions that you made. (b) Determine M and u using the data in the table. (Hint: Rearrange the expression that you derived in (a) to obtain a new equation with the linear dependence on m.)

m (m_0)	v (v_0)
2.0	0.55
4.0	0.45
6.0	0.35
8.0	0.30
10.0	0.25

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Eugenia Etkina

Admin
Top Contributor
·
4 days ago
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I am posting this in response to Roby Rod post, I could not attach this to my comments. I had this poster on the door of my office for 20 years. All my students know it.

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Eugenia Etkina
Admin
Top Contributor
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3 days ago

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Hi all! I wanted to continue the conversation that started yesterday by Roby Rod. We mostly focused on the students in our explanations of why Roby is experiencing difficulties with her students accepting ISLE as a method of learning. Everything that was said here is true. However, I wanted to focus our attention now on another aspect - of a teacher implementing ISLE for the first time.

I started playing tennis without a coach. I watched other people play and managed to get the ball over the net (most of the times) and as I am quick on my feet I could compensate for the lack of technique by getting to the balls quickly and hitting them back. I thought I could play until a friend of mine, a really good player, joined me. Man, it was a total disaster. I could not get anything. He was playing a different game, 10 levels up compared to mine. So, I found a coach and asked him for help. He watched me play and said: "Eugenia, you hit the ball incorrectly and you serve incorrectly, but you compensate by running fast. If you wish me to teach you how to really play, prepare to be very frustrated and playing much worse than you do now at the beginning. But if you stick with learning and practicing, your game will improve tremendously."

I told you this story as switching from traditional or even semi traditional teaching to ISLE is like playing a completely different game in the classroom. Who said that we would be good at it at once? If you an ISLE master, your classroom feels like magic (watch Danielle Buggé's classroom, or Debbie Stephanie's, or Michael J. Gentile's, or anyone who spent years practicing ISLE), but when you are a novice, it will take time for you to master all the moves. My physics teacher preparation programs has 7 graduate courses in which future teachers learn how to use ISLE and they also practice it with the master teachers though clinical practice during all two years of their program.

Thus, if you are just starting, even if you attended EVERY workshop that I conducted here, prepare to spend time perfecting your craft. You do not expect to start playing a musical instrument like a pro instantly, right? Same with ISLE - it is a true music of teaching and it will take time mastering it. Try, reflect, revise, improve, try again, day after day. This is what we all do, did, and will do to learn anything that is difficult. Is ISLE

difficult? Yes. Can you learn to do it perfectly instantly? No. Will you learn and become a master if you persevere? YEEEEEESSSSSS!
Bottom line: the same way that it takes our students multiple exposures to learn a concept, it takes multiple exposures over the years to master ISLE.
NO FEAR!
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Eugenia Etkina
Admin
Top Contributor
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2 days ago
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Hi all, thank you for contributing to the discussion of the reasons why the first year of the ISLE approach implementation is difficult. Thank you, Roby Rod for starting this discussion!
A few things today. First, I wanted to announce that our Second Work-energy workshop will be in January 6. Unfortunately I cannot offer you poll choices this time as my all other Saturdays in January are committed and also, I thought, the sooner we finish energy - the better. So, January 6th it is! I will create the EVENT for the workshop - please sign up!
Second, I wanted to continue our conversation about work and energy. In the workshop the issue of systems came up - that it is a new concept for many and we do not feel confident operating with it. I completely understand. I taught physics for many years before I learned the importance of this concept from Alan Van Heuvelen.
Why is it so difficult? In physics system is ANYTHING we want to include in it. We want to be one object - fine, we want to be two - also fine. It is our choice. But this choice has consequences. If an object is not included in the system, it is still VERY important, as it can exert a force on it, an impulse, do work, etc. Objects, internal to the system do not exert forces

on the system, as due to Newton's third law all these forces add to zero (that is why we need external forces to accelerate). Same is with work - internal objects do work on each other but all these works add to zero, that is why we do not consider them when we think about the changes of energy of the system. What the internal works do is convert one type of energy to another - from GPE to KE for example (if Earth is in the system). The difficulty with this approach might come from biology, where if an object is not in the system, it is not important for the behavior of the system. In physics, as you see, it is very different.
Why is is so important to choose a system before doing any analysis - forces, momenta, energy, charge, anything! Because, in energy analysis for example, the system's choice determines what energies are present in the system. If Earth is in the system, the system has GPE. If not - Earth does work on the system, but there is no GPE in the system.
How to choose the best system for analysis? It depends on what you know about the objects, and if you can assign energies to their interactions or movement. But once you realize how important it is to remember that only external forces can do work on the system that changes its energy, many difficulties go away.
But there is another issue. The only conserved quantity is TOTAL energy of the system, not mechanical, and not kinetic. Therefore, if you wish to do energy analysis, you have to think about internal energy. The problem with it that we only know how much it changes, not the initial or final value. That is why, with internal energy we only deal with deltas, not absolute value.
We did several studies of the understanding of the concept of the teachers and of the students. I am attaching our latest study that shows the importance of this concept. It will not only clarify for you the concept of a system, but also helps you see how work-energy bar charts work (no pun intended), one of the major topics of our first energy workshop. Please download and read!
If you live in the US, you know that the concept of a system is one of the crosscutting concepts in the Next Generation Science Standards. Thus, we need to learn how to operate with it.

