Exploring and Applying Physics

Facebook group

Posts by Eugenia Etkina from 2024

Eugenia Etkina
Admin
Top Contributor
·
January 1
·
Hi all, Happy New Year!
Yesterday Tom Prewitt posted a comment about his students who have trouble reflecting on what they have learned. How to help them learn how to reflect?
Once I asked (in desperations) the principal of my school where I taught for 13 years: What tools do we have to convince our students in the right stuff? He responded: "Eugenia, we have two tools in our disposal: Word and personal example." Tom Prewitt, you used the words, so maybe, it is time to use your personal example. Do your students have an image of what it means to reflect on learning? Probably not?
If this is the case, I would start reflecting myself. What do you learn at the end of each lesson? Show them how to reflect first and then ask three questions in the homework: What did you learn today? How did you learn it? What questions remain unclear? And then, after they submit the answers, comment, provide feedback individually. We have analyzed the relationship between students' ability to reflect on their learning and their learning gains. Please read the attached paper and share with your students what you learned from it and HOW you learned. Please let me know if this advice helped.

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Please read the attached paper and share with your students what you learned from it and HOW you learned. Please let me know if this advice helped.

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Eugenia Etkina
Admin
Top Contributor
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January 2
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Hi all Exploring and Applying Physics people! Two things today: if you have not signed up for our second energy workshop on Jan 6, but plan to attend, please sign up. The link is https://www.facebook.com/events/886602089514050
If you are new to ISLE, we will be funning a short (4 hours) online introductory workshop on February 10 through the OPTYCs (Organization of two year colleges). You do not need to teach in a TYC to participate. Here is the link to register. It is a free as all our workshops are and you can receive a certificate with 4 hours of Professional Development.

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Eugenia Etkina
Admin
Top Contributor
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January 4
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Hi @everyone I am trying the everyone tag to see if it makes a difference.
Three things today (please read to the end).
I am reminding you of the Energy II workshop on Saturday. Please go to your EVENTS on Facebook and check the zoom link posted there. It is always the SAME link for all our workshops.
Yesterday I made a post and it was not visible for some as it was a shared post. I put a comment there explaining what it was about. The post is about Einstein's first wife and how her contributions were completely overlooked.
Our member, Danielle Buggé, who was 2022 Teacher of the Year selected by the Physics Teacher Education Coalition (PhysTEC), is presenting a very interesting talk. The announcement about it is below, it is free to watch. I strongly recommend.
Reminder!

The Physics of Living Systems Teacher (PoLS-T) Network invites all who want to advance the teaching of high school physics to join, especially physics teachers, physics education researchers, and decision makers in school administration and government.

Please register and Save the Date for the PoLS-T January 27 virtual talk!

SPEAKER: Danielle Buggé, physics teacher at West Windsor-Plainsboro High School South, NJ
2022 PhysTEC Teacher of the Year
TITLE: Thinking (and Failing) Like a Scientist: Cultivating Growth Mindsets of High School Physics Learners
DATE: Saturday, January 27, 2024
TIME: 9am MST (11am to noon EST)
VIRTUAL via Zoom, and FREE.
Register now, at this URL!
docs.google.com/forms/d/e/1FAIpQLSedyXjSwWTOBOeJJqpA26SVphv3ywIucPtuUgQbktlu16mPnA/viewform

Harvard's PoLS-T Network Team is funded by NSF to strengthen high school physics worldwide.
PoLS-T LINKS:
Website: projects.iq.harvard.edu/pols-t-network
Join the PoLS-T Network here!: forms.gle/cj87TLRzJ6zcCEUL6
Twitter: @PoLSTNet
YouTube Channel: www.youtube.com/channel/UCRzn7nZ4f8JksXXUTrouSZg

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Eugenia Etkina
Admin
Top Contributor
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January 6
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Hi @everyone! We had a really good workshop today. Thank you all those, who participated, for working hard and for contributing to our discussions, thank you! Here is the link to the recording:
https://rutgers.zoom.us/.../3Lz2F83iBM4J6N3bTbVQlyNJTgU52... Password is qY4^5U2z
Here is the link to the slides:
https://docs.google.com/.../1NPhUsK2fOVgTrRFiX.../edit...
I am also pasting the reflection slide.
The next workshop is on Gases, and after that will on the First law of Thermodynamics. Possible dated for the gases workshop are Feb 3 or 17. I will post the poll tomorrow.

What did you learn today?

I appreciate the discussion on sum of the forces and distinguishing between the operation of summing, and then thinking about and assigning direction (signs) to forces. Many of my students have difficulty with net force, and summing forces. I think if I introduce it this way, and separating the sets "add the forces" then "assign direction to the forces" more students will develop a better understanding of net force.

Absolutely Amazing workshop!

I understand better what the point of bringing up the the block dilemma

Internal forces convert energy and external forces add energy

Change in internal energy = friction force over displacement which the block moves

Friction is a key component in the understanding of Physics, because most of the world we live on has friction and interactions. In fact, it is quite the opposite for studying kinematics where friction is considered 0 or negligible. Also, explain the algebra as a component a bit different than what is to add and subtract in a Sum of Forces equation. It is important to review the problems as students work out to understand the relationship of the concepts.

Force diagrams ever for starting

How the concept of internal energy and divided it to chemical, sound, and thermal energy is important

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Eugenia Etkina
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Top Contributor
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January 9
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I already posted about Cecilia Payne who discovered that stars are made mostly of hydrogen. A person who thought she was absolutely wrong ended up getting credit for this. History is very cruel to women in science. Cecilia Payne is one of those women.

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Eugenia Etkina
Admin
Top Contributor

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January 11
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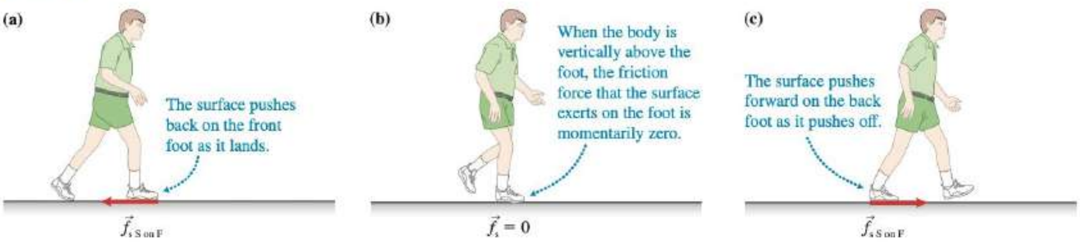
Hi all, two things today: first I am reminding you to sign up for the KMT workshop (see your events). So far only 6 people signed up. If this workshop is not of interest to you, then we should do a different one. Please sign up if you wish to learn how to teach kinetic molecular theory through the ISLE approach.
Second, I wanted to continue our conversation about energy. Specifically, the difference between impulse and work. I pasted below a figure from Chapter 4 (long before momentum and energy) showing how friction force component of the force that the surface exerts on us helps us walk. When we walk without slipping this force does NO WORK on us, but it exerts an impulse that changes our momentum. If the surface does not do work on us, how can we change our kinetic energy? This is where changing the system helps a lot. If we include the surface in the system, then the energy of the person/surface/Earth/surrounding air should remain constant. It is our chemical energy that is converted into kinetic energy (if we walk for a long time we get hungry) and some thermal energy (the shoe soles, the surface, and surrounding air) get warmer and we sweat. Thinking when to include the surface in the system and when not to is important for both energy and momentum analysis.

FIGURE 4.5 The surface exerts a static friction force that helps you walk or run.



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Eugenia Etkina
Admin
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January 14
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Hi @everyone! Two things today:
Very few people registered for the Gases/KMT workshop. If the workshop is not needed I will cancel it. Please register if you are planning to attend. We have never run it, I made a whole new workshop for this as people in our previous Energy II workshop requested it. This is a prequel to the first law of thermodynamics which is a huge problem for both students and teachers. If you wish your students to understand the first law of thermodynamics, they need to first learn kinetic molecular theory, the subject of this workshop. The one after will be on the first law of thermodynamics.

We are skipping chapters 8-11 in the series of our workshops - Statics, Rotational dynamics, vibrational motion and waves. Which of these topics should we discuss here between now and the next workshop? What are the issues that you are having? What problems do your students have with these topics? Please reply here.
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Eugenia Etkina
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January 15
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Hi all Exploring and Applying Physics people! Two things today:
Thank you all those who signed up for the KMT workshop. The workshop is about how to connect ideal gas laws to a microscopic understanding using the ISLE approach. We now have over 20 people who signed up, so the workshop will go on. Thank you for responding!
Yesterday I asked what topic should I start posting here before the workshop and Anne L. Caraley, Meagan Vinson, and Sue Chase mentioned rotational motion (do not confuse with circular motion which is Chapter 5). I will be happy to start a conversation about it. A few days ago Gorazd Planinsic posted an excellent problem with a video for RD. But I will start from the beginning.
How does the ISLE approach work when we are trying to help our students learn something? We first identify WHAT ideas exactly we want them to construct. Then we think of what they should definitely know before to be able to construct these new ideas. Then we think of what they can observe, that is simple and they can see a pattern easily. Then we think how they can explain the found patterns (if there is a mechanistic explanation, or should we stay with a causal explanation only), and then how they can test their explanation (or a pattern) in new experiments. Sometimes, if this process is not possible to follow quickly, we replace it with hypothetical experiments or reasoning connecting new ideas to the old ones.
So, to start rotational dynamics, I will identify the necessary prerequisite knowledge that the students should develop BEFORE they start rotational motion:
Concepts of force, acceleration, Newton's second law, center of mass, torque, equilibrium conditions, linear momentum, kinetic energy.
Skills: drawing force diagrams, determining the sign and magnitude of a torque.
The concepts that the students need to develop in rotational motion:
kinematics and dynamics physical quantities describing rotational motion in addition to what students already know: rotational position (theta), rotational (angular) velocity (omega), rotational acceleration, and rotational inertia.
Newton's second law for rotational motion
Rotational momentum and its conservation

Rotational kinetic energy
The next questions is WHAT the students will observe to come up with those ideas? We will start tomorrow with the quantities first. We will go step by step so that you can see the process clearly. However, before we do this, I am asking you to read through Chapter 8 to see HOW students construct the ideas of the center of mass and torque. I am also posting the chapter opening photo for chapter 9 in the textbook - Rotational motion. Why would we have radio telescopes as the need to know for this chapter?

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Eugenia Etkina
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Top Contributor
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Hi all Exploring and Applying Physics people! Thank you again all for registering for the Gases/KMT workshop - we have over 20 people and please keep signing up! The workshop is definitely on and I will start posting the homework for those who signed up soon.
I continue with rotational motion. To invent kinematics quantities of the rotational position, rotational velocity, etc. I recommend three things:
Bring a bicycle to class, turn it upside down to sit on the saddle, mark several points on the same spike and let tthe students observe how much they moved when you stip the wheel for about 90 degrees. Let them think about similarities and differences in their motion.
Use the following activity with the students:
OALG 9.1.1 Observe and find a pattern
Equipment: 2 1-meter sticks or 1 2-meter stick.
For this activity, you need to collect all of your housemates and go outside (you will need 5 people in total for this experiment). Use two meter sticks (or any other sticks about 1-m long) connected together to form a 2-m long stick, or use a 2-m stick. Have one group member

hold one end of the meter stick and stand at the same position at all times. The second group member holds it at the 50-cm mark, the third one at the 1-m mark, the fourth one at the 150-cm mark, and the last one at the end of the second stick (the 2-m mark). The four non-fixed group members need to move so that the one member holding the 2-m end of the stick runs in a circle at a comfortable constant speed.

a. Observe the motions of these four moving group members. What do you notice? Discuss with your group.

b. What physical quantities characterizing motion are different for the four group members? Discuss with your group.

c. What quantities are the same?

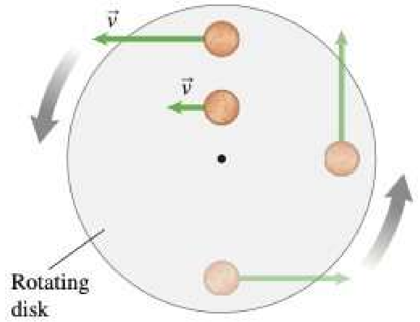
d. Compare your answers to Figure 9.7 on page 255 in the textbook. How does it help you with the answers?

3. Let the students interrogate the following figures (9.1 and 9.2 in Chapter 9). If you are not familiar with elaborative interrogation technique, please read Instructor guide Chapter 1 (Posted here in the FILES).

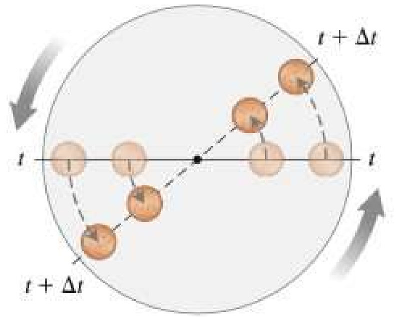
These three activities will help them construct all of the needed kinematics quantities that I mentioned in my post yesterday.

FIGURE 9.1 Top views comparing the velocities of coins traveling on a rotating disk.

(a) The direction of the velocity $\vec{v}$ for each coin changes continually.



(b) Coins at the edge travel farther during Δt than those near the center. The speed v will be greater for coins near the edge than for coins near the center.



(c) All coins turn through the same angle in Δt, regardless of their position on the disk.

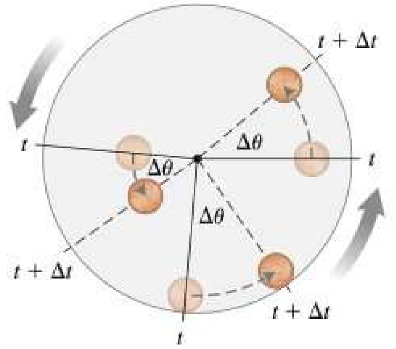
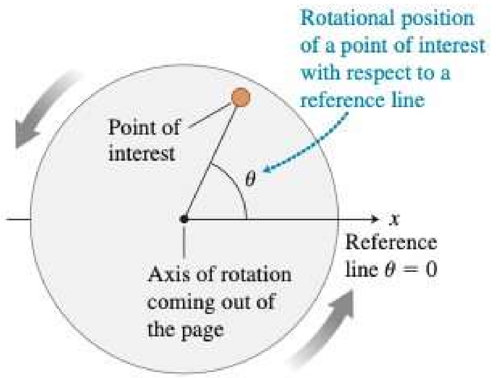


FIGURE 9.2 The rotational position of a point on a rotating disk.



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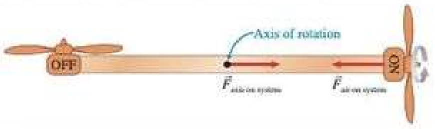
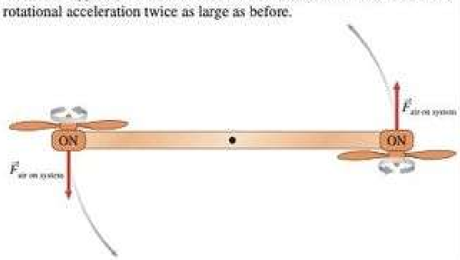
Eugenia Etkina
Admin
Top Contributor
· ·

Hi all, I continue with rotational motion today. After students constructed kinematics quantities needed to study rotational motion, we proceed to helping them construct Newton's second law for rotational motion. We have an excellent series of observational experiments (thanks to the ingenuity of Gorazd Planinsic) that allow them to see the role fo the torque. The activities are in the textbook (I am pasting a screen shot) and the link to the video. But this series of experiments leads students to think of a mass as a contributing factor. How do we help them construct the idea of rotational inertia? This is tomorrow!
https://mediaplayer.pearsoncmg.com/.../secs-egv2e-turning...

OBSERVATIONAL EXPERIMENT TABLE 9.2 Turning effects of forces exerted on a rotating arm

VIDEO OET 9.2

Observational experiment	Analysis
Experiment 1. Two fans are fixed on the arm. One fan is switched on, and it pushes air along the arm. The arm does not rotate. (Note that all figures show the top view of the experimental setup.)  	The arm with the fans is the system. The horizontal forces are shown in the figure at left. Because the arm does not accelerate translationally, $\vec{a}_1 = 0$. This is only possible when $\Sigma\vec{F} = 0$. The force exerted by the air on the system and the force exerted by the axis on the system therefore add to zero. The arm does not rotate ($\omega_1 = 0$) or accelerate rotationally ($\alpha_1 = 0$). This is only possible when $\Sigma\tau = 0$; in this case, the torques produced by both forces are equal to zero.
Experiment 2. The turned-on fan rotates so that it pushes air perpendicular to the arm. When the fan is on, the arm rotates faster and faster. We determine its rotational acceleration by measuring the change in rotational velocity and the time interval.  	The air exerts a force on the fan and the arm and causes a positive torque, $\tau_2 > 0$. The arm has increasing positive rotational velocity and a positive rotational acceleration, $\alpha_2 > 0$. The arm does not accelerate translationally, $\vec{a}_2 = 0$; this is only possible when the sum of the forces exerted on it is zero, $\Sigma\vec{F} = 0$.
Experiment 3. Both fans are turned on so that air pushes on the fans and the arm in opposite directions. The arm rotates faster and faster, with the rotational acceleration twice as large as before.  	The air pushing on the fans and the arm creates two torques of the same magnitude that are both positive: $\Sigma\vec{F} = 0$ $\vec{a}_3 = 0$ $\tau_2 + \tau_3 = 2\tau_2$ $\alpha_3 = 2\alpha_2$

(CONTINUED)

Observational experiment	Analysis
Experiment 4. While the arm is rotating, you simultaneously turn off the fans. The arm continues to rotate at a constant rotational velocity.  	$\Sigma\vec{F} = 0$ $\vec{a}_4 = 0$ $\Sigma\tau = 0$ $\alpha_4 = 0$ $\omega \neq 0$

Patterns

- An external force that produces a zero torque on the arm does not change the arm's rotational velocity. If the arm is at rest, it remains at rest.
- When there are no external forces exerting torques on a rotating arm, its rotational velocity remains constant.
- External forces that produce a nonzero net torque on the arm cause rotational acceleration. Doubling the net torque doubles the rotational acceleration of the arm.