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Eugenia Etkina
Admin
Top Contributor
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December 15, 2023
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Hi all, thank you for understanding my yesterday's post! I am feeling much better today!
My post today is about work-energy bar charts. The idea of work-energy bar chart belongs to Alan Van Heuvelen. I learned it from him. I also know that many took his idea and implemented it in their textbooks and curriculum materials. However, most did not understand that the key to making a bar chart is identifying a system, and initial and final states. Without these two steps making a bar chart is impossible. The other important thing that the bar chart work only work for conserved quantity, and thus, in the field of energy they are drawn for TOTAL energy, not just mechanical energy. The internal energy component is not known in initial and final states, but we can calculate the change. That is why on work-energy bar charts there are bars for initial and final mechanical energy but only INTERNAL ENERGY CHANGE bar on the right side of the chart. Notice the steps in making the bar chart and then play with the best game that helps you see the role of the system and initial and final change at https://universeandmore.com/energy.

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Eugenia Etkina
Admin
Top Contributor
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December 16, 2023
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Hi all, two things today:
First, I wanted ot remind you to sign up for the second part of our Energy workshop on Jan 6. The link is in this message.
Second, after all our discussions about implementing ISLE I wanted to remind you about 3 successful elements of ANY ISLE-based lesson. Those were found by my student, Heather Briggs, now Heather E Patel. Here is the story of her discovery:
Heather worked with her cooperating teacher (Richard Therks Rich Thekhorn, also Eugenia's former student) during her student teaching internship and noticed that while she did everything that they planned together, her lessons sometimes were good and exciting and sometimes they were not. Rich's lessons were always excellent. What was his secret? She started taking notes of everything that he did in every lesson and soon found that three important elements repeated all the time. Those were: the need to know, the tools for success, and opportunities for success. In other words, Rich always motivated each lesson. He told the students explicitly what tools they needed to use to be successful and he crafted the lessons in a way that the students could be and—most importantly—feel successful (the best sources of feeling of success are testing experiments). After Heather found these elements and started incorporating them into her lessons, they improved dramatically. In the course that accompanied her teaching internship, Heather shared her findings with the class. Since then (more than 10 years ago), all students in our Rutgers Physics Teacher Preparation program learn these three elements and incorporate them into their lesson planning. I encourage you to try!
And here is the link to the Work-Energy Workshop Part 2.

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Eugenia Etkina
Admin
Top Contributor
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December 17, 2023
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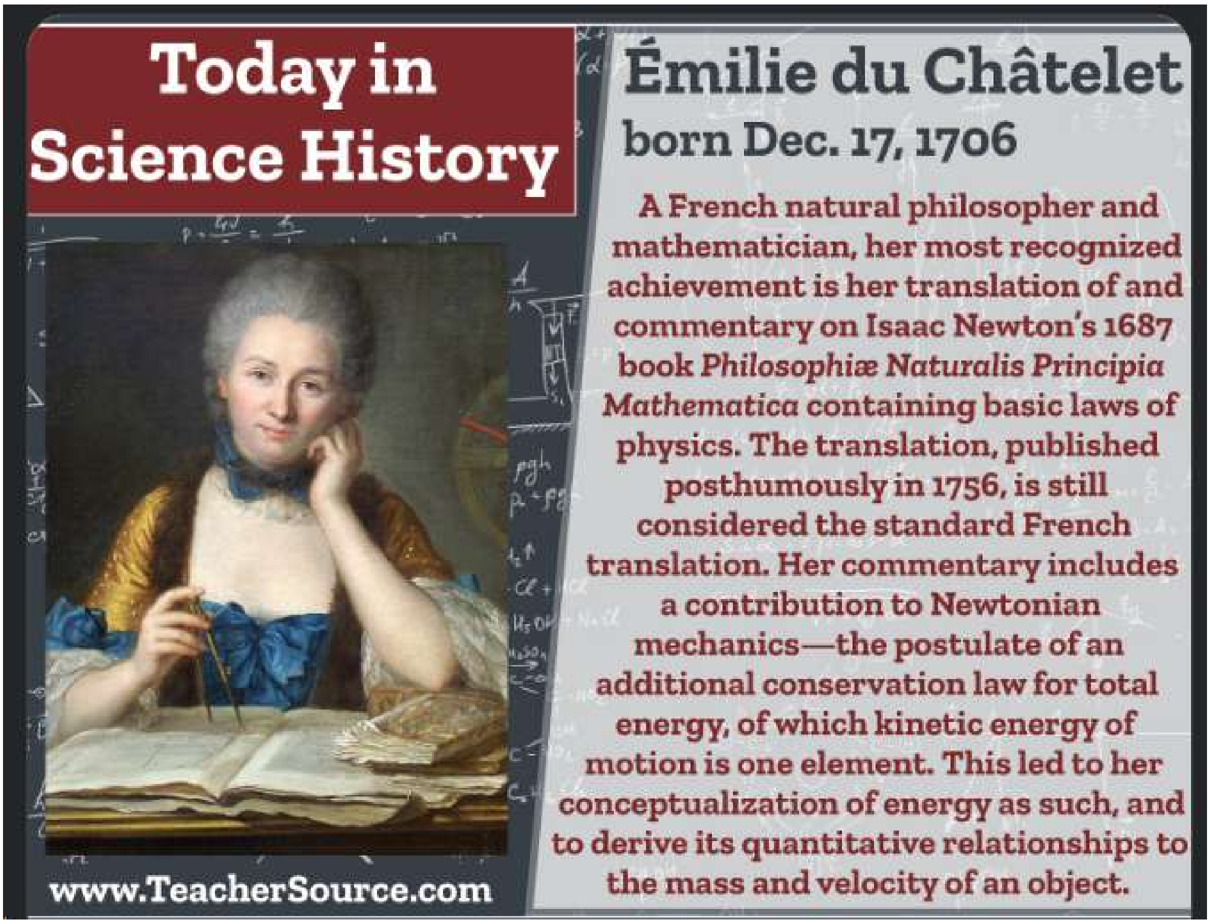
Hi all, speaking of energy and women in the history of physics. When you read about the history of total energy conservation idea in physics (remember, mechanical energy is not a conserved quantity and should not be treated is such), you usually see three names: Julius Robert von Mayer (German physician), James Joule (British beer maker), and Hermann von Helmholtz (German physiologist and psychologist). Google them or ask ChatGPT about them to learn more. But nobody ever writes about Emilie de Chatelet (French physicist and mathematician, she only lived 43 years). Now we do!