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Eugenia Etkina
Admin

Top Contributor
· ·

Hi all, I continue with rotational dynamics today. Please see my post of yesterday to learn how students develop the dependence of acceleration on the torque idea. But how do they construct the concept of rotational inertia? Here is the next step in the development of Newton's second law for rotational motion using the ISLE approach. Here is the video, the text of the Testing experiment table is in the attachment.
https://mediaplayer.pearsoncmg.com/.../secs-egv2e-testing...
Please comment on this sequence - will it be helpful for your students?

Using these patterns, we can hypothesize that the rotational acceleration of an object with fixed axis of rotation depends on the external net torque exerted on the object. But is it just the torque that determines the acceleration? In translational motion, the other quantity affecting translational acceleration was the mass of the object. What is the analogous quantity in rotational motion? Could it be the mass, too? Let's test the hypothesis that the rotational acceleration depends on the sum of the external torques and the mass of the object in Testing Experiment Table 9.3.

TESTING EXPERIMENT TABLE 9.3 Testing the hypothesis that mass affects rotational acceleration (VIDEO TET 9.3)

Testing experiment	Prediction	Outcome
Experiment 1. Repeat Experiment 2 from Table 9.2, but this time move the turned-off fan closer to the axis of rotation. 	If the rotational acceleration depends on the external torques and the mass of the system and we have the same fans as in Experiment 2 from Table 9.2, then changing the location of the turned-off fan should not change the rotational acceleration of the system.	The rotational acceleration of the arm is greater than in Experiment 2 from Table 9.2.
Experiment 2. Remove the turned-off fan from the arm and repeat Experiment 2 from Table 9.2. 	Because the mass of the system decreases, the rotational acceleration should increase.	The rotational acceleration of the arm is greater than in Experiment 2 from Table 9.2 and greater than in Experiment 1 above.

Conclusion

Although we found that the mass of the system affects its rotational acceleration, we rejected the hypothesis that the rotational acceleration depends *only* on the net exerted torque and the mass of the object. We found that the distribution of mass with respect to the axis of rotation is important, too.

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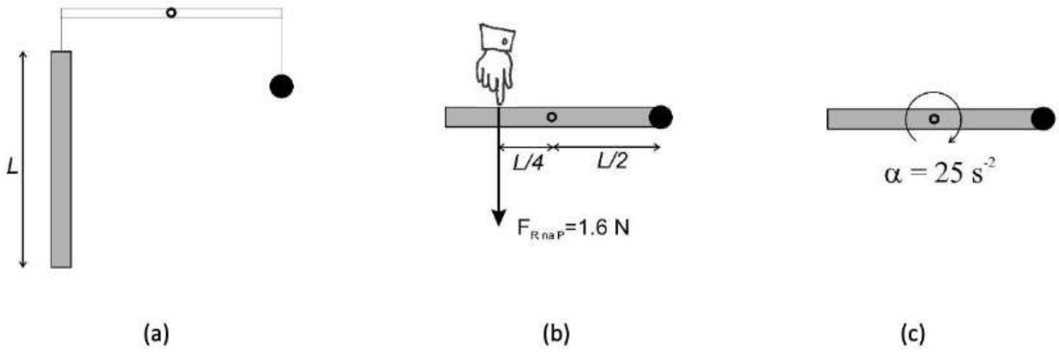
Eugenia Etkina
Admin
Top Contributor
· ·

Hi all, two things today: First we have a big group of people who joined recently and I wanted to welcome them; and second, I will continue with rotational dynamics.

2. We talked about how students develop Newton's second law for rotational motion. Today, I am sharing a problem, in which they need to apply it. The problem is completely new and has not been published anywhere. The author is Gorazd Planinsic. Here it is!
You perform the following three experiments with a rod and a small metal object:
Experiment 1: You suspend the rod and the object on each side of a balance, as shown in figure (a), and you find that the objects are at rest.
Experiment 2: You place the rod on a stationary axis and fix the object on the right end of the rod (see figure (b)). When you exert a force of 1.6 N perpendicularly to the rod as shown in figure (b), the rod is stationary.
Experiment 3 (continuation of experiment 2): When you remove your finger you observe that the rod with the object starts to rotate with the rotational acceleration of 25 s-2 (figure (c)).
What can you tell about the rod and the small object from these experiments? List as many physical quantities as you can and calculate them. Indicate any assumptions you have made.
What do you think about this problem?



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Eugenia Etkina
Admin
Top Contributor
· ·
Hi @everyone! I continue with rotational motion. We have a quick and beautiful sequence for rotational momentum in the OALG. I am pasting it here with the link to the video. Just two activities that do a marvelous job. The sequence also shows that sometimes we do not start with observational experiments, but with reasoning when students have enough knowledge about the situation. Just as physicists do. Please let me know what you think. Also, please do not forget to like the post or comment on it to make it more visible for the rest of the group. Thank you. I a, also reminding you that all OALG files are posted here in the FILES.
https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...

OALG 9.4.1 Analyze and find a pattern

Below is a table describing several observational experiments. Read through the experiments and describe the patterns you find. Put those patterns on a whiteboard.

Observational experiments	Analysis
a. A figure skater initially spins slowly with one leg and two arms extended. Then she pulls her leg and arms close to her body and her spinning rate increases dramatically.	*Initial situation:* Large rotational inertia I and small rotational speed ω. *Final situation:* Smaller rotational inertia I and larger rotational speed ω.
b. Watch video OET 9.6 on page 267 in the textbook. A man sitting on a chair that can spin with little friction initially holds barbells far from his body and spins slowly. When he pulls the barbells close to his body, the spinning rate increases dramatically.	*Initial situation:* Large rotational inertia I and small rotational speed ω. *Final situation:* Smaller rotational inertia I and larger rotational speed ω.

OALG 9.4.2 Reason by analogy

Discuss with your group and put your ideas on a whiteboard:

a. Use the analogy between translational and rotational motion to write a mathematical expression for rotational momentum (do not forget to check the units) and one expression for rotational momentum constancy in an isolated system. After you write the expressions, read and interrogate Section 9.4 in the textbook. Did you arrive to the same expression as Equation 9.11?

b. If the system is not isolated, what physical quantity would account for the change in rotational momentum (think of an analogous quantity for impulse in translational motion)?

OALG 9.4.3 Analyze

A solid disk (radius 114 mm, thickness 25 mm, mass 1418 g) can rotate with almost no friction around a vertical axis (see photo at right). You make the disk rotate with a constant speed and hold a hollow cylinder (outer radius 64 mm, inner radius 56 mm, thickness 50 mm, mass 1428 g) directly above the disk so that the axes of both objects coincide. When you release the cylinder, it falls onto the disk and slides on it for a few seconds until both objects rotate with the same constant speed. A high-speed video of the experiment (recorded at 300 frames per second) is given here [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-9-4-3]. Answer the questions below:

a. Draw a rotational momentum bar chart for the experiment (for help, check the bar charts in Example 9.6 in the textbook on page 269). Indicate your choice of system and the initial/final states.

b. Estimate the ratio between the rotational inertia of the cylinder and the rotational inertia of the solid disk, $\frac{I_{\text{cylinder}}}{I_{\text{disk}}}$, using data from the video. Calculate the same ratio from the dimensions and masses of the objects given above. Compare both results and explain any differences between them.

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Eugenia Etkina
Admin
Top Contributor

Hi all Exploring and Applying Physics people! Today I finish the rotational motion chapter - if you go through my latest posts you will see the ISLE based progression, experiments, videos, etc. The end of chapter problems are in the textbook, here I only outline the

chronological progression of students' invention of 4 most important ideas: kinematics quantities, Newton's second law for rotational motion, rotational momentum conservation and rotational kinetic energy (today). Below is a short sequence of activities for energy. Check them out and try with your students! And please do not forget to like the post or comment to make it more visible. Lately even if I tag everyone, the number of views is relatively small. I guess it it winter fatigue or something else? Thank you!
OALG 9.5.1 REASON BY ANALOGY
Discuss with your group and put your ideas on a whiteboard:
Use the analogy between translational and rotational motion to write a mathematical expression for rotational kinetic energy. Check whether the units of rotational kinetic energy are as expected. After you finish, read and interrogate Section 9.5 in the textbook and compare your expression to Equation 9.14.
OALG 9.5.2 ANALYZE
Use the video from Activity 9.4.3 and work with your group to answer the following questions:
a. Draw a work-energy bar chart for the experiment. Indicate your choice of system and the initial/final states.
b. Estimate the change in the internal energy of the disk and the cylinder during the experiment.
OALG 9.5.3 OBSERVE AND ANALYZE
The experiment in the video shows a ball rolling up a ramp https://mediaplayer.pearsoncmg.com/.../_fr.../sci-OALG-9-5-3. Use the data that you can collect from the video to decide whether the ball can be modeled as a point-like object, a solid sphere, or a hollow sphere.
a.Draw an energy bar chart to represent the process for three different models of the ball.
b. Using the speed of the ball on the horizontal surface, predict how high each model predicts the ball to climb.
c. Compare the actual height of the climb to the height that each model predicts. What additional assumptions do you need to make to explain the outcome of the experiment?
OALG 9.5.4 OBSERVE AND ANALYZE (ALG 9.5.3)
Observe the video of a solid and a hollow cylinder of equal masses rolling down an incline [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]. Draw energy bar charts to explain why the solid cylinder wins the race.

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Eugenia Etkina
Admin
Top Contributor
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Yesterday I posted the end of the rotational motion chapter. Very few people see the post. I will not post anything new today to let people catch up. My next question is what to focus on next? In the textbook the next step is Vibrational motion. Should I start posting about it or do something else?

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Eugenia Etkina
Admin
Top Contributor
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Hi @everyone! Some were asking me about summer ISLE workshops. The best one is a week long workshop at Rutgers (NJ).
It is run by Danielle Buggé and Rob Charles (Rob Zisk) with contributions by Debbie Stephanie (Debbie Andres, our famous AAPT vice-president!). I am attaching a flyer for the workshop. With all details, please go to Rob Charles (Rob). His email is in the flyer.
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Eugenia Etkina
Admin
Top Contributor
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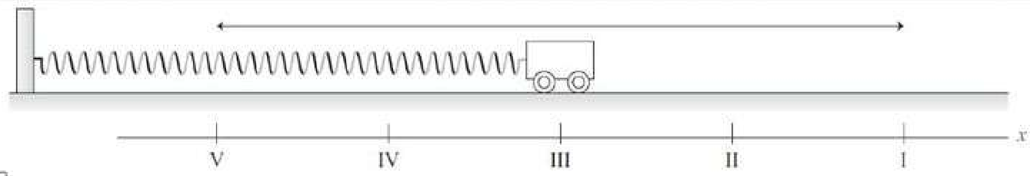
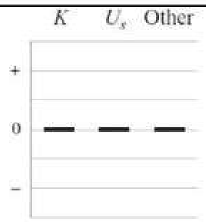
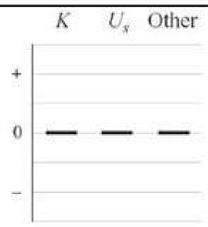
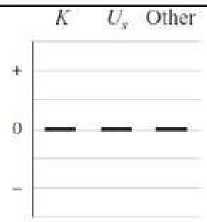
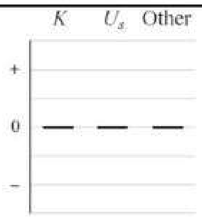
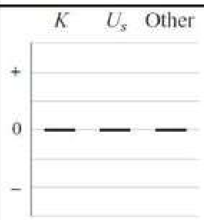
Hi all, yesterday I asked what to comment on now that we have finished rotational motion and the opinions were different. Some wanted optics, some waves, and some - vibrational motion (which is the next chapter after Rotational Motion). As I cannot satisfy everyone, I will go with the vibrational motion (chapter 10 in the textbook).
The most important thing for students to learn there is that all the tools that they have been developing so far - motion diagrams, force diagrams, energy bar charts - they all come together to help them analyze this new type of motion. Not only in this motion nothing is constant even in magnitude, but it has a special point - an equilibrium position and a special force - restoring force that changes direction during each cycle. And despite of all this craziness, our tools work! This is the most amazing aspect of learning vibrational motion.
Now, here is the start (I am pasting the words here and do screen shots of the graphs separately). ALL of those activities are in the OALG file posted here in the FILES.
10.1 OBSERVATIONS OF VIBRATIONAL MOTION
OALG 10.1.1 OBSERVE AND FIND A PATTERN
Equipment: Two small ~200-g objects, a soft spring (if available), piece of string.
For this activity, you will need a soft spring. If you do not have one, a rubber band can be used too. In addition, find some string (dental floss will work) and a couple of small objects to attach to the string and to the spring. Conduct the following two experiments and describe common patterns concerning the behavior of the hanging object.
a. Perform the experiments and record your observations.
Experiment 1: Tie a string to a small object and let the object hang freely. Then, pull the object to the side and release it. Record your observations.

Experiment 2: Hang another object from the spring (or the rubber band), pull the object down, and release it. Record your observations.
b. Identify patterns common to both experiments.
c. Compare and contrast the motions of the objects in these experiments with the motion of objects at constant speed or at constant acceleration.
OALG 10.1.2 REPRESENT AND REASON
The cart in the figure below is attached to a light spring that can stretch and compress equally well. The cart and spring rest on a low-friction horizontal surface. The cart is shown at rest and not accelerating at position III. The cart is pulled to position I (by stretching the spring) and then released. The cart moves to position V, where it then reverses direction and returns again to position I. This motion then repeats.
Observe the cart in the video [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...] and represent the cart's motion with motion diagrams and force diagrams, between each of the points indicated in the table that follows.
AS FACEBOOK DOES NOT ALLOW ME TO PUT TABLES AND FIGURES HERE, I WILL PUT THE TABLE IN THE SCREENSHOT.
a. Do the force diagrams depend on whether the cart was moving left or right? Explain.
b. Are the force descriptions consistent with the motion descriptions? For example, is the net horizontal force in the same direction as the acceleration? Give several specific examples.
c. At each position, compare the direction of the force exerted by the spring on the cart and the cart's displacement from equilibrium when at that position.
d. Summarize the patterns in the direction of the sum of the forces exerted on the cart and displacement of the cart. Compare the patterns you identified with the patterns in Observational Experiment Table 10.1 on page 285 in the textbook and patterns 1 and 2 on page 287. Make sure you read and interrogate the definitions of the equilibrium position, restoring force, and amplitude.
OALG 10.1.3 REPRESENT AND REASON
a. Construct five qualitative work–energy bar charts for the cart–spring system described in Activity 10.1.2 at the points described in the table that follows.
SAME HERE. SEE THE SCREEN SHOT.
b. Do the charts depend on whether the cart is moving left or right when at a particular position? Explain.
c. Identify patterns in the energy conversions during this activity's example of vibrational motion. Compare those to the patterns identified in Observational Experiment Table 10.2 on page 286 in the textbook and pattern 3 on page 287.
d. How would the charts change if the surface had considerable friction? Explain.
OALG 10.1.4 REASON AND EXPLAIN
Summarize the results of Activities 10.1.3–10.1.4 to describe and explain the motion of the cart. The description should include your observations, and the explanations should include your reasoning based on force and energy analyses for the observed phenomena.



Draw a motion diagram for the motion between points I–III, while the cart is moving left.	Draw a motion diagram for motion between points III–V, cart moving left.	Draw a motion diagram for motion between points V-III, cart moving right.	Draw a motion diagram for motion between points III-I, cart moving right.
Draw a force diagram for the cart while it is at point I and moving left.	Draw a force diagram for point III, cart moving left.	Draw a force diagram for point V, cart moving left.	Draw a force diagram for point II, cart moving left.
Draw a force diagram for point I, cart moving right.	Draw a force diagram for point III, cart moving right.	Draw a force diagram for point V, cart moving right.	Draw a force diagram for point II, cart moving right.

Construct a work–energy bar chart for point V.	**Construct a work–energy bar chart for point IV.**	**Construct a work–energy bar chart for point III.**
		
Construct a work–energy bar chart for point II.	**Construct a work–energy bar chart for point I.**	
		

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Eugenia Etkina
Admin
Top Contributor
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Hi all, congratulations to Danielle Buggé who gave a great talk about ISLE, students growth mindset and climate change yesterday for Harvard PoLS-T network. See the posts about it and comments of Jane Jackson yesterday. I am not posting anything today to let people catch up with Vibrations that I started yesterday. There many other posts that did not have lots of views, so, please, catch up!

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Eugenia Etkina
Admin
Top Contributor
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Hi all, I am interrupting the sequence of posts about vibrational motion to ask a question. We started working on a new edition of our textbook and all supporting materials. Current users do not need to worry, all problem numbers and chapter numbers remain the same, we are adding new problems, videos and editing/enriching the content. You will not need change anything in your present materials, just have more and better stuff.
But in this work we have a problem: in DC circuits chapter we help students learn to reason qualitatively about DC circuits using experiments with small incandescent bulbs. Simple example - lighting a bulb with a battery and one wire - a classic. But those bulbs are not used in everyday life anymore and our students do not meet them anywhere outside of a physics course (all bulbs are LEDs and those are too complicated to use for initial concept development). Is this a problem? Do you still use incandescent bulbs teaching DC circuits? Are they available for replacement? If not, what can be used to help students reason qualitatively about DC circuits? Please share your thoughts! Thank you!

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Eugenia Etkina
Admin
Top Contributor
· ·

Hi all, three things today. First, thank you all who responded to my question about incandescent light bulbs yesterday. It looks like they are very useful and we will not remove them. Thank you!

Second, a continuation of my posts concerning vibrational motion. The sequence of activities is in the ALG and OALG (all OALG files are posted here in the FILES). I will just describe the flow: once the students learned the important features of vibrational motion the next steps are: let them observe motion graphs of an object attached to a horizontal spring (not a vertical spring) and analyze their shape. As the shape resembles sin curves, we create a model of simple harmonic motion (it is only a model). Here come new physical quantities, such as amplitude, frequency, etc. We analyze the relationships between position, velocity and acceleration graphs (all these are observational experiments) and start thinking what causes such motion (explanations). We come up with an explanation that the restoring force also needs to be variable and changing the same way as the acceleration. The dynamics analysis follows. Then we add friction to the system and see what energy changes occur and how they lead to the change of amplitude. Finally, we analyze systems with the external driving force and come up with the idea of resonance. The whole flow is beautiful - please check it out in the textbook and in the ALG/OALG. There are several labs described there, do not miss!
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Eugenia Etkina
Admin
Top Contributor
· ·

This post is for those who signed up for the our Saturday workshop for Gases and kinetic molecular theory. I am asking you to do an activity at home so that we save time during the workshop as it takes about 5-7 minutes. You will need a sheet of printing paper, a paper towel and rubbing alcohol. You can use water instead of alcohol but the experiment will take longer. Today I used hand sanitizer and although it took longer than rubbing alcohol, it still worked.
So, here is the experiment: Dip your paper towel in alcohol and make a we streak on the paper. Then observe what happens. Write down what you saw using simple words. Only what you saw. Not any explanations. OK? Please keep the record of your observations as the first thing in the workshop would be to put it on a slide for your team. Thank you!
The link to zoom is in the announcement that I am pasting here. Check your time zone so that you do not miss the start.

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Eugenia Etkina
Admin
Top Contributor

· ·

Hi all, two things today. First, a reminder about gases workshop tomorrow, the link to the event is in my yesterday's post. Second, I am sharing an activity that is a great lab for vibrational motion and at the same time a testing experiment where the students can practice hypothetico-deductive reasoning.

OALG 10.3.3 TEST AN IDEA

Equipment: a spring or a rubber band with an object to hang on it or a rubber band, a stopwatch, a ruler.

In the previous activity, you found that the period of an object vibrating on a spring does not depend on the amplitude of vibrations.

a. Explain whether this finding makes sense to you. Shouldn't a larger amplitude lead to a longer time for an object to come back to the equilibrium position?

b. Design an experiment to test whether the hypothesis that the amplitude of vibrations does not affect the period applies to a system of an object attached to a rubber band.

c. Write a brief outline of the experimental procedure that you will use to test the hypothesis that the period of vibrations of an object attached to a rubber band does not depend on the amplitude of vibrations. Include a labeled sketch.

d. Conduct the experiment and record the data that you collected. What are the uncertainties in your data?

e. What is your judgment about the hypothesis?

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Eugenia Etkina

Admin

Top Contributor

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Hi all, thank you all participants of today's workshop on GASES. We had an amazing group and the whole spirit of the workshop was great. Thank you all for spending two hours on Saturday to learn how to help our students construct them ost important concepts of physics and chemistry.

For those who missed the workshop, here is the recording:

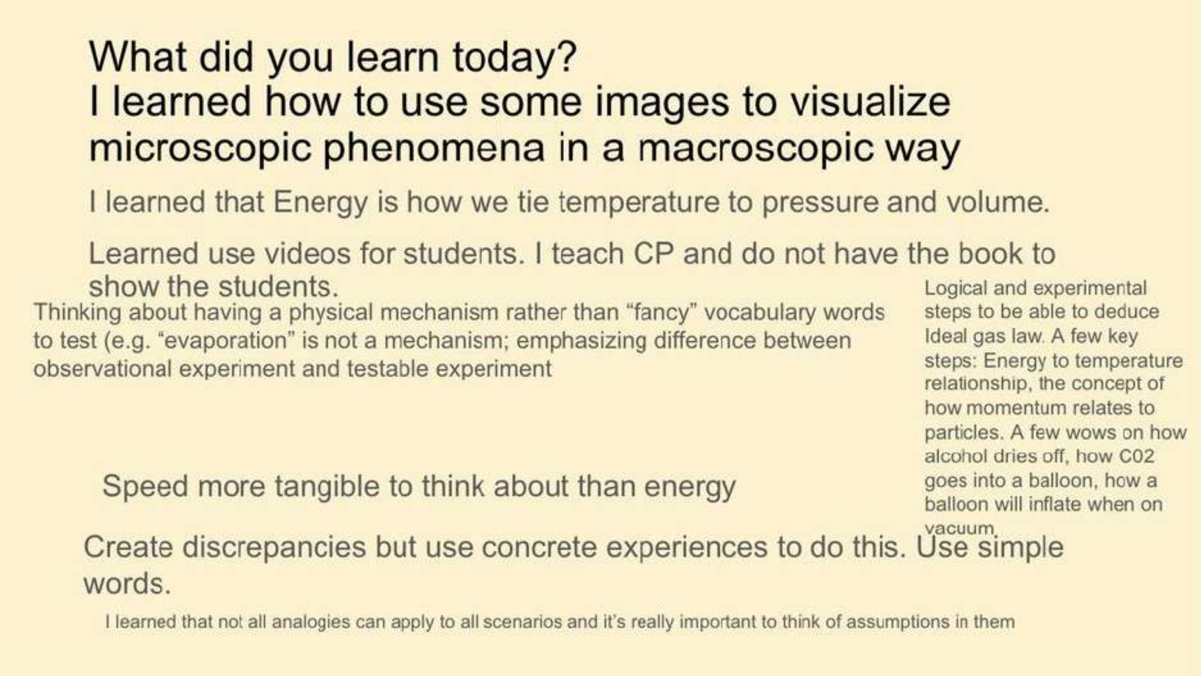
https://rutgers.zoom.us/.../SJJiCxx1uJqcz9fcGU2QOX0it...

The password is @hAi+3Y^

The slides are at https://docs.google.com/.../1IkfjXnfTbBAZF5.../edit...

And here is the slide with what people learned.

The second part of the workshop and the first part on the first law of thermodynamics will be in March. Possible dates are 9th or 16th. I will post the poll tomorrow. Thank you all again who attended the workshop!



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Eugenia Etkina
Admin
Top Contributor
· ·

Hi all, we got electricity back (after 5 days!) and I am on my regular schedule again. Two things today. First, please vote for the date for the second workshop on GASES (scroll down through the posts to find the poll, now votes are split equally). I am especially inviting those who attended the first part of the workshop to vote. If you did not attend the first part but wish to attend the second, please watch the video and work through the activities on your own. Everything is posted here.
The second thing is that I am starting posting about waves. When students learn about waves, there are three important ideas: the source of the waves, the medium in which the wave propagates and the fact that mathematically the description of a wave is a function of two variables - time and space. So far our students dealt with only functions of one variable at a time.
We begin the exploration with focusing on the first two ideas. The sequence that I am pasting below does not require videos but it is great if the students do the first experiment on their own, video it and come to class to discuss. Based on the first ideas they come up with two explanations for how the disturbance spreads in water. They design experiments to test those. Please read the sequence and say what those explanations are and how the students test them. We offer one experiment, but they ocme up with more. What are those?
OALG 11.1.1 OBSERVE AND EXPLAIN
Equipment: a pond or a large bowl, a small object to drop, a smartphone.
Go to a nearby pond, find a small rock (the smaller, the better), drop it into the pond, and video what happens. You can do it at home too if you have a large bowl. In case doing your

own experiment is impossible, observe the following high-speed video [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...].
Devise two (or more) explanations as to how the disturbance created by the falling droplet spreads outward. What experiments can you design to test these explanations?
OALG 11.1.2 TEST YOUR IDEAS
Use the explanations from Activity 11.1.1 to predict what will happen to pieces of light Styrofoam if we place them on the surface of the water before we drop the rock. Write the predictions down, and then observe the following high-speed video [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]. Compare your predictions to the outcomes. Which of your explanations devised in Activity 11.1.1 can be rejected?
OALG 11.1.3 EXPLAIN
Based on your observations and reasoning, what is necessary for you to observe a wave? What property of the medium is essential for wave propagation? After you answer these questions, read and interrogate material on page 316 in the textbook (do not forget to watch the video!). Do your ideas agree with the ideas you read in the textbook? Explain.

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Eugenia Etkina
Admin
Top Contributor
· ·
Hi all, a few things today. First, please read my post from yesterday and sign up for the second workshop for Gases/Thermodynamics. I hope more people will see this post compared to yesterday and sign up. We had a big group in the first workshop (27 people!) and I hope that everyone who attended the first workshop will join the second. If you could not attend the first workshop but wish to attend this one, please scroll down through the posts and find my post with the slides and the recording to prepare.
Second, as you know, we have many members from Italy in the group. Eugenio Tufino translated my article in Physics Today about ISLE into Italian. I am attaching his beautiful translation here. Check it out even if you do not speak Italian. The original article is at https://pubs.aip.org/.../When-learning-physics-mirrors...

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Eugenia Etkina
Admin
Top Contributor
· ·

Hi all, I continue with waves today. In my first post I showed one way for the students to construct two important ideas for waves: that a mechanical wave needs a source and a medium to propagate. Here is another way to do it, using a Slinky. It is especially important for them to understand that the parts of the medium do not move translationally, but the energy does. It is clearly seen when you use a Slinky. I would actually use both types of activities to help students solidify this idea. Here are the activities from the ALG:

11.1.1 OBSERVE AND FIND A PATTERN

PIVOTAL Lab or class: Equipment per group: Slinky, smooth floor, brightly colored tape, whiteboard, markers.

With another member of your group hold both ends of a Slinky and place it on a smooth floor. Stretch the Slinky to about 3-4 meters between the two of you. Do not lift it off the smooth surface. Wrap a small piece of brightly colored tape around a single coil of the Slinky somewhere near the middle. Perform the following experiments and analyze your observations. It is best if another member of your group takes a high-speed video of the Slinky with their cell phone.

a. Keeping the Slinky on the smooth surface and stretched along a straight line, give the end of the Slinky in your hand a quick push along its axis. Your friend should just hold her end without doing anything. Describe what you observe.

b. Sketch the entire Slinky at one instant of time during the propagation of the disturbance you created in part a. Then choose another, later instant and make another sketch. Describe the motion of the disturbance in words as precisely as you can.

c. Indicate in words and draw a motion diagram describing how an individual Slinky ring (the one you wrapped in tape) in the middle of the Slinky moves with respect to the floor as the disturbance passes.

11.1.2 OBSERVE AND FIND A PATTERN

PIVOTAL Lab or class: Equipment per group: Slinky, smooth floor, brightly colored tape, whiteboard, markers.

Keep the Slinky from Activity 11.1.1 on a smooth, hard surface. Perform the following experiments and analyze your observations. It is best if another member of your group takes a high-speed video of the slinky with their cell phone.

a. Give the end of the Slinky in your hand an abrupt sideways shake, perpendicular to the Slinky, all the while keeping it on the smooth surface. Your friend should just hold her end without doing anything. Describe what you observe.

b. Sketch the entire Slinky at one arbitrary instant of time during the propagation of the disturbance you created in part a. Then choose another, later instant and make another sketch. Describe the motion of the disturbance in words as precisely as you can.

c. Indicate in words and draw a motion diagram describing how an individual Slinky ring (the one you wrapped in tape) in the middle of the slinky moves with respect to the floor as the disturbance passes.

11.1.5 EXPLAIN

Lab or class

Discuss with your group members what is necessary for you to observe a wave. What property of the medium is essential for wave propagation?

11.1.6 TEST YOUR IDEAS

Lab or class

In Activity 11.1.5 you came up with an idea that the interaction of the parts of the medium are necessary for a wave to propagate. Use this idea to predict what will happen if you hit (lightly) a person’s arm (you tap the flesh on the forearm). Write the predictions down, then observe the high-speed video [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-11-1-6] and compare the predictions to the outcomes.

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Eugenia Etkina
Admin
Top Contributor
· ·

Hi all, there are days when I just can't post anything about physics. Today is one of those days. If you do not know who Alexey Navalny is (or was), please google. If you do not know what happened to him, please google. If I were in the classroom, I would tell my students about him and about the tyranny that exists in the world. We do not teach physics, we teach people. And they should know the heroes and the villains. They are above politics.

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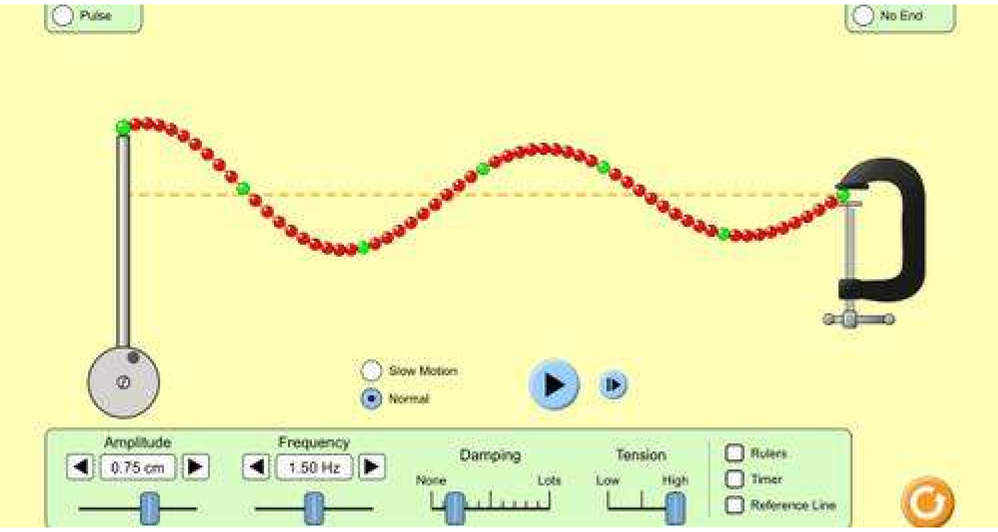
Eugenia Etkina
Admin
Top Contributor
· ·

Hi all, I continue with the waves today. I am posting a sequence of activities that helps students construct the physical quantities describing a sinusoidal wave and most importantly the quantity of wavelength as the distance between two closest point that undergo the same motion It is a really cool sequence but to see its benefits you need to go through the activities yourself. The sequence is quite long, so be patient!
11.2.1 OBSERVE AND EXPLAIN
PIVOTAL Lab or class: Equipment per group: whiteboard, markers, laptop or tablet.
Work with your group, putting all your ideas and representations on a whiteboard. Open the PhET simulation at the link:
https://phet.colorado.edu/.../wave-on-a-string_en.html
Set damping to “none”, set tension to “low”, select “no end”, and select “oscillate”.
Now set frequency to 0.5 Hz, check “rulers” and “timer”. You’re set to go.

a. Start the string vibrating by hitting “restart.” Look at the wave as it progresses down the string. Use the “slow motion” function if it helps. As accurately as possible describe the motion of the disturbance in words. What type of motion is it (constant speed/constantly speeding up)?
b. If you hit the pause button, you’re now looking at a picture of the disturbance at an instant in time (a single snapshot of the action). Based on this snapshot, construct a graph that shows on the vertical axis how the medium is disturbed at that instant of time at different positions x along the horizontal axis. (Think carefully about what physical quantity you want to put on the vertical axis.)
c. Start the string oscillating again by hitting “restart.” Now pick one of the green dots on the string and focus your attention on it. Describe the motion of the green dot in words and draw a rough motion diagram for that dot.
d. Based on your observations construct a graph that shows how the green dot moves as a function of time. (Think carefully about what physical quantity you want to put on the vertical axis.)
e. Now try varying the frequency of the oscillation up to, say, about 1 Hz. Does the speed at which the wave moves down the string depend on how fast the end is oscillating up and down? Describe what happens to the whole wave when the frequency is increased. Explain why this happens.
11.2.2 OBSERVE AND EXPLAIN
PIVOTAL Class or lab: Equipment per group: whiteboard, markers.
Work with your group, putting all your ideas and representations on a whiteboard. Imagine that somebody oscillates a Slinky by moving their hand in a sinusoidal motion along the axis of the Slinky as shown in the snapshot picture below.

a. Imagine you can watch the wave as it progresses down the string. Describe as accurately as possible the motion of the wave in words. What type of motion is it?
b. If you look at the picture above, you are looking at a picture of the disturbance at an instant in time (a single snapshot of the action). Based on this snapshot, construct a graph that shows on the vertical axis how the medium is disturbed at that instant of time at different positions x along the horizontal axis. (Think carefully about what physical quantity you want to put on the vertical axis.)
c. Imagine now that the Slinky is oscillating. Imagine you focus on one single coil on the Slinky. Describe the motion of that coil in words and draw a rough motion diagram for that particular coil.
d. Based on your observations construct a graph that shows on the vertical axis how the single coil moves as a function of time. (Think carefully about what physical quantity you want to put on the vertical axis.)
11.2.3 Represent and reason
PIVOTAL Lab or class: Equipment per group: whiteboard, markers, laptop/tablet.
Work with your group and put your work on a whiteboard to share with another group. Open the PhET simulation at the link:
https://phet.colorado.edu/.../wave-on-a-string_en.html
Set damping to “none”, set tension to “low”, select “no end”, and select “oscillate”.
Now set frequency to 0.5 Hz, check “rulers” and “timer”. You’re set to go.
a. Hit “restart” and observe the motion of every other green dot. Describe what you see concerning the relationship between the motions of the green dots in words, as clearly as possible.
b. Construct a displacement-versus-time graph for one green dot on the string. Show the period Tof that dot’s motion on your graph. (If the frequency is 0.5 Hz, what is the period?)

c. Pause the simulation and construct a displacement-versus-position graph for a segment of the infinitely long string. Show the green dots, and number them 1, 2, 3, etc. Number 1 green dot is the one attached to the oscillator. What name shall we give to the distance between every other green dot?
d. Pause the simulation, hit “restart” and use “slow motion.” Now let the simulation run. How long does it take for the front of the disturbance to get from dot 1 to dot 3? How long does it take for the front of the disturbance to get from dot 1 to dot 5? Step the simulation one frame at a time if needed.
e. If the disturbance moves down the string at a constant speed v, come up with a mathematical relationship that relates the distance l between every other green dot to the period T of the oscillator and the speed v of the wave.