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Eugenia Etkina
Admin
Top Contributor
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December 18, 2023
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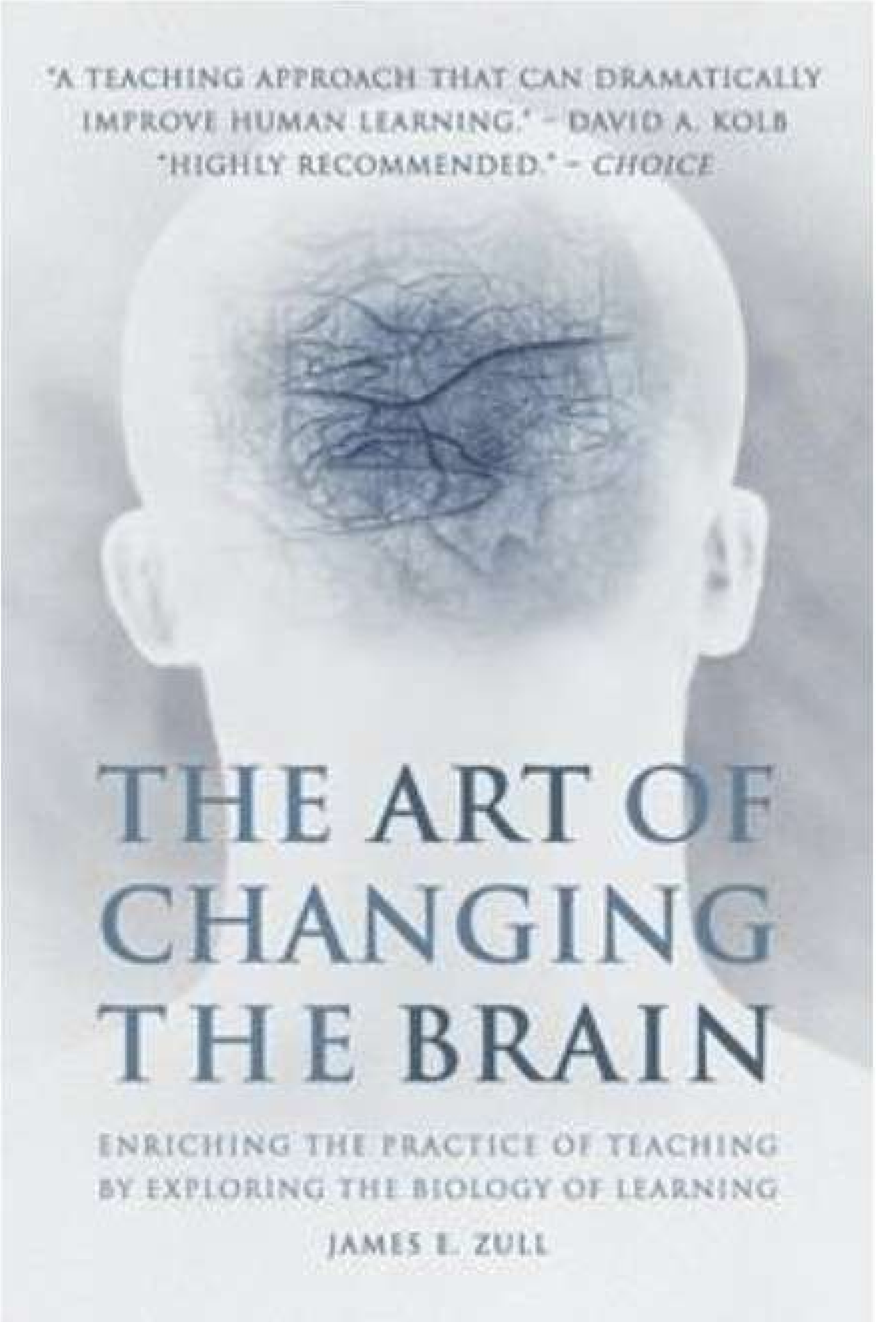
Hi all, today I wanted to talk about a moment that we all love but it is often deceptive. It is a moment when we say: "A bulb went off" - meaning that the students says: "I get it! Thank you for explaining!". When we hear these words and see the spark in their eyes we feel great - the student learned! But if you follow up and ask the person to explain what they understood or "got" will might be very surprised that the student either cannot do it or tells you something completely different from what you just beautifully explained. Even in the case when they can explain immediately after your explanation by repeating it, a few days later, when you use the same idea they will look at you as if they never heard it. Sounds familiar? It should. Not only that people cannot learn from listening to somebody's explanations (this is just not how our brains work) but they often cannot judge what and how they learned. Therefore, unless they can apply what they learned in a different context a few days later after a lesson, you should not assume that they created necessary brain connections for this particular concept.

Another thing to keep in mind is that research debunked the myth of learning styles again and again. People only think that they have a preferred learning style but in reality everyone needs to do similar things to learn. We need to have sensory input, we need to reflect on it, we need to hypothesize what his input is by connecting it to existing neuronal networks and then test our hypothesis actively by involving a motor function. This process is beautifully described in the book by J. Zull The art of changing the brain. I strongly recommend it!



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Eugenia Etkina
Admin

Top Contributor
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December 20, 2023
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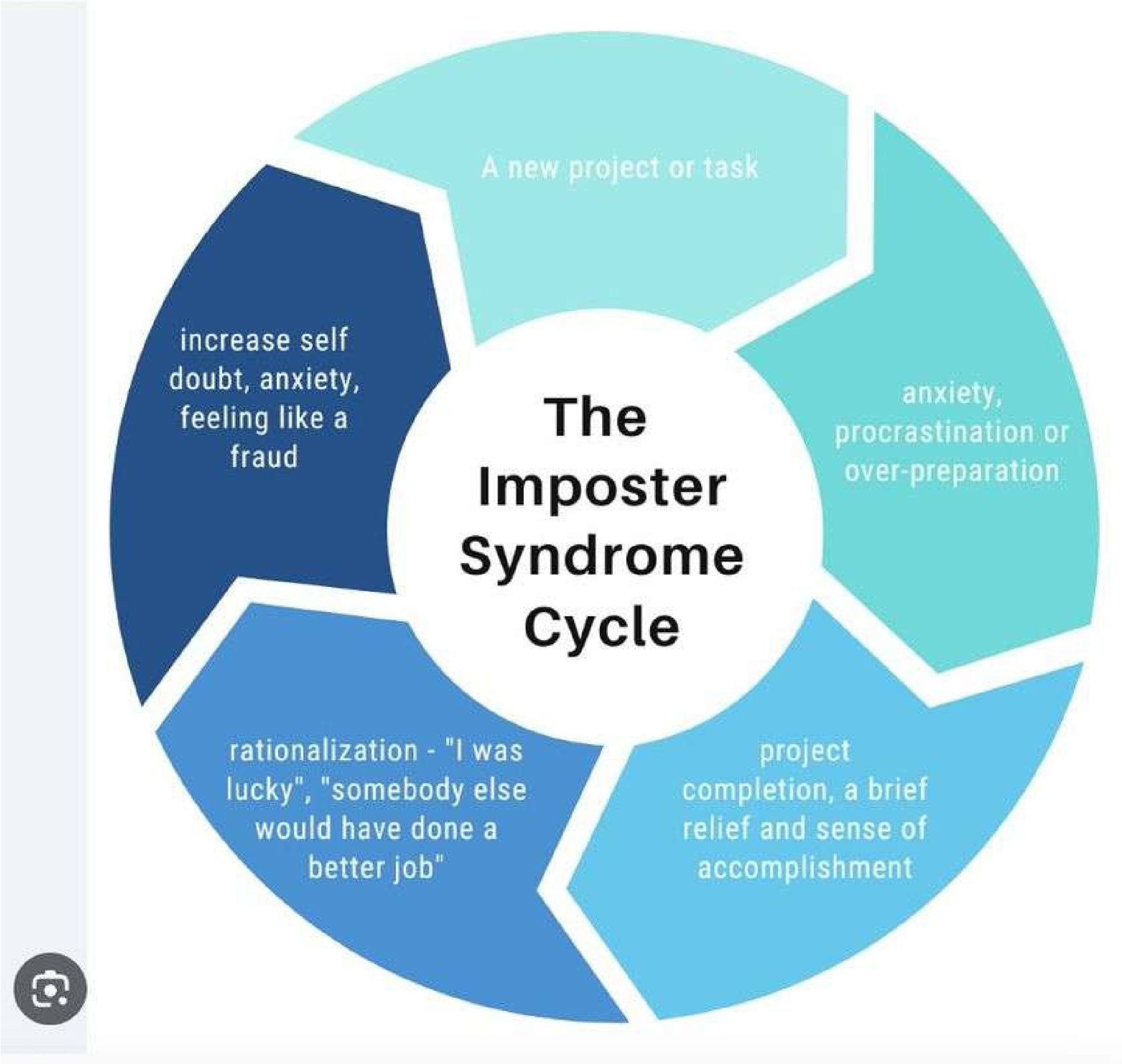
Hi all, two things today:
First, let's welcome our new members:
Chris Kozura,
Deborah Ward,
Ray Kuhn,
Harry Wong,
Barina Mottegović,
Jennifer Hayes-Jones,
Elbert E. N. Macau,
Branda Gilpin,
Jennifer Hall,
Olivia Jensen
Dear new members, to benefit from the group, please visit islephysics.net website and learn about the underlying philosophy of this group and all the resources we offer. Check out the messages pinned to the top of the group's page and the FILES. If you have questions, please post them here. Checking posts every day and liking or commenting on them will help you follow group's activity. Free online workshops are once a month, check your EVENTS to see the next one - on Jan 6.
My second thing is in response to a very important post of Elisabetta Sassaroli today. Please read it!
I wanted to add that there are two things that we need to remember when thinking about the difficulties that females and all other members of underrepresented groups in physics face every day. They are well documented and actually can be true for every person, but they are exacerbated for those who feel different in our classes.
First is the "impostor syndrome". You probably heard about it. It is the feeling that you are a fraud. That one day people will find out that you are not that smart and that you just faked your skills to be where you are. That you will be "found out". I have this syndrome and worry every day that one day I will be found out. I am sure that many of you do too. The consequences for students with this syndrome are that they do not engage or socialize with other students and thus do not benefit form a community

of learners. It also leads to procrastination - what if I cannot do this perfectly? But there is a benefit if having this syndrome - people with it try to work super hard to make sure that their work is of high quality. So, if you talk to your students about this syndrome and explain to them that working hard helps deal with it, they will benefit.