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Eugenia Etkina
Admin
Top Contributor
· ·

Hi @everyone! In a previous post by Allison Daubert Jason Chung asked a question: How do we show a student how to read a textbook?" This is a great question and although I posted about it before, I would like to come back to this issue. First, as Allison Daubert said, in ISLE students read the textbook AFTER they do ALG/OALG activities in class, not before. Our textbook College Physics: Explore and Apply by Etkina, Planinsic and Van Heuvelen (the original reason for the creation of this group) discuses the SAME activities that the students have done, thus, they have personal experience and an image of the ideas described in the book. And yes, they need to know how to read the textbook. It is not the same as reading fiction books. Here is a long post about this. Be patient, it is indeed very long.
"One of the goals of the ISLE approach is to help students experience learning physics similar to how physicists construct knowledge. A crucial part of functioning as a physicist or any scientist is reading scientific texts. Although evidence suggests that the ability to

effectively read science texts is important, students enrolled in STEM courses do not regularly read science texts (Podolefsky and Finkelstein 2006). In one survey of life science and engineering majors (Stelzer et al. 2009), the researchers found that 70 percent of students never or rarely read texts. A study of students enrolled in introductory physics courses found that while 97 percent of the students report buying the text, fewer than 40 percent of those students regularly read it. Studies in other content areas have yielded similar results, finding that less than 30 percent of students regularly complete reading assignments. This lack of consistent reading can be detrimental not only to the students' learning in school, but also to their success out of school.

Why don't students read the textbook even if they spent money on it? We can see three reasons here. The first one is the textbooks are written in a way that does not help students learn. The second one is that the students do not know how to READ textbooks. They usually approach a textbook as they approach fiction, thinking that just by reading a sentence after a sentence they can learn new ideas and solve problems. But reading is just one part of the brain learning cycle (Kolb 1984 and Zull 2002). According to brain research, the learning process starts with sensory input. It then proceeds to the reflection of this input and the subsequent formulation of a hypothesis that explains the input by connecting it to existing knowledge. Finally, the hypothesis explaining the input needs to be tested through the engagement of the learner in active testing of the hypothesis which involves motor functions (it can be talking, writing, performing an experiment, etc.). Based on this process, reading involves sensory input. However, if after this input the reader does not reflect on the read sentence and does not try to place it in the set of knowledge that they already possess by making connections, does not hypothesize what this read sentence or paragraph can mean, and does not talk to other people about it, or write it, then the read information does not become "knowledge" or "understanding". Therefore, if we wish the students to learn something from reading the textbook, they need to learn to go through the above processes. The third reason for the students not reading textbooks might lie in the use of internet and social media. Research points to the reduced attention span and inability to concentrate of those who spend a lot of time on online social networks (Paul et al. 2012). To benefit from textbook reading, one needs to invest significant time and mental energy. The lack of this time and inability to focus on the same content for a prolonged time might also contribute to the lack of textbook reading. However, this reason might not be that important as even before the expansion of social media our students did not read textbooks much.

To help students develop abilities to comprehend and think critically about their reading, we need to teach them to read scientific text the same way we teach them how to design experiments, collect and analyze data, solve problems, etc. One method that was found effective to achieve this goal is called Elaborative Interrogation (Smith et al. 2009). Elaborative interrogation is a reading strategy in which students are prompted to read the text and then answer a "Why is this true?" question based on the reading. The results of interrogation studies are encouraging, as the method shows increased comprehension over more traditional comprehension techniques such as rereading. Two studies examined the reason for the effectiveness of this method and both came to a similar conclusion. The "Why" questions help focus students' attention on the relevant information within the text, which reduces the cognitive load of irrelevant information. But the reduction of cognitive load is not the only benefit of the Elaborative Interrogation approach. If you think of what is happening in our brain when we ask ourselves "Why is this true?", you will see that the steps resemble Kolb's learning cycle. To answer this question, the reader needs to first think of what this "this" is – reflective observation. Then they need to figure out how this new piece of information relates to what they already know to answer the question why this is true – making a hypothesis. Finally, if the assignment requires the student to write an answer to the question as a part of the homework assignment or class activity, then they engage in active testing as motor function is involved.

While it might seem that Elaborative Interrogation is just another technique that we, as teachers, need to learn, in fact, there is nothing new to it. All experts, when reading scientific papers, interrogate them. They ask themselves the following questions: How do the authors know this? What is the evidence? What is the uncertainty in the evidence? How does this new idea fit into my previous knowledge? How can we test this new idea? And so forth. These are interrogation questions and when we ask them, we go through the Colb's cycle again and again. How can we teach our students to do the same?

Here is an example. We call it "reading aloud with the students". Ask the students to open a page in their textbook (it needs to be the same page for the whole class) and read a paragraph. Then you model how to interrogate each sentence in the paragraph. For example, here is a paragraph from the textbook mentioned above (Chapter 17, p 506):

"We now understand why rubbed objects acquire opposite charges. Two objects start as neutral—the total electric charge of each is zero. During rubbing, one object gains electrons and becomes negatively charged. The other loses an equal number of electrons and with this deficiency of electrons becomes positively charged. Sometimes when you rub two objects against each other, no transfer of electrons occurs. When the electrons in both materials are bound equally strongly to their respective atoms, no transfer occurs during rubbing."

Below I show how to "read it aloud" with your students to help them learn how to interrogate this text. I will show the original text in Italics and the interrogation progression in a regular font.

We now understand why rubbed objects acquire opposite charges. When did we learn that? Oh, right, we did experiments when we saw that when you rub the foam stick with fur, this fur attracts that stick and repels the stick rubbed with plastic. Assuming that the stick rubbed with fur is negatively charged, and the stick rubbed with plastic is positively charged, then the fur should be positively charged. I guess the sentence makes sense.

Two objects start as neutral—the total electric charge of each is zero. That is right, zero does not mean the absence of charge as I remember though. Maybe a neutral object already has both charges inside, but they cancel each other?

During rubbing, one object gains electrons and becomes negatively charged. The other loses an equal number of electrons and with this deficiency of electrons becomes positively charged. We just studied that atoms are made of positive nuclei and negative electrons and only electrons are mobile. When we charge objects by rubbing, then it is possible that some of the electrons of one object jump onto the second object. Then the first object that lost electrons is now positive and the object on which the electrons jumped is negative. But the total charge is still zero as we did not create or destroy any electrons.

Sometimes when you rub two objects against each other, no transfer of electrons occurs. Hmm, this does not make any sense. Does this sentence contradict the previous sentence?

When the electrons in both materials are bound equally strongly to their respective atoms, no transfer occurs during rubbing. Oh, I see now. If the electrons are bound equally strongly in both objects, then nobody can pull electrons from this other object. Then it means that for charging by rubbing to work, the electrons in the two rubbing objects need to be bound differently to their nuclei. However, if I think about it, it does not make sense. It is very hard to imagine that all electrons are bound equally strong to an object. So, maybe, if the electrons are bound approximately equally strongly in both objects, each object takes about the same number of electrons from the other object. Therefore, the total number of electrons on each object practically does not change. I wonder which one is more correct…

The process described above takes about 5-7 minutes in class, but it is extremely important as it shows your students how you think. When we talk about cognitive apprenticeship, the most difficult part of it is to make the thinking of an expert visible to a novice so that the novice can use it as an example. Thinking aloud when reading the text achieves this goal. The next step is to engage the students in the same activity for a couple of examples and then to assign reading and interrogation for homework. But how do you know that the students did indeed interrogate the text at home? One way to do it is to explicitly assign interrogation questions as homework and then put them on quizzes and tests. In our textbook each section ends with an interrogation question, the answer to which can be found in the text of the section."

If you read the post to the end please 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
· ·

Hi @everyone two days ago Hisashi Kuriki asked about ISLE am misconceptions. You probably noticed that I never talk about students' misconceptions in my post. Why? It is a long story and it will require a few posts. Here is the first one:

How do we treat student ideas?

The disagreement of how to treat student ideas is as old as the idea that the students are not blank slates when they come to us. The recognition that students come to class with existing knowledge is the first step in helping them learn (Dehaene 2020; Zull 2002). Investigating those ideas is the next important step. Often, these ideas look “wrong” at a first glance as they do not match the normative physics understanding that we wish our students to develop. However, after that the viewpoints of educators diverge.

Some educators label the ideas that students bring into the classroom as “misconceptions” (sometimes labelled as preconceptions, alternative conceptions, etc. (Clement 1982; Halloun and Hestenes 1985; Kaltakci-Gurel et al. 2016; McCloskey 1983), some label them as “resources” (Smith et al., 1994, and more below).

When researchers or teachers talk about misconceptions (or whatever label they give to those) they usually mean that students strongly hold firm cognitive structures (conceptions) that are different from experts, affect how students understand and explain natural phenomena, and must be overcome or replaced. 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 (Hammer 1996), “This view frames research designed to identify misconceptions and instruction designed to reveal, confront, and replace them.”

This view appears consistent with the constructivist idea that students are not blank slates. Plus, it agrees with our experience: students do come up with incorrect ideas, don’t they? We all have experiences when our students express views completely inconsistent with the laws of physics. For example, many researchers have documented the student

“misconception” that “motion implies a force, and when there is no force, motion ceases” (impetus theory as described by (Hestenes, et al.1992)). It looked like in many instances (including standardized assessment instruments, such the Force Concept Inventory described in the paper cited above) students have this robust wrong idea.
Yet this “misconception” viewpoint imposes certain tasks on the teacher, namely to identify such misconceptions in students’ minds and help them get rid of those ideas. That last step breaks the connection with constructivism. If we remove those prior “wrong” ideas from students’ minds, then how do we help our students build new ideas which (as brain research tells us, see (Dehaene, 2020)) can only be developed if they connect to previously existing ideas? In fact, when Brookes and Etkina (Brookes and Etkina 2009) conducted a linguistic analysis of student responses about the “misconception” that motion implies a force, 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). Thus their responses are completely correct and only require some language correction, not the replacement of the conception. Based on similar analysis, other researchers (Smith et al. 1994, diSessa 1988, diSessa 1993) have 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.
So, are there alternatives to the "misconceptions" approach to student ideas? Yes! There are and the ISLE approach is built on those alternative approaches. What those approaches are and how ISLE incorporates them will be in my post tomorrow. Stay tuned!
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Eugenia Etkina
Admin
Top Contributor
· ·

Hi all Exploring and Applying Physics people! I continue a series of posts about students ideas and why we do not have the term misconceptions in our ISLE vernacular and why we do not consider students to be carriers of incorrect physics ideas (however, we do not reject the concept of "student difficulties" - something that is inherently difficult and needs to be paid attention to; those are identified in every chapter of the Instructor Guide - posted here in the FILES). So, here it goes - and it is again, very long. Be patient!
Knowledge in pieces
“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 marshaled 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 in (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" or 'p-prims', which refer to simple ideas that grew out of generalizations of everyday phenomena (DiSessa 1993).
As Hammer 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 its effect on the electric current, 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 modifying 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 is reasoning 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 they are activating rather quickly. Richards, Jones, and Etkina in the paper "How Students Combine Resources to Make Conceptual Breakthroughs" (Richards et al. 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 p-prims, 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, it might lead to the 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 will want their teacher to "give them an answer". Like p-prims, conceptual and epistemological resources are activated when we ask students questions or when they are interpreting reading materials. While these p-prims and

resources sometimes lead the students to give answers that are “wrong”, we should try to “diagnose” the source of their ideas and channel this source in a productive direction.
Here is an anecdote might help. In the Rutgers Physics Teacher Preparation Program in the course “Development of Ideas in Physical Science”, there is an assignment when the students need to interview a novice about a specific physics topic, transcribe the interview, and then interpret what the subject said. One of the pre-service teachers had to interview a novice about electric charge. This was his comment at the end of the discussion of the interview: “It looks like my interviewee did not know anything about electric charge, but if you replace the word “energy” with the words “electric charge” in his answers, most of them are absolutely correct”. This comment shows how important it is to listen to the students carefully and think of what resources they activate when responding to our questions. Without a doubt, we both consider the frameworks of p-prims and resources much more productive in helping students learn than the framework of misconceptions (or alternative or naïve conceptions), and we try to avoid the term “misconceptions” when talking about student ideas.
If you read the post to the end, please like it or comment on it to make it more visible for the rest of the group. To be continued tomorrow.
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Eugenia Etkina
Admin
Top Contributor
· ·
Hi all, I continue the series of posts about why we do not use the term misconceptions in the ISLE approach. Please read my previous posts to see what came before this one. Again this is a long post, so please be patient.
Without a doubt, we consider the frameworks of p-prims and resources much more productive in helping students learn than the framework of misconceptions (or alternative or naïve conceptions), and we try to avoid the term “misconceptions” when talking about student ideas.
Naturally, within the resource framework, we still appreciate that students often need to overcome difficulties when constructing physics ideas. There are several well-documented student difficulties (most created by instruction, or by the confusing language, or by the context of our questions that is unfamiliar to the students) that we acknowledge and list them in every Chapter of the Instructor Guide (posted here in the FILES).
Here is an example from Chapter 3, Newtonian mechanics:
“The most difficult is the meaning of the word “force” as a quantity that characterizes an interaction between two objects as opposed to the motion of an object. The reason for this difficulty is the language we use in everyday life. The difficulty that stems from our teaching is thinking that ma is a force and using ma to calculate any force. Other common difficulties include thinking that objects move in the direction of forces, and that any two forces that are the same in magnitude and opposite in direction are Newton’s third law forces. When drawing force diagrams for an object of interest, students mistakenly put forces exerted by the object of interest on some other object.”

This example shows the causes of the first two difficulties but does not address the causes of others. We can think of the “moving in the direction of the force” difficulty as arising from focusing on the experience when any motion starts – the object always starts moving in the direction of the sum of the forces. Therefore, this difficulty stems from generalizing from some of our real-life experiences and forgetting about others. If we start from this experience and then ask students to analyze their experiences when the forces are exerted on an already moving object (for example, an object upward, under the condition that the students apply the correct definition of force), they will see that their rule only applies for the beginning of the motion, and not when an object is already in flight on the way up. The difficulty with Newton’s third law stems from teachers’ focus on “equal in magnitude and opposite in direction” with less emphasis on the fact that these two forces characterize the same interaction. Here, student thinking is very productive for applications of Newton’s second law and all we need to do is ask on what systems those equal and opposite forces are exerted and what interactions they describe. Again, there is nothing wrong with students’ thinking here, it is simply misapplied. And the last difficulty can again be caused by teaching – through not identifying the system and the environment before drawing the forces. Here it is interesting that combining student reasoning related to Newton’s third law (above) with this difficulty can help students with the application of the third law when they are trying to put the forces that the system exerts on an object in the environment on their force diagram. Therefore, none of these difficulties is a firm wrong concept that needs to be removed from students’ minds but a productive resource that can be used to develop conceptual understanding.

The ISLE approach and student ideas

At this point you may be wondering: how does the ISLE approach address students’ ideas, including p-prims and resources? As we do not ask students to make predictions before initial observational experiments, they are free to observe the phenomenon/a without any expectations. When they describe what they observe using simple language, again, we are trying not to tap into their resources (yet). But when they have to come up with “wild ideas” explaining the observational experiments, this is when their resources and p-prims come into play. For example, students conduct an observational experiment with a light bulb illuminating the walls and the ceiling of the room. The students need to represent how the bulb’s light rays reach all the points of the room. Their first model that they come up with is that each point on the bulb sends one ray (see the image attached to this post).

Why would they come up with this model? The resource here that they tap is a commonly used drawing of the Sun where one point sends one ray. While this will turn out to be a wrong model, the beauty of this model is that it is easily testable. Then the students themselves devise the testing experiments, make predictions of their outcomes using their model, run the experiments and find that the outcome do not match the predictions. They get intrigued and think how they can tweak the model to account for the outcomes. Therefore, you can see that in ISLE the students bring their ideas at the stage of the testing experiments and reflect on why those ideas may be rejected sometimes. These actions become epistemological resources – e.g. every idea needs to be experimentally testable – which help them navigate new physics knowledge.

As another example of the ISLE approach to address student ideas, we can use observational experiments to help students create a “correct” model when the model so counterintuitive that they do not believe it. This is how one of the users of the ISLE approach, Allison Daubert described this experience in her post last year:

“The biggest place where I think we bring in student ideas is during testing experiments. (Key here - not observational experiments at the beginning). So, as an example, for Newton's 3rd Law, students observe that the readings of F 1 on 2 is always the same as F 2

on 1, but really, they don't believe it yet. We let them test all of these ideas about how motion or mass might affect the sizes of these forces in the testing experiments where they themselves design the experiments and they themselves get to disprove these ideas. I often discuss with students at the end of the testing experiments about how their initial ideas just contained slightly wrong language - that's all. While yes, the objects exert the same magnitude forces on each other their accelerations are drastically different, and that's the experience that they have in life, and that's the value in their idea.” (Allison Daubert, December 27th, 2022)
From the above two examples emerges a very big idea. One of the mains goals of the ISLE approach is to help students create new epistemological resources which resemble epistemological resources of scientists! In other words, one of our main goals is to help our students develop scientific epistemology (the word epistemology means the study of the structure and development of knowledge). Having scientific epistemology, i.e., the approach to the nature and development of knowledge that scientists have, will allow our students to learn how to question claims that people make, how to view scientific knowledge as continuously improving (this is something that lay people have a hard time accepting), how to separate experimental facts from hypotheses or opinions, and so forth. If you are truly implementing the ISLE approach, your students will develop all these resources and they will be using them for the rest of their lives.

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Eugenia Etkina
Admin

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Hi all, after a brief interruption, I continue the series of posts about students ideas. Please see my posts in the last 5 days before reading this one (if you did not read those). This post is about how ISLE naturally builds on students' strengths.
Unexpected treasure: student learning resources
While we discuss conceptual resources that students bring into learning and epistemological resources that we wish them to develop, it is good to remember that our students have other resources that they bring into learning. We can call them learning resources. Normally when we talk about those, people mean resources that the students can use - textbooks, websites,

etc. to learn. Here, we mean a completely different thing: RESOURCES THAT THE STUDENTS BRING INTO LEARNING that relate to how people learn. 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. What skills do they develop doing it and how can those skills help them learn physics through the ISLE approach?
1. 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 when the experiment that they have designed works, the new explanation fails to be rejected, or the resubmitted work allows them to learn more and get a better grade. ISLE offers a system that rewards perseverance and respects that different people may need different numbers of attempts or different amounts of time to learn something. It is the final outcome of this learning, not the speed with which it is achieved, that is rewarded.
2. Our students know how to work in a group and learn from group mates (e.g. they play with other people online where there is a ton of learning going on; 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. As members receive the same grade for their work, they are motivated to work together. The same is true for any group activity that is organized well.
3. 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 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.
4. Our students know how to look for feedback and how to deal with feedback (think again about all the activities that they engage in). In the ISLE approach, a lot of feedback is provided 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.
5. They are creative (watch them play Minecraft!). ISLE builds on their creativity through engaging them 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 detailed instructions in the labs, which mainly verify what they have heard in lectures. All these elements (and many others) serve to reject the learning 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 or your grade, and there is no room or no time for creativity. Slowly, day by day in such an environment, they stop brining their wealth to the table and start developing apathy, boredom, and lack of interest to struggle. We all are familiar with these issues and often blame the students for their lack of motivation, perseverance, etc. But really it is the result of our educational system. Now, when you get the students who have been in this system for many years and have stopped applying their real learning resources in school a long time

ago, how do you remind them that they have these resources? We need to remind them because otherwise they will not be successful in the ISLE classroom.
To help your students remember all the learning resources that they possess, you can engage your students in the Expertise Activity, brilliantly designed by Yuhfen Lin and David Brookes (Brookes and Lin, 2012). David Brookes described it and other methods to help students activate their learning resources in one of the interludes in our first ISLE book (Etkina et al. 2019, page 3-9). (BTW, we are finishing up the second book about ISLE, it will come out in the summer)
“In this activity, we ask students to identify a hobby they are accomplished at and divide them into thematic groups based on their responses. For example, there is often a cooking group, a sports group, a board and computer games group, etc. We task each group with drawing up a learning cycle on their whiteboard that explains to the rest of the class how one can move from becoming a novice to an expert in their chosen field of expertise. The important point is that they must draw a repeatable cycle, not a list of ‘what does it take to become good at something.’ Having them construct a learning cycle draws out all the keys features of real-life learning: the need for motivation and persistence, the role of critical self-evaluation and seeking feedback from others, etc. These are all features of the ISLE classroom. At the end, students present their learning cycles to each other and I draw the discussion together at the end, highlighting common features, connecting those features to how the ISLE class is set up, and sometimes have them watch Dr. Tae’s TED talk.”
https://www.youtube.com/watch?v=lHfo17ikSpY

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Eugenia Etkina

Admin
Top Contributor
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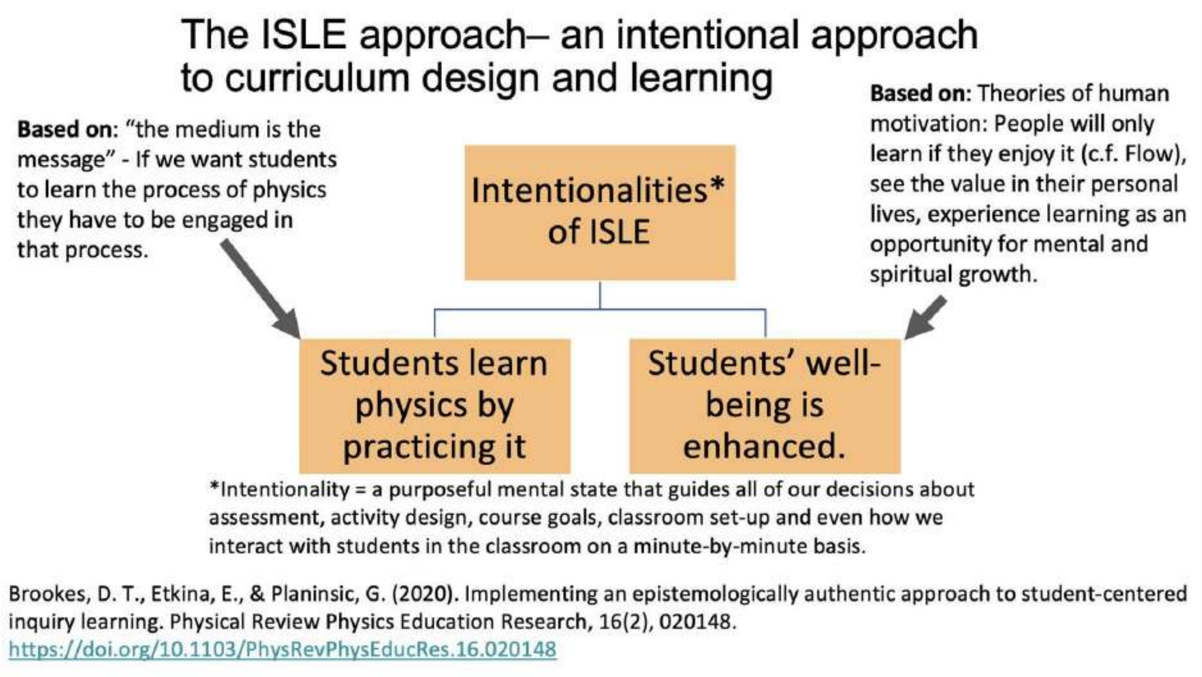
Hi all, as we have been seeing a huge number of people joining our group, I wanted to remind everyone that ISLE is an example of an intentional approach to curriculum design. I pasted a screen shot to the slide that explains what the word intentionality means and what intentionalities govern ISLE. But today, in light of those intentionalities, I wanted to share a metaphor that I invented a long time ago to help me make decisions in the classroom. It is called a compass.
Here is the story:
During a lesson, there can be multiple moments when a teacher needs to make a split-second decision on how to proceed. If the decision is successful, the lesson improves. If the decision is not successful, the lesson might tank. How do we make these in-the-moment decisions? As I said above, a long time ago I came up with a metaphor of a “double headed compass”. The main idea of the compass is that it guides you when you need to make a decision. One “head” of the compass arrow aligns with the direction of more learning for the students (or less learning for the students) and the other one aligns with the direction of better well-being for the students (or worse well-being for the students). When making decisions one should think of whether the decision will lead to more learning and/or better well-being for the students or the opposite. For example, when a lesson is in progress, a student walks in late. What to do? Here, the compass tells you to not discuss the reasons of being late with the student in front of the entire class in order to not distract the rest of the students from learning (more learning). This also allows the student who was late to proceed to their seat and start working while helping them catch up (more learning). At an opportune moment or after class, talk to that student about the reasons for being late and provide help if needed (better well-being).
I found that this compass helps me not only in the classroom but also with my own children/grandchildren and my friends - what to say and when... What do you think?



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Eugenia Etkina
Admin
Top contributor

Hi all Exploring and Applying Physics people (and Julie Zaborac), I continue with waves today. We have discussed so far how to analyze wave motion using phet simulations. From those activities (see my posts a week ago) the students should come up with the idea that a wavelength of a wave is the distance between two closest points that vibrate the same way (this is the operational definition of the wavelength). This distance depends on the period of the wave (how long it takes ONE point to repeat the same motion) and how fast the wave propagates during this time. Therefore, the wavelength should be equal to the period multiplied by speed. The period (or the frequency) depends on the source of the wave and the speed of propagation depends on the medium (this is actually only true in the absence of dispersion, but we do not study dispersion in mechanical waves, only with light waves). Therefore, the wavelength is the function of both - the source and the medium and we should write the mathematical expression for it as lambda = T x v = v x (1/f). This is a cause-effect relationship as both T and v can be varied independently. Unfortunately, in many textbooks this relationship is written a v = lambda x f, which makes students think that the speed of the waves depends on the wavelength and frequency. The same issue occurs when Ohm's law is written at voltage=current x resistance, while voltage does not depend on the current. Thus Ohm's law needs to be written as current = voltage / resistance. There are many other examples of writing cause-effect relationships properly, we just need to pay attention.

If you read the post to the end, please like it or comment on it to make it more visible for other group members. Thank you.
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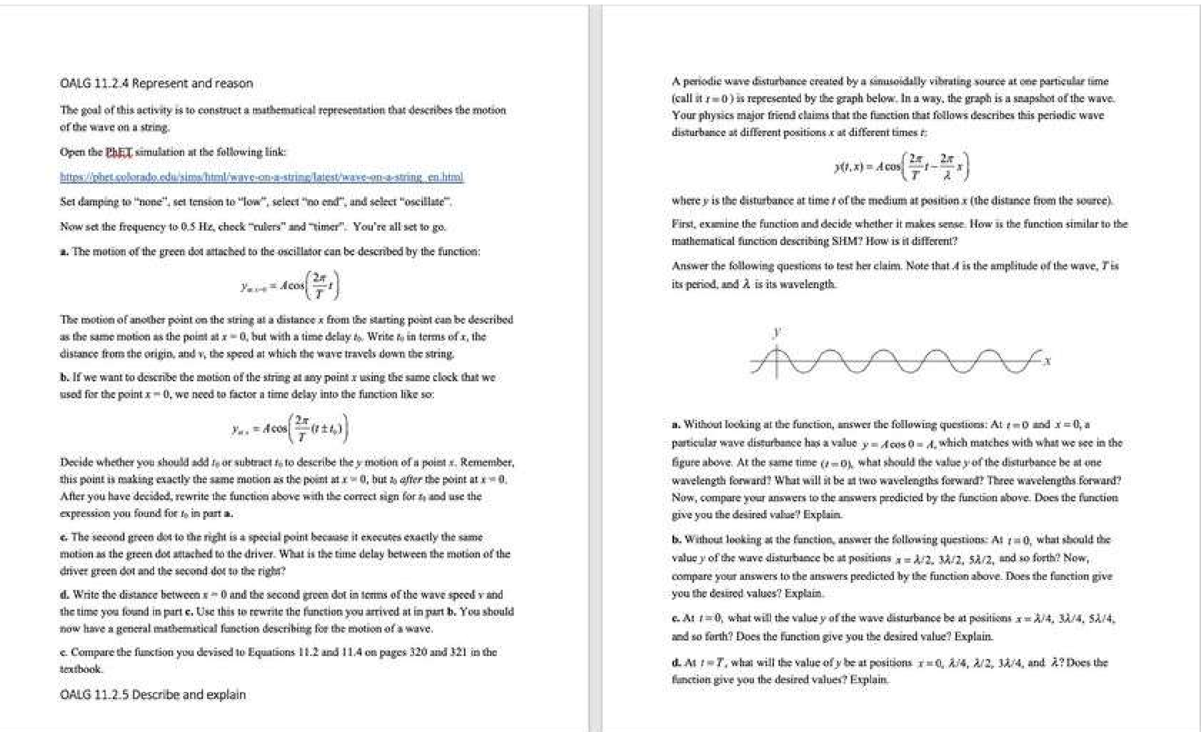
Eugenia Etkina
Admin
Top contributor
· ·

Hi all @everyone, two things today: 1) If we were to run a two day (4 hours a day, 8 hours total) introductory ISLE workshop online in the summer, who would be interested in attending it? I need people to express their interest in comments to this post. Please comment here if you are interested in attending. As always, these workshops are free (AAPT summer in-person workshop which is also 8 hours is not free, as well as the week-long in-person workshop at Rutgers). We will only run the workshop if there is enough interest. So, please respond by commenting.
2) Yesterday I posted the reasoning behind two definitions of wavelength (operational and cause- effect). But how will students arrive to these ideas and how will they construct the wave equation - a function of two variables? The screenshot of two OALG activities is posted here, the full chapter is in the FILES. Please ask questions.



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:

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

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:

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

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.

OALG 11.2.5 Describe and explain

A periodic wave disturbance created by a sinusoidally vibrating source at one particular time (call it $t = 0$) is represented by the graph below. In a way, the graph is a snapshot of the wave. Your physics major friend claims that the function that follows describes this periodic wave disturbance at different positions x at different times t:

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

where y is the disturbance at time t of the medium at position x (the distance from the source).

First, examine the function and decide whether it makes sense. How is the function similar to the mathematical function describing SHM? How is it different?

Answer the following questions to test her claim. Note that A is the amplitude of the wave, T is its period, and λ is its wavelength.

a. Without looking at the function, answer the following questions: At $t = 0$ and $x = 0$, a particular wave disturbance has a value $y = A\cos 0 = A$, which matches with what we see in the figure above. At the same time $(t = 0)$, what should the value y of the disturbance be at one wavelength forward? What will it be at two wavelengths forward? Three wavelengths forward? Now, compare your answers to the answers predicted by the function above. Does the function give you the desired value? Explain.

b. Without looking at the function, answer the following questions: At $t = 0$, what should the value y of the wave disturbance be at positions $x = \lambda/2,\ 3\lambda/2,\ 5\lambda/2,$ and so forth? Now, compare your answers to the answers predicted by the function above. Does the function give you the desired values? Explain.

c. At $t = 0$, what will the value y of the wave disturbance be at positions $x = \lambda/4,\ 3\lambda/4,\ 5\lambda/4,$ and so forth? Does the function give you the desired value? Explain.

d. At $t = T$, what will the value of y be at positions $x = 0,\ \lambda/4,\ \lambda/2,\ 3\lambda/4,$ and λ? Does the function give you the desired values? Explain.

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Eugenia Etkina
Admin
Top contributor
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Hi all, yesterday Jeff Funkhouser posted about our group on the AP Facebook group and over 40 new members joined us. We welcome all new members! If you joined yesterday, please take some time to learn what this group is about. The foundational philosophy of the group is the Investigative Science Learning environment approach (ISLE). It is briefly described at islephysics.net and there you will find lots of resources that we offer. The goal of the group is to help teachers of all levels engage their students in a consistent learning of physics by practicing it. We do not do individual worksheets. We have a continuous sequence of activities for every concept that follow the same logical progression: students working in groups observe simple experiments, find patterns, devise explanations for them and then test them experimentally by using hypothetico-deductive reasoning logical chain. Un-rejected explanations are later used for practical purposes. We have these sequences for every concept but to understand those you need to see the big picture of the ISLE approach. I am posting a paper here that describes it Please read to know what this group is about. We run monthly online free 2-hour workshops. The next workshop on Gases-First Law of Thermodynamics is on March 16 noon-2 pm EDT. The information is in the EVENTS but it is a continuation of the previous workshop, so you will need to review that one if you wish to join the one on March 16. I know that many of you joined because of the workshop on fluids that Jeff talked about, but gases are fluids and therefore all those workshops are necessary. Finally, in these workshops we use the tools that the students developed in the previous chapters. To learn those, you need to get the AP Edition of the textbook College Physics: Explore and Apply by Etkina, Planinsic and Van Heuvelen. The instructions on how to get a free copy are on islphyscs.net. Wow, it is a long post, hope you had patience to read ot the end. We never had such a huge group join in one day, that is why I wrote this long post.