Second, is that some people blame the environment for their failures and others blame themselves. Women are often belong to the latter group and men to the former (statistically, not individually). This makes them see small setbacks as personal failures. For example women who quit physics in college usually have much higher grades than men who stay, but they think that they are not doing well enough to continue.

I am sure that you have students who need to hear that they are not the only ones who think this way. For many years I thought that I was the only one with the "fraud" mentality. But then I learned that it is a normal reaction. Knowing it does not remove it from my brain, but helps me deal with it.



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Eugenia Etkina
Admin
Top Contributor
·
December 22, 2023

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Hi all, if you are are new to ISLE, or have not attended our introductory summer workshop, you have a chance to participate in a shorter (4 hours) online workshop. It is run by two-year college community but they said that any person can register (college teachers or high school teachers). The workshop is on Saturday February 10, 2024 from 10:00am- 2:00pm PST. There is still room to sign up. Here is the link:

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Eugenia Etkina
Admin
Top Contributor
·
December 23, 2023
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Hi all, as holidays start I want to summarize what we have accomplished this year. In 2023 our group grew more than a 1000 members to 2414 members today!

We ran 11 ELEVEN 2- hour workshops, ONE - 4 hour workshop and ONE 8-hour workshop for the group members. 34 hours of professional development!
We had posts here 363 days (missed 2 days in the whole year!) and many of them had over 1000 views. Interestingly, the greatest number of views belongs to the posts by the group members, not me.
Eugenio Tufino and Hrvoje Miloloža created a video archive of the workshops, so that the video do not disappear with time. They can post the link here again.
Hrvoje Miloloža continued to maintain the archive of all posts.
ISLE is not an easy way to help your students learn physics but you persevere, struggle, improve, and share. This is the best way to tackle a problem. And a problem we are trying to solve is HUGE. We are helping people learn how to think. Thank you for joining me in this difficult but amazing journey. Happy holidays!