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Eugenia Etkina
Admin
Top contributor
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Today (March 8th) is the International Women's day.
I already posted about Joselyn Bell Burnell, a graduate student (at that time) who discovered pulsars and did not receive the Nobel prize for it. Her PhD advisor did though (he was not part of the discovery but contributed to the explanation of it). A perfect story for the 8th of March - the International Women's day celebrated in many countries in the world (but sadly not in the US). Interestingly, making an explanation for a new discovery does not guarantee

a Nobel prize if you are a woman either (Lise Meitner is and good example for it). But now times are changing - women get Nobel prizes!
Happy International Women's day for all of the brave women who dare to teach physics! We rock it, right?
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Eugenia Etkina
Admin
Top contributor
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In case you have not seen this. This is about our biases. Let's fight them hard.
I will tell you a story of me witnessing these biases. About 25 years ago I was observing a very good 4th grade teacher teaching a science lesson to a class of infinitely cute and curios 4th graders, eager to learn, jumping out of their seats with their hands high up eager to answer the questions asked by the teacher (a FEMALE teacher). And guess what?
She almost never called on the girls, only on the boys. At fist I did not pay attention - the class seemed to get engaged, things were moving forward and everyone was working. But then I saw one girl who was holding her hand up without ever lowering it even when there were no questions asked and yet, she was never called on by the teacher. After the lesson, I asked the teacher if she remembered if she had called equally on boys and girls and she said: "Of course I did!" She was not aware of what was going on at all...
After that I started watching myself to make sure that I call on everyone equally when their hands were raised. I encourage you to do it on Monday. Who do you call on? What is your first impulse? Another thing that I wanted to say is that I never call on anyone who does not have their hand up. But this is a different story...

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Eugenia Etkina
Admin
Top contributor
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Hi all, Jason Chung and Valentina Bologna Longo asked about the classification of engineering-based problems in our textbook College Physics: Explore and Apply. I am attaching the file with the classification. The file was made by Gorazd Planinsic.
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RBCizqBoEm9iHZ39ID2Hj2RbrtIqpjyENj3Jis1_nxbeRcURcKT_XGko3WqoPhJfo3KXpOdvakRHgzswIPt3SYcJyaWiqa9uUk2WentAKIX8sr6XohUEf7MFPUhfptg&__tn__=%2CO%2CP-R

Second, I continue with waves. As the students meet many new physical quantities in waves, it is good to have a summary lesson after all new quantities are invented by the students. I am attaching the screenshot of the activity. And finally, it is good to discuss with the students how wave motion is different from all other motions that they have studied. To describe wave motion you need TWO independent variables, not ONE (time as it was before). Now it is TIME and Position. The period of a wave refers to the time repetition of motion and the wavelength - to the spatial repetition. That is why we need two graphs to describe a wave - displacement vs time and displacement vs position. See ALG/OALG activities that emphasize this very important idea. Here is the screen shot of the summary and the activity number. The file is posted here in the FILES.

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
Admin
Top contributor
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Hi @everyone! This is my first "reminder" post about the workshop on Saturday. If you plan to attend, please go to your EVENTS on Facebook and sign up there. If you already have signed up, I just posted the homework there and I am repeating the post here. We have not run KMT and Thermo workshops here yet, so this one is the first of its kind. Make sure that you know your time zone and knew when the workshop will start for you. It is 9 am US Pacific Coast time, noon US East coast time and 5 pm (not 6) Central European time (as the US changed the clocks for daylight savings time already and Europe has not). If you live somewhere else, PLEASE find our with the time difference is now.
Here is the homework post:
Hi all those who signed up for the workshop. I timed all the planned activities and they are coming out to be 2 hours 15 minutes (best). Please have some extra time so that we can finish as the very last activity is absolutely crucial for understanding the first law and I do not know what to cut more to fit into 2 hours. Here is the link to the slides form the previous workshop to review what we did and most importantly, please do activities 12.4.3 and 12.4.4 (the last two activities that we did in the workshop, but every activity is a must to be able to follow the workshop on Saturday). Plus, if you are not familiar with bar charts, please read Chapter 7 in the textbook.

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Eugenia Etkina
Admin
Top contributor
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Hi all, as always two days before our workshop I only post reminders as not everyone sees the posts every day. The workshop is on Saturday, March 16. It starts at noon EDT (if you are not in the US, please check your time difference as the US went to daylight savings time last Sunday and Europe has not). The topic is gas laws (continuation) and the first law of thermodynamics. Our unique systems approach to energy allows to connect energy in mechanics to energy in gases seamlessly and students truly understand the first law of thermo which they commonly do not in traditional approach. The workshop is very full with the material, so be prepared for a little longer meeting than our normal 2 hours. The zoom link is in the workshop announcement in the EVENTS but I am also posting it here. for the homework please review the slides from workshop 1 (I posted the link two days ago) and chapter 7 if you are not familiar with our approach to energy and bar charts. See you on Saturday!

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Eugenia Etkina
Admin
Top contributor
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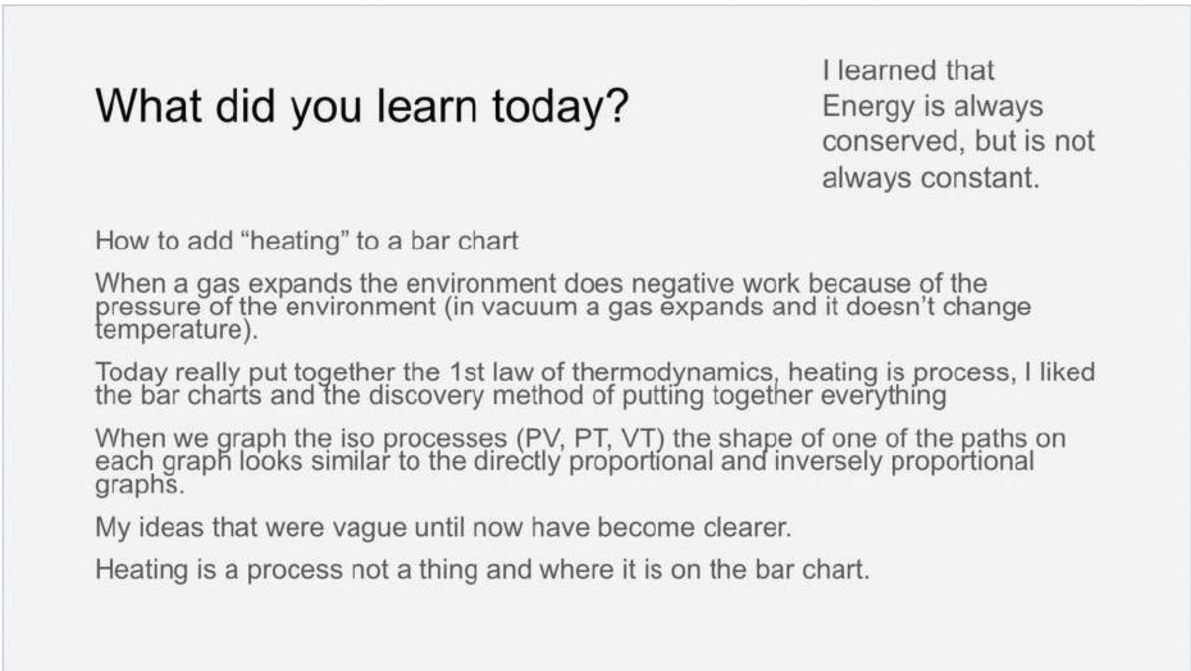
Hi @everyone! We had a great workshop today. I am posting the link to the video, to the slides and the summary reflections slide that w always do at the end of the workshop. Thank you all who joined the workshop and worked for over 2 hours without losing steam. Special thanks go to Hisashi Kuriki who has not missed a single workshop this year despite living in Japan and having to be awake from 1 am to 3 am in the morning to participate. This is true commitment!
The next workshop will be on fluids. Possible dates are April 20th or 27th. I will post the poll tomorrow. Thank you again all who came to the workshop today!
Video recording: https://rutgers.zoom.us/.../R3YtWrkfGxAuZTCFXA...
password Yq3e+9dA
Link to the slides with activities
https://docs.google.com/.../1KWYJLP2YxrPYzzgCw3pR.../edit...



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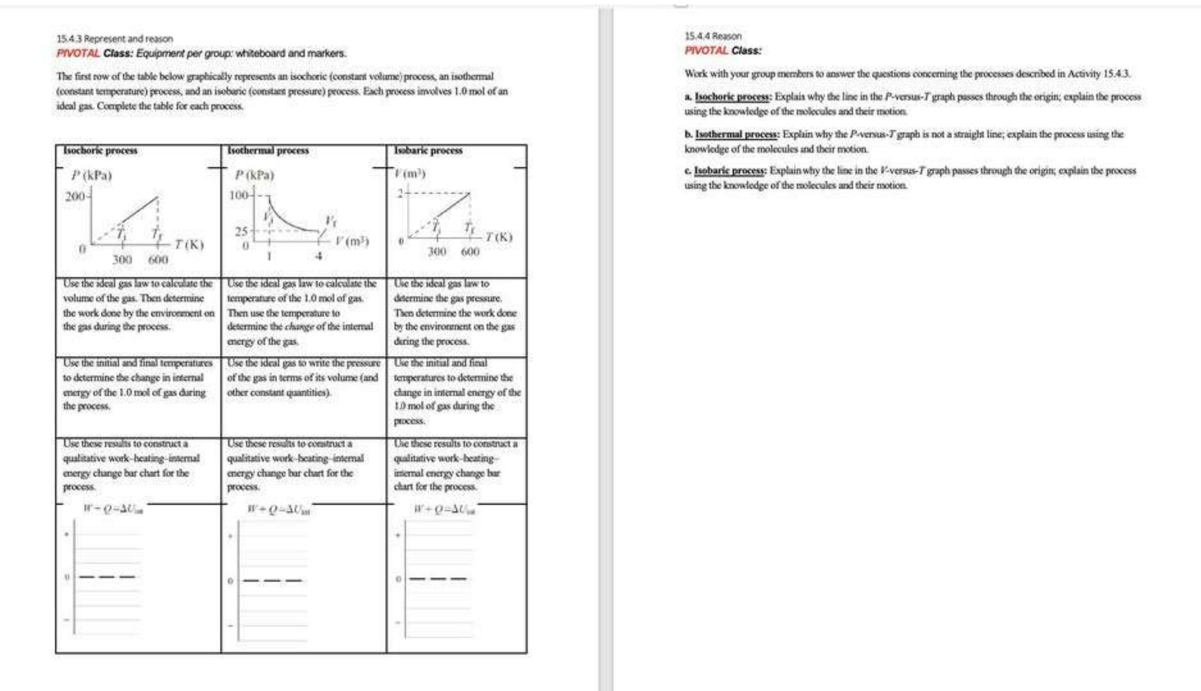
Eugenia Etkina
Admin
Top contributor

Hi all, two things today. First, I wanted to remind you to vote for the date of our Fluids workshop. So far we have move votes for the earlier date.
Second, I wanted to follow up on our workshop on Saturday. In the ISLE approach gas laws are the macroscopic consequences of the p=1/3xmsub0xnxv^2 relationship for the pressure of the ideal gas. We tested the laws experimentally and represented them graphically in many different ways. Now it is time to connect them to energy reasoning - the first law of thermodynamics. Here are two activities in the ALG (similar ones are the OALG) for the students to make these connections. I chose to do a screen shot from the ALG not OALG as in the ALG we have PIVOTAL markings, meaning that hose activities should not be skipped. Energy bar charts are crucial for understanding there! Please See the attached screen shot and comment! Thank you!



15.4.3 Represent and reason

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

The first row of the table below graphically represents an isochoric (constant volume) process, an isothermal (constant temperature) process, and an isobaric (constant pressure) process. Each process involves 1.0 mol of an ideal gas. Complete the table for each process.

Isochoric process	Isothermal process	Isobaric process
P (kPa) 200, 0, T_i, T_f, T (K), 300, 600	P (kPa) 100, 25, 0, V_i, V_f, V (m³), 1, 4	V (m³) 2, 0, T_i, T_f, T (K), 300, 600
Use the ideal gas law to calculate the volume of the gas. Then determine the work done by the environment on the gas during the process.	Use the ideal gas law to calculate the temperature of the 1.0 mol of gas. Then use the temperature to determine the *change* of the internal energy of the gas.	Use the ideal gas law to determine the gas pressure. Then determine the work done by the environment on the gas during the process.
Use the initial and final temperatures to determine the change in internal energy of the 1.0 mol of gas during the process.	Use the ideal gas to write the pressure of the gas in terms of its volume (and other constant quantities).	Use the initial and final temperatures to determine the change in internal energy of the 1.0 mol of gas during the process.
Use these results to construct a qualitative work-heating-internal energy change bar chart for the process.	Use these results to construct a qualitative work-heating-internal energy change bar chart for the process.	Use these results to construct a qualitative work-heating-internal energy change bar chart for the process.
$W + Q = \Delta U_{int}$	$W + Q = \Delta U_{int}$	$W + Q = \Delta U_{int}$

15.4.4 Reason

PIVOTAL **Class:**

Work with your group members to answer the questions concerning the processes described in Activity 15.4.3.

a. **Isochoric process:** Explain why the line in the P-versus-T graph passes through the origin; explain the process using the knowledge of the molecules and their motion.

b. **Isothermal process:** Explain why the P-versus-T graph is not a straight line; explain the process using the knowledge of the molecules and their motion.

c. **Isobaric process:** Explain why the line in the V-versus-T graph passes through the origin; explain the process using the knowledge of the molecules and their motion.

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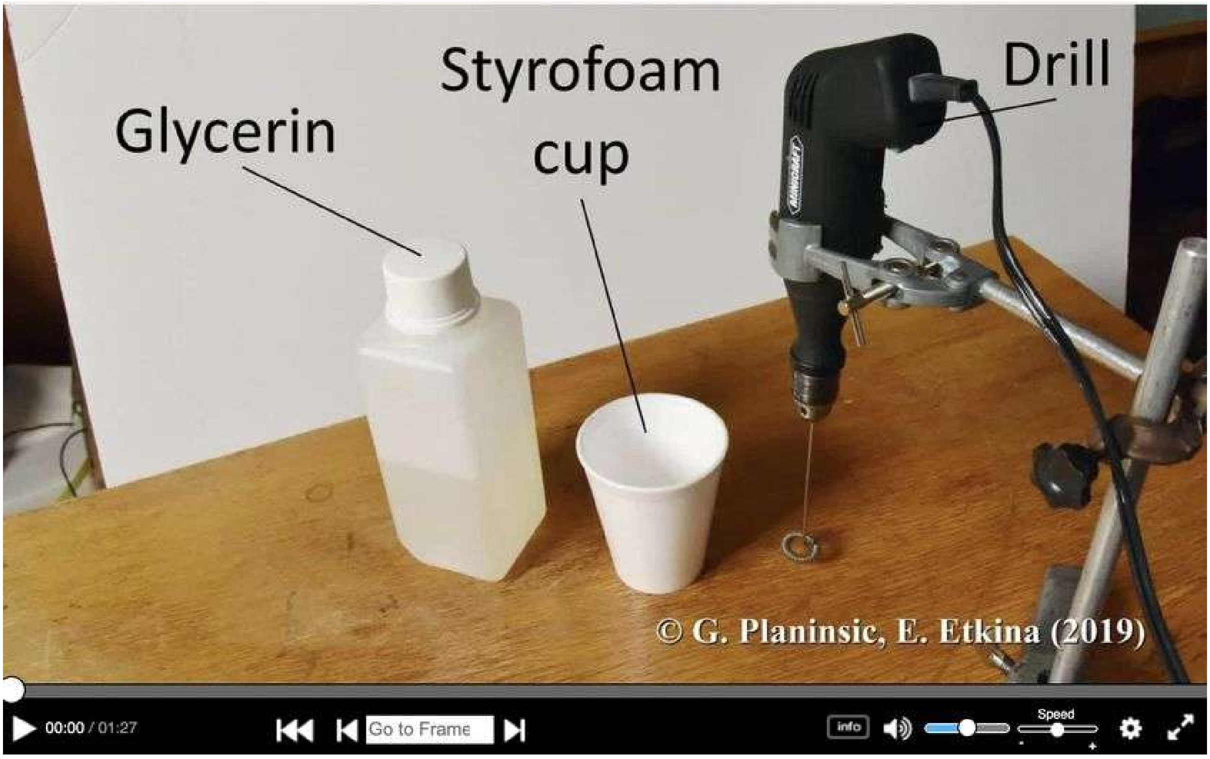
Eugenia Etkina
Admin
Top contributor

Hi all Exploring and Applying Physics people! Two things today: 1) please vote for the date of the Fluids workshop (the poll was posted on Sunday). It looks like the first date is winning so far.
2) I continue with Thermodynamics. First, I wanted to reiterate our approach - the CHANGE IN THE TOTAL ENERGY OF THE SYSTEM is equal to the sum of the external work done ON the system and the energy transferred though the process of heating. If the mechanical energy of the system remains constant then this statement turns into deltaUinternal = W + Q. Q is not called heat but it is called HEATING to underscore tat it is a process not a thing.

While internal energy is a state function, Work and Heating ARE NOT (they do not reside in the system).
We only consider the word done ON the system in the formulation of the first law, thus in the equation is is always W+Q. Work can be positive or negative, the same is for Q. In this approach there is an equivalence between mechanical work and heating as two MECHANISMS of energy transfer (not something that a system possesses). This equivalence was first suggested by Julius Robert Mayer and experimentally measured by James Prescott Joule. 1 cal of energy transferred through heating (to raise the temperature of 1 g of water by 1 degree C) is equivalent to 4.2 J of energy transferred through mechanical work.
The activity pasted below allows the students to figure out this equivalence themselves. Do not miss!
OALG 15.5.6 ANALYZE (ALG 15.5.7)
Watch the video of a cup of glycerin being stirred by a mixer used to whip cream [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]. The video is taken with a thermal camera and allows you to follow the temperature of the glycerin at the location of the cross hairs.
a. Use the data provided in the video to estimate how much energy provided by the mixer went into warming up the glycerin.
b. Could this experiment be used to test the equivalence of work and heating as a means for energy transfer similar to the historical experiment performed by James Joule? Explain why or why not. This historical experiment is described in Testing Experiment Table 15.2 in the textbook.



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Eugenia Etkina
Admin
Top contributor
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Hi @everyone! Here is the link to the sign in form for the summer introductory ISLE workshop July 17-18. The workshop is 8 hours - 4 hours each day from noon EDT to 4 pm EDT. As the number of attendees is limited, please try to sign up ASAP but only if you know for sure that will be able to attend. The workshop is free and will introduce you to the philosophy of the approach, give examples for different topics and share students' and teachers' attitudes toward ISLE. If you need a PD certificate, it will be for 10 hours as you will need to do homework prior to the workshop. Here is the link to the google form.
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Eugenia Etkina
Admin
Top contributor
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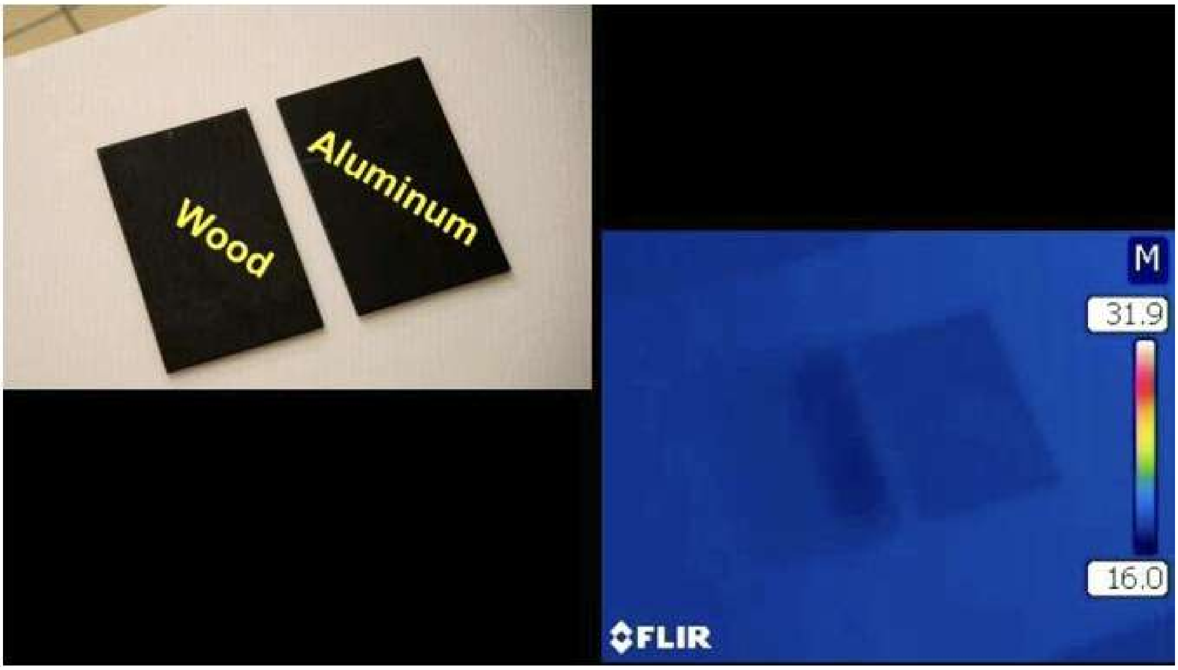
Hi all, there is still space in the ISLE intro workshop in July, please sign up if you plan to attend. The link is in my yesterday's post. Today, I am sharing two ISLE-based activities that incorporate all elements of the ISLE process and are for the first law of thermodynamics. They can be done in a lab or in class - up to you, but they are wonderful!
15.7.2 OBSERVE AND EXPLAIN
Lab or class:
Observe the video of an experiment taken with a regular camera and a thermal camera [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-15-7-2]. In the experiment, two identical metal objects (made of brass) are taken from the same hot water bath and placed on two identical-shape (height, length, and width) plates made of wood and aluminum (colored with the same black paint to reduce the reflective properties of aluminum) that have been sitting on the table for a long time.
a. Describe what you observe.
b. Devise one or more explanations for your observation.
15.7.3 TEST YOUR IDEAS
Lab or class:
You use the same plates as in Activity 15.7.2, but this time you place an ice cube on each one.
a. Use the explanations you made in Activity 15.7.2 to predict what you will observe.
b. View the video [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...] and compare the outcome to your predictions. Do you need to revise your explanation?
The credit goes to Gorazd Planinsic



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Eugenia Etkina
Admin
Top contributor

Hi all, if you are still teaching waves, here is a thought about the difference between traveling and standing waves: in a traveling wave (assuming a simple sinusoidal wave with no friction in the medium) all points have the same amplitude but different phases (are in different positions at the same time), while in a standing wave points have different amplitudes but have the same phase at the same time.
If you plan to attend the summer online workshop in July but did not see the link to the google form to sign up, please scroll down, find the form and sign up. I am waiting for the last people to sign up to close the registration. The workshop is almost full.
Happy Sunday!

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Eugenia Etkina
Admin
Top contributor

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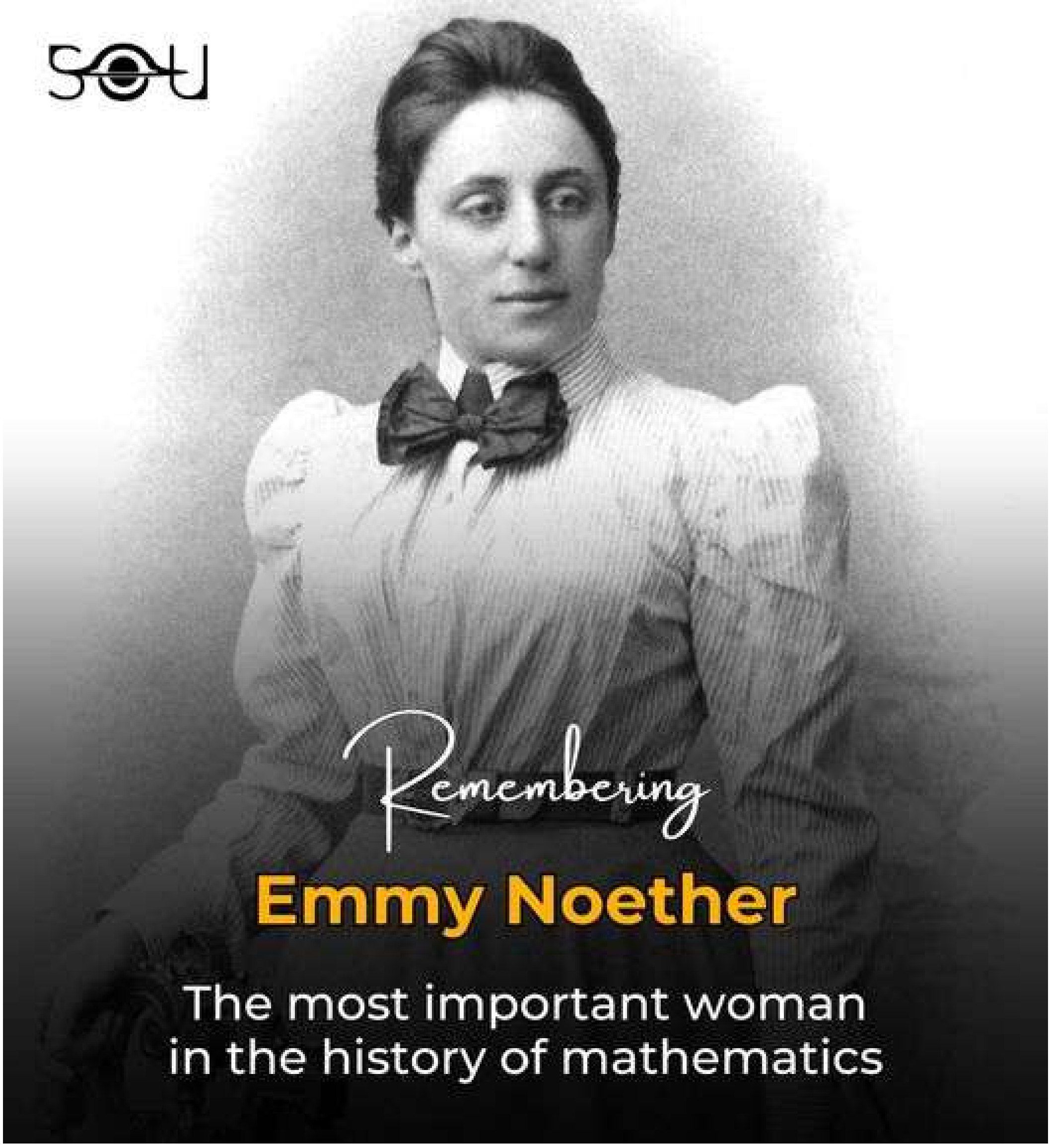
I posted about this amazing woman several times before, but we have lots of new members, so I am sharing again. Emmy Noether explained why we have laws of conservation.



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Eugenia Etkina
Admin
Top contributor
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Hi all! Two things today. I am reminding you to sign up for the Fluids workshop, April 20th, noon EDT, see the workshop in your EVENTS.
Second, I will start commenting on Electric Charge, Force and Energy concepts (Chapter 17). We had a workshop on this topic on March 11 last year. Here is the link to the slides. The sequence of Activities and new videos are there. Please read the slides, follow the

Activities in the slide deck and post questions here. If you wish me to comment on each idea separately, please say it here in the comments. I never posted links ot the old workshops, let's see if this is helpful.

https://www.facebook.com/groups/320431092109343/posts/1591905101628596/?__cft__[0]=AZV--qDD_jM9c27OsdgnyBH07zYZLHRmwZMn3oscb6MitOhbQgFAJd0RDF8Qs_WXUPOAJZRzpyoVcya35imEgL7Yj6D3NBwbB1a3ZYat2W5ppsXnhTq_2Yeza0hJWx-p3hsdefMdvTLdjntnP7jDZqUOw9jltLEUYAqOOEbnwnF28COvFEnU2eaz6f0DLsxB488mWoBzJdChJiy8K0NF-NoI&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
Top contributor
· ·

And here is another group of women who did not get the credit. I have a major in physics and a minor in astronomy. I learned a lot about the role Edward Pickering in stellar classification and even the O BE A FINE GIRL, KISS ME (OBAFGKM - spectral class sequence) rule to remember the spectral classes when I was a student but did not hear a word about the women who did the work and came up with this mnemonic rule. Here they are.

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Eugenia Etkina
Admin
Top contributor
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Hi all, yesterday I posted the link to the workshop's "Electric Charge, Force and Energy slides". I am asking those who were interested in my posts about electricity and magnetism (Roby Rod, Hisashi Kuriki and others) if you looked at the slides and watched the videos. The first videos in the slides dedicated to the observational experiments of charing are new, they are not in the textbook or the ALG/OALG. What do you think of them?
Please reply in the comments. Thank you.
Should I post about the process of student knowledge construction or are the slides with the progression enough?
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Eugenia Etkina
Admin
Top contributor
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The eclipse was better than ever. As it was a very warm day in a cold environment (snow around, as we went to Newport, Vermont) as the Moon started covering the Sun it got noticeably cooler until it was really cold. The brightness of everything was dimming and the eerie feeling filled up the crowds. Then when the Sun was no more thousands pf spectators started cheering - screaming like crazy, and so did I. It was an unforgettable 4 minutes of a natural miracle. It was even be… See more
Ting-Hui Lee
Top contributor

Nice picture of the solar prominence! We could even see it with our naked eyes during the totality. Not the detailed structure, but just one pink spot on one side of the sun.
10w10 weeks ago
Reply
Meg Tredinnick
Top contributor
Traveling home now after viewing the eclipse in Indiana. Truly amazing experience.
10w10 weeks ago
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Eugenia Etkina
Admin
Top contributor
· ·
Hi all, we have been talking about electric potential energy. I am sharing a few conceptual questions at the end of Chapter 17 in the textbook that might help you asses student understanding.
Also, I will not post anything tomorrow as I will be driving to and from the eclipse. Wish me clear skies!
If you are going to be in the path of totality, please share your photos and thoughts. My previous experience with the total eclipse left me with the feeling of awe that is not g… See more
Anne L. Caraley
Top contributor
My city is in the path of totality. The college has no classes and has organized loads of science outreach instead. The roads and shorefront (Lake Ontario) are expected to be jam packed.
For health reasons, I'm avoiding the crowds and staying home… See more
11w11 weeks ago
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Edited
Jane Jackson
Top contributor
Even a partial eclipse is awesome. I was working outside, pulling weeds in the common area of my subdivision near Phoenix, at the last solar eclipse -- and all of a sudden I noticed that the light was dimmer, muted. It seems like everything got QUIET -… See more
11w11 weeks ago
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Julia Brodsky
·
A free pre-conference event for teenagers interested in space science - in case you know some students who may benefit from this.
Julia Brodsky
·
#science #highschool
Attention high school students interested in space science and astrobiology! This year, you have a unique opportunity to participate at an … See more
Jason Chung
Thank you for the sharing information
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Eugenia Etkina
Admin
Top contributor
· ·
Hi all Exploring and Applying Physics people! Yesterday I posted the introductory activities for the development of the concept of electric potential energy. The activity below will allow your students to dive deeply into the concept. It requires working with the textbook too. You can get a free examination copy if you follow instructions at islephysics.net.
Here is the activity, please ask questions and post your comments!
17.5.5 READING EXERCISE
PIVOTAL
Read Section 17.5 in the… See more

Anne L. Caraley
Top contributor
Looks like my own lecture notes… a potential energy ‘mountain’ along with the more familiar potential energy well. Had a classroom observation done on one of the days I covered this, many many years ago before tenure. My colleague complimented me an… See more
11w11 weeks ago
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Eugenia Etkina
Admin
Top contributor
· ·
Hi all, I am continuing with Electric energy.
An important thing here is that one charge cannot have any electric energy, only a system of electric charges can. The same way an object elevated above Earth does not have any gravitational energy if Earth is not in the system. Therefore, the same way as choosing the system and initial and final states was crucial for energy analysis in mechanics and thermo, it is also crucial in electricity.
If you want to have potential energ… See more
Amin Rainy
Top contributor
I did this activity yesterday in my class. There was a confusion about configurations. For example, students hesitate to select configuration 1 as initial state or configuration 2. Also, some group compare configuratio 1 of Scenarion A with configuratio 1 of scenario B.
10w10 weeks ago
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Eugenia Etkina
Admin
Top contributor
· ·
Hi all, this is just came out and while the findings are positive, there is still a lot of lecturing going on... Check it out!
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Eugenia Etkina
Admin
Top contributor
· ·
Hi all, I am not going to post any new stuff today so that you have time to catch up with posts on electric charge and force in the last 5 days. Tomorrow we will do electric energy.

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Eugenia Etkina
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· ·
Hi all, I continue with electric charge. So, we are pretty far in the topic, but there is no math yet. Now is the time to investigate how electrically charged objects interact with teach other. I am pasting a screenshot of the activity that not only helps your students do that but also shows one of the approaches that we use when real data are hard to get and are messy. We "cook" data for the students to help them find a pattern. This way they can focus on the mathematical re… See more
Amin Rainy
Top contributor
Okay, I covered this activity in my class today. It was challenging for students to remember electric force as a function has three variables. I gave them some hints and finally, they got it. I told my students to suppose one of the charges is a variab… See more
11w11 weeks ago
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Maggie Gran
I did this activity with my high school Honors Physics students who are in their first physics course. The activity was very valuable. Most of the students got stuck on how to graph the data since it had 3 variables. I coached the students into coming … See more
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Eugenia Etkina
Admin
Top contributor
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Hi all, I am continuing with electric charge. See my post from yesterday if you missed it as it will not be clear today without it.

Once students figured out that electric interactions are not magnetic, but are something else, they need to explain those. Especially how the objects that were not rubbed before could attract rubbed objects and why ANY rubbed object attracts BOTH poles of a magnet. It means that they need to learn about conductors and dielectrics - macroscopically… See more
Amin Rainy
Top contributor
I will teach this section on Tuesday and will share my experience.
12w12 weeks ago
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Hisashi Kuriki
Top contributor
There is a simulation of the foil voltage detector that I use in class. I showed students this simulation while having the students work with the foil voltage detector. Japanese word switches at the top left of the video indicate "explanation using ele… See more
MIYAZAKI-CATV.NE.JP
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Eugenia Etkina
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Top contributor
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Hi all, this is the post about a logical flow of the concepts in Chapter 17: Electric charge, force and energy. Please do not forget to like it it or comment on it to make the post more visible for other group members.
As always, we start with students having personal experience with electrical phenomena. Those are activities in Section 1 of chapter 17 in the textbook and in Section 1 in ALG/OALG. The students figure out that rubbed objects exhibit certain patterns of behavior when they interact and some of these patterns (attraction not repulsion) appear even when an object has not been rubbed but is interacting with the rubbed object. We give those interactions a name - electric interactions. Why electric? Because they were observed by Greek women using spindles made of amber - those spindles attracted their long hair, and as amber is ELEKTRON in Greek, the phenomena were called electric. (Later people (Benjamin Franklin, indeed) added the word "charge" to the property of objects to participate in electric interactions. Interesting, that in times of Franklin, electric charge was considered a fluid. But this is for the later story for the students, for now we stop at the word electric).
Section 2 in the textbook and the ALG/OALG starts with the question - what causes electric interactions? When I first asked my students this question I was shocked when they said "MAGNETISM". I was like "what"???? And then I realized that everyone is familiar with magnets attracting and repelling each other, so no wonder people (ask your students and you will get the same answer, we got lots and lots of evidence that it is a common idea) think that electric interactions are due to magnetism. This is a PERFECT opportunity for the students to practice hypothetico-deductive reasoning. They need to design an experiment to test whether electric interactions are magnetic. Give this task to the students and you will be amazed by their creativity and their surprise when they reject this idea.
Here are two activities - one for the classroom and one for the online learning that address this goal.
In person learning:
17.2.2 TEST THE EXPLANATION
PIVOTAL Lab: Equipment per group: a light magnet on a swivel, two foam tubes, felt, and plastic wrap, whiteboard, markers.