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Eugenia Etkina
Admin
Top Contributor
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December 24, 2023
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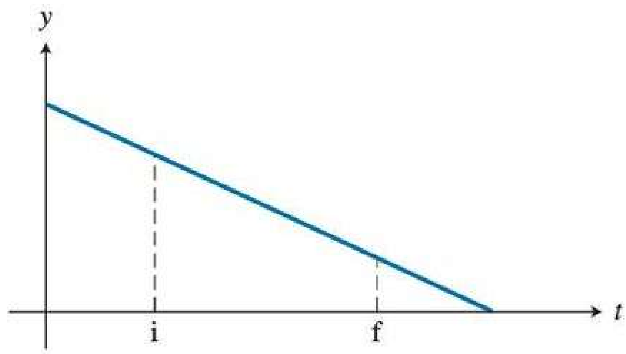
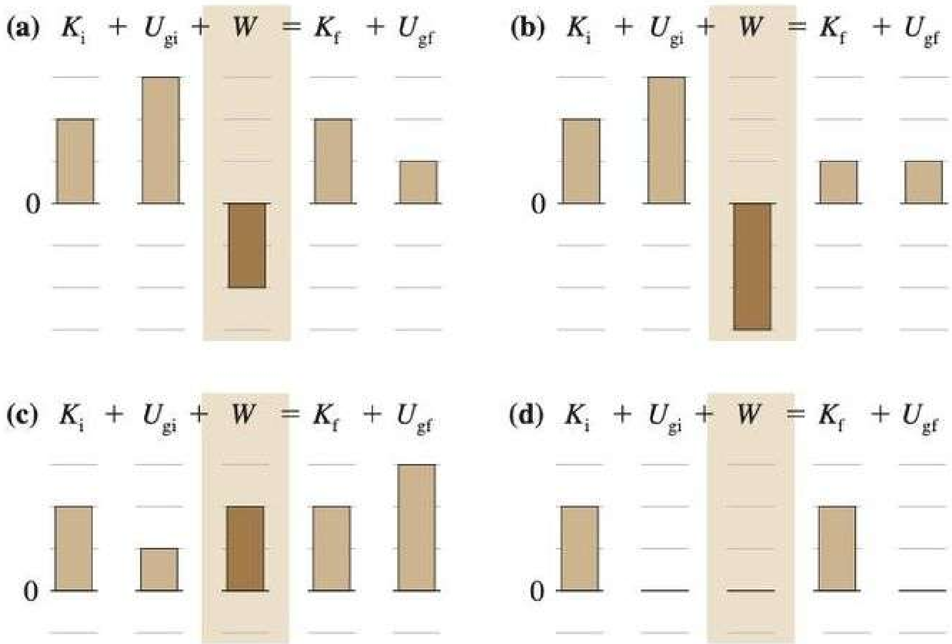
Hi all, two things. First, yesterday I watched Oppenheimer for the first time. I know, I am late with this, but what a movie! Every moment there tells us the history of physics, the history of politics and war, and the history with a person's struggles with their decisions. You see all the people you read about who contributed to the Manhattan project and how they did it. There

is a lot of physics and astrophysics in small pieces that only we can understand. And a lot of history, that only those who know history, can understand. But even those who do not know all this, can still get the main point of the movie. I will not reveal here what it is, but I welcome your comments. The acting is astounding. If you have not watched, do!
Second I wanted to share with you one of my favorite energy problems. It does not require any calculations, but it is incredibly rich. If you are using our textbook, do not miss it, if you are not -try is anyway.
Happy holidays!

11. The graph in **Figure Q7.11** shows the time dependence of the vertical displacement of a lead ball with marked initial and final states. Choose all the work-energy bar charts (a) to (d) that can represent this process (multiple answers may be correct). Note that the y-axis can point either up or down.

FIGURE Q7.11





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Eugenia Etkina
Admin
Top Contributor
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December 26, 2023
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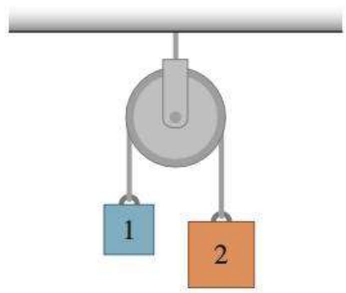
Hi all, I hope you are having some rest during the holidays, whatever you celebrate. Yesterday I was talking to my daughter in law, who runs an entertainment business and she was interested in the concept of energy. She never took physics, so we had in impromptu physics lesson on the porch. I was sharing with her our experiment with the brick crashing the chalk and explained that it is the system of brick and Earth that is important. And she could not understand what Earth had to do with it. So, my son, a biologist, came up with a great analogy.
Imagine that you have a spring that is not attached to anything. You pull it and the whole spring moves, you you not put any effort into it, and the spring does not "resist". But if the same spring is attached to a hook on the wall, and you try to pull it, it is hard, you need to put a lot of effort to stretch it. So, a brick without Earth is the same as the spring that is not attached to the hook. Earth is necessary for use to put an effort in lifting the brick. And the work that we do increases the energy of the spring the same way as lifting the brick increases the GPE of the brick-Earth system. Therefore, when we say "an object elevated above ground is gravitational potential energy", it is nonsense. (Sorry for my language). The object by itself does not have any gravitational energy. It is the SYSTEM object-Earth that has the energy. A single object (if we disregard its own internal energy) can only have KINETIC energy. Does it make sense?
Sometimes talking to people who have no physics background really helps you clarify your thinking. Systems reasoning is key to understanding energy processes. When drawing a bar chart (see my previous post) the most important first step is to identify a system that you are analyzing. See another problem from our textbook that helps you see this importance.

3. An Atwood machine is shown in **Figure Q7.3**. As the blocks are released and block 1 moves downward, the energy of the block 1-Earth system
   (a) increases.
   (b) decreases.
   (c) stays constant.
   (d) It's impossible to say without including block 2 in the system.

FIGURE Q7.3



4. Below you see several statements analyzing the process described in the previous question. Match the energy analysis with the system choice for which the analysis is correct.
   I. The total energy of the system decreases.
   II. The total energy of the system increases.
   III. The total energy of the system stays constant.
   Systems:
   (a) Block 2 and Earth
   (b) Block 1 and Earth
   (c) Both blocks, the string, and Earth
   (d) Both blocks and the string

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Eugenia Etkina
Admin
Top Contributor
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December 27, 2023
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Here is a question: is energy a phenomenon, a model, or a physical quantity? How can you explain?
ISLE definitions of these words:
Physical phenomena and physical objects are things that happen (exist) and can be observed directly or indirectly. Examples of phenomena include mechanical motion of objects, waving of a string, water flow in a river, light shining on a surface, and clothes sticking to each other after being pulled from a dryer.

While the word “model” is ubiquitous in educational vernacular, the definitions of models vary in textbooks and science education literature (https://plato.stanford.edu/entries/models-science/). In the ISLE approach, we adopt the definition of a model as a simplified version of a phenomenon, object, a system, or a process (Etkina et al. 2006). Examples of models are free fall (model of a phenomenon when you consider objects falling in the absence of air - simplification) and point-like objects (model of an object when you disregard the object’s size – simplification). There are different types of models including models of systems (ideal gas), models of processes (constant motion model, isobaric process, isothermal process), or models of interactions (electric field model and magnetic field model). It is possible to think of what we call hypotheses or explanations of phenomena as models because these are simplifications in some ways too.
Explanations can be causal or mechanistic. A causal explanation (a causal model) shows how one physical quantity depends on another quantity, but it is not concerned with a mechanism. A mechanistic explanation involves a mechanism explaining the relationship (for example, the liquids cool during evaporation as the fastest molecules leave and the average kinetic energy of the remaining molecules decreases).
A physical quantity is a feature or characteristic of a physical phenomenon or a model that can be compared to some unit using a measuring instrument (see below). Examples of physical quantities are your height, your body temperature, the speed of your car, the force that Earth exerts on you, or the temperature of air or water.

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Eugenia Etkina
Admin

Top Contributor

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December 29, 2023

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Hi all, yesterday I posed a question - what is energy? Is energy a phenomenon, a model, or a physical quantity? There were no responses. So, what do you think?

I asked because often our students see physics as a collection of facts, things to memorize. In fact, physics is a very coherent filed of knowledge. It is comprised of a very few "structural elements". If you think of everything that we know in physics, all this everything belongs to one fo the following categories:

- physical phenomena and physical objects,
- models of phenomena, objects, systems, interactions,
- physical quantities and their relationships,
- measuring instruments,
- physics devices,
- testing experiments,
- predictions of the outcomes of testing experiments,
- application experiments, and
- assumptions.

These elements are organized is a very special way (our picture of the ISLE process does it, see attached) and this organization shows the coherence of physics. It is very important that our students view physics as an organism, not a random collection of stuff to memorize. Thus my question stands: WHAT IS ENERGY IN THIS ORGANISM?

Eugenia Etkina

Admin

Top Contributor

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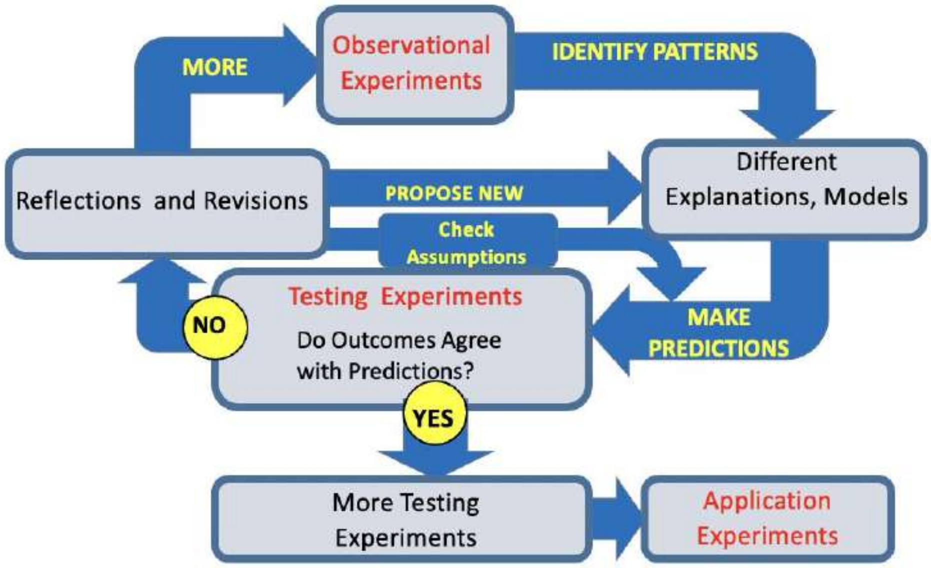
Investigative Science Learning Environment (ISLE) process



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Eugenia Etkina
Admin
Top Contributor
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December 30, 2023
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Hi all, yesterday Jane Jackson brought up the concept of theory in our conversation of structural elements of physics. This is a very important idea in physics and I wanted to share my thoughts about it. Here they are. The word “theory” is probably the most misunderstood and misused word in physics and in everyday language. When looking up the word “theory” in search engines, we find the following definitions: “a supposition or a system of ideas intended to explain something, especially one based on general principles independent of the thing to be explained", "an idea used to account for a situation or justify a course of action" and the synonyms that are listed are hypothesis, conjecture, speculation, etc. From these definitions and synonyms, it looks like we are speculating when we say "theory" and that there is no "proof".

However, if we look up the word "scientific theory", the definition comes back completely different. From Wikipedia: "A scientific theory is an explanation of an aspect of the natural world and universe that has been repeatedly tested and corroborated in accordance with the scientific method, using accepted protocols of observation (read observational experiments), measurement, and evaluation of results. Where possible, theories are tested under controlled conditions in an experiment (read testing experiments). In circumstances not amenable to experimental testing, theories are evaluated through principles of abductive reasoning (astronomy for example) that seeks the simplest and most likely conclusion from a set of observations. Established scientific theories have withstood rigorous scrutiny and embody scientific knowledge." This is quite different from a speculation, right?

If we think of physics, then we have for example:

· Newtonian Theory, which explains the wide range of mechanical phenomena involving macroscopic objects at speeds much smaller that the speed of light; has its own set of physical quantities, conceptual and mathematical models which were tested in numerous experiments, measuring instruments and physics devices, and has its own limitations;

· Kinetic Molecular Theory, which explains a wide range of mechanical and thermal phenomena involving microscopic objects, has its own set of physical quantities, conceptual and mathematical models which were tested in numerous experiments, measuring instruments and physics devices and has its own limitations;

· Special Relativity Theory, which explains a wide range of mechanical phenomena involving macroscopic and microscopic objects moving at the speeds close to the speed of light, has its own set of physical quantities, conceptual and mathematical models which were tested in numerous experiments, measuring instruments and physics devices and has its own limitations.

From the examples below, we see that the word theory in physics is much more specific than even the definition of a scientific theory in Wikipedia. To be called a “theory” in physics, a set of knowledge has to account for a wide variety of observational data, has its own set of physical quantities, mechanistic and causal explanations, and mathematical models relating those quantities, has been tested in numerous testing experiments, and applied for practice. All kinds of reasoning—inductive, hypothetico-deductive, analogical, and abductive—are used to create the conceptual and mathematical structure of the “theory”. The development and testing of these models is impossible without special measuring instruments and physics devices. Therefore, all of the elements of physics knowledge discussed above and all types of reasoning come together to form a “theory” in physics. Finally, each theory has its own very carefully defined set of limitations – statements when it can be applied to produce predictions that match the outcomes of the testing experiments. Thus, the word “theory” in physics and in science in general is as far from a “hypothesis” or a “speculation” as a finished house is far from individual bricks, doors, window frames, etc. Only a proper understanding of the word “theory” would allow teachers and students to argue against those who think that science education should only involve “facts”.

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Eugenia Etkina
Admin
Top Contributor
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December 31, 2023
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Hi all, two things today:

Let's welcome our new members

Happy New Year!

Happy New Year to you all! Let's continue our relentless work in 2024. Helping young people learn how to think is our main goal. Newton's laws and electric fields are byproducts. Useful and valuable, but still not the main goal.

Let's welcome our new members:

YA Chen,

Rebecca Beck,

Sarah Smith,

Amy Berkhousen,

Chris Boyle

These are the last people joining our group this year. Welcome!!! To benefit from the group, please visit islephysics.net and learn about the philosophy of this group and all the resources that we offer. The archive of the posts is pinned to the top of the group. Reading recent posts will help too and try to check new posts every day. Comment on them or like them to make them more visible for the rest of the group.

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