Your friend Hector says that electric interactions are the same as magnetic interactions because magnets also attract and repel each other. Consequently, he believes that when you rub objects, they become magnetized. Work with your group members to design an experiment(s) whose outcome will allow you to test Hector's idea.

a. Describe an experimental set-up to test the idea that rubbing causes materials to become magnetic (Hector's idea).

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

c. Perform the experiment and then describe the outcome.

d. Make a judgment about Hector's idea based on the outcome.

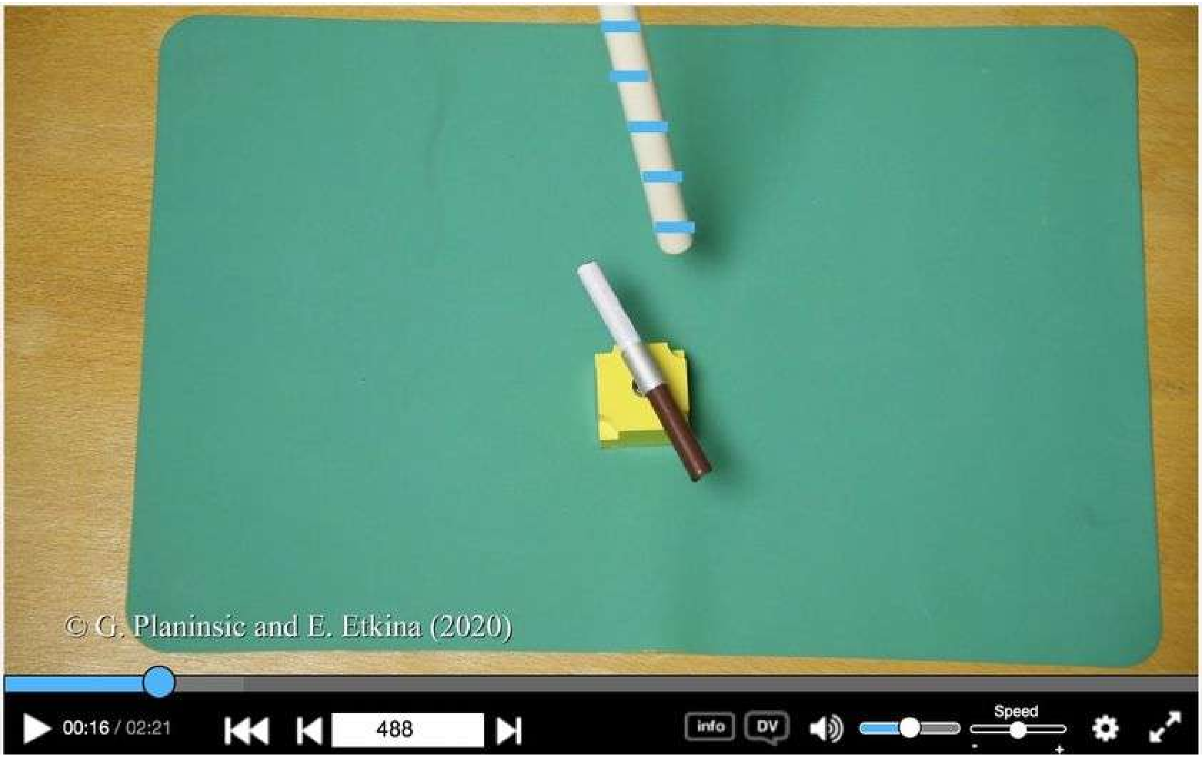
On-line learning environment

OALG 17.2.2 TEST THE EXPLANATION

Your friend Hector says that electric interactions are the same as magnetic interactions because magnets also attract and repel each other. Consequently, he believes that when you rub objects, they become magnetized. What experiment(s) will allow you to test Hector's idea?

a. We decided to test Hector's idea by using a magnet on a pivot with a set of materials that can be charged positively and negatively. Watch the following videos of the experiments that we conducted https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-17-2-2 and decide which ones can be used to reject Hector's idea and which ones cannot. Explain how you made your decision.

b. Make a judgment about Hector's idea.



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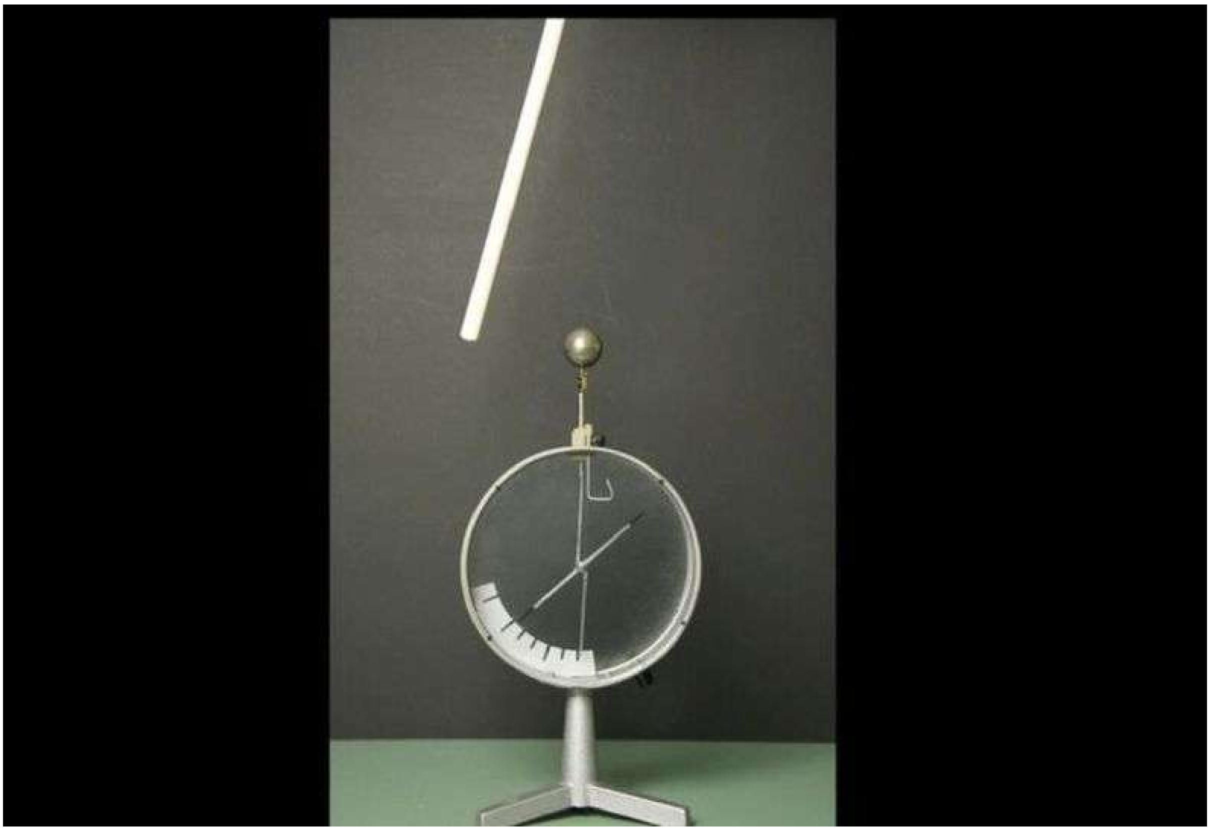
Admin
Top contributor
· ·
Hi all, I am continuing with electric charge. See my post from yesterday if you missed it as it will not be clear today without it.
Once students figured out that electric interactions are not magnetic, but are something else, they need to explain those. Especially how the objects that were not rubbed before could attract rubbed objects and why ANY rubbed object attracts BOTH poles of a magnet. It means that they need to learn about conductors and dielectrics - macroscopically and microscopically.
Here are the activities in the OALG (a complete file is posted here in the FILES). Activities in the ALG deal with real experiments, not videos, I am posting the on-line version so that you can see the experiments at home. The progression of activities is very important - they build on each other, so I suggest that you go slowly through them to see the goal of each and what the students learn from each.
OALG 17.3.1 OBSERVE AND EXPLAIN
a. Watch the experiments at https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-1.
b. Describe your observations for each of the 4 experiments.
c. Think of what model of the internal structure of the conducting and dielectric materials could explain your observations?
d. Watch the experiment at http://islephysics.net/pt3/experiment.php?topicid=10.... Do you need to adjust the model that you devised to explain the outcome of this experiment?
d. Read and interrogate subsections “Conductors” and “Dielectrics” in Section 17.3. Use the text in these subsections to revise your explanations if necessary.
OALG 17.3.2 TEST YOUR IDEAS
Watch the 4 experiments in the following video https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-2.
a.Sketch the set-up for each experiment and describe the outcome.
b. Can the models of conductors and dielectrics that you devised in Activity 17.3.1 predict the outcomes of the experiments? Justify your answer using charge diagrams such as those in Figures 17.5 and 17.6 on page 508.
OALG 17.3.3 OBSERVE AND EXPLAIN
Watch the following video https://mediaplayer.pearsoncmg.com/.../sci-OALG-17-3-3 and answer the following questions:
A. WHY DO THE LIGHT METAL STRIPS STICK OUT WHEN A CHARGED ROD IS BROUGHT CLOSER WITHOUT TOUCHING?
B. WHY DO THE LIGHT METAL STRIPS STICK OUT MORE AT THE ENDS OF THE METAL BAR THAN CLOSER TO THE MIDDLE?
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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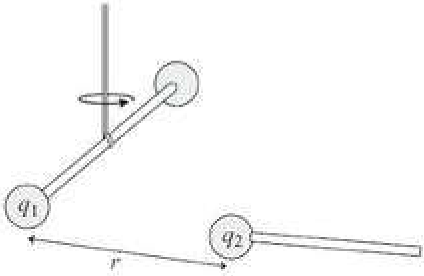
Eugenia Etkina
Admin
Top contributor
· ·

Hi all, I continue with electric charge. So, we are pretty far in the topic, but there is no math yet. Now is the time to investigate how electrically charged objects interact with teach other. I am pasting a screenshot of the activity that not only helps your students do that but also shows one of the approaches that we use when real data are hard to get and are messy. We "cook" data for the students to help them find a pattern. This way they can focus on the mathematical relationships not on the intricacies of data analysis.
You might wander if this is a good way to help students invent relationships when they do not collect their own data. In fact, this is what many physicists do. They analyze and make sense of data collected by somebody else. This is especially true in astronomy. For example X-ray data come from X-ray telescopes and then lost of research groups analyze them. Same is true for all other telescopes.
If you used this activity with the students, please comment! Thank you!

OALG 17.4.1 Find a pattern

Charles Coulomb used a torsion balance (see the figure at right) to measure the force that one charged ball exerts on another charged ball to find out how the force between two electrically charged objects depends on the magnitudes of the charges and on their separation. Coulomb could not measure the absolute magnitude of the electric charge on the metal balls. However, he could divide charges in half by touching a charged metal ball with an identical uncharged ball.



a. The table that follows provides data that resemble what Coulomb might have collected. Represent the data graphically. What 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.

Charges (q_1, q_2)	Distance	Force
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

b. After you constructed your mathematical relationship, compare it to Equation 17.1 on page 513. How are they similar and how are they different?

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Eugenia Etkina
Admin
Top contributor
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Hi all, this is just came out and while the findings are positive, there is still a lot of lecturing going on... Check it out!
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Eugenia Etkina
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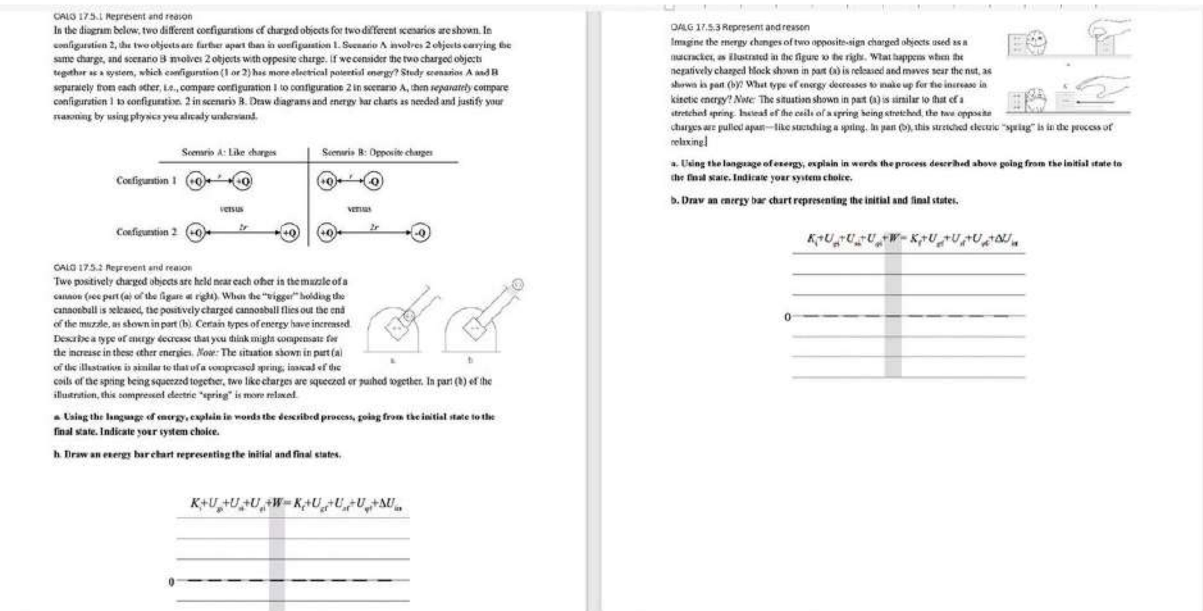
Hi all, I am continuing with Electric energy.
An important thing here is that one charge cannot have any electric energy, only a system of electric charges can. The same way an object elevated above Earth does not have any gravitational energy if Earth is not in the system. Therefore, the same way as choosing the system and initial and final states was crucial for energy analysis in mechanics and thermo, it is also crucial in electricity.
If you want to have potential energy, you need to include more than one charged object in the system. The language here is important. For example, in an atom, an electron by itself does not have any electric potential energy, but the system nucleus-electron does.
Attached is a sequence of 3 activities that will allows your students to invent the concept of electric potential energy. The same way the gravitational potential energy of two interacting objects is NEGATIVE, the electric potential energy of oppositely charged objects is also negative. This means that when the charges come closer due to mutual attraction the electric potential energy becomes more negative (you need to do more work to separate them) and thus larger in magnitude but SMALLER as for negative numbers the larger the magnitude, the smaller the number itself. This is a very difficult concept, and it needs special attention of your students.
Here are these three activities:


OALG 17.5.1 Represent and reason

In the diagram below, two different configurations of charged objects for two different scenarios are shown. In configuration 2, the two objects are further apart than in configuration 1. Scenario A involves 2 objects carrying the same charge, and scenario B involves 2 objects with opposite charge. If we consider the two charged objects together as a system, which configuration (1 or 2) has more electrical potential energy? Study scenarios A and B separately from each other, i.e., compare configuration 1 to configuration 2 in scenario A, then *separately* compare configuration 1 to configuration 2 in scenario B. Draw diagrams and energy bar charts as needed and justify your reasoning by using physics you already understand.

OALG 17.5.2 Represent and reason

Two positively charged objects are held near each other in the muzzle of a cannon (see part (a) of the figure at right). When the "trigger" holding the cannonball is released, the positively charged cannonball flies out the end of the muzzle, as shown in part (b). Certain types of energy have increased. Describe a type of energy decrease that you think might compensate for the increase in these other energies. *Note:* The situation shown in part (a) of the illustration is similar to that of a compressed spring; instead of the coils of the spring being squeezed together, two like charges are squeezed or pushed together. In part (b) of the illustration, this compressed electric "spring" is more relaxed.

a. Using the language of energy, explain in words the described process, going from the initial state to the final state. Indicate your system choice.

b. Draw an energy bar chart representing the initial and final states.

$K_i+U_{gi}+U_{si}+U_{qi}+W=K_f+U_{gf}+U_{sf}+U_{qf}+\Delta U_{int}$

OALG 17.5.3 Represent and reason

Imagine the energy changes of two opposite-sign charged objects used as a nutcracker, as illustrated in the figure to the right. What happens when the negatively charged block shown in part (a) is released and moves near the nut, as shown in part (b)? What type of energy decreases to make up for the increase in kinetic energy? *Note:* The situation shown in part (a) is similar to that of a stretched spring. Instead of the coils of a spring being stretched, the two opposite charges are pulled apart—like stretching a spring. In part (b), this stretched electric "spring" is in the process of relaxing.]

a. Using the language of energy, explain in words the process described above going from the initial state to the final state. Indicate your system choice.

b. Draw an energy bar chart representing the initial and final states.

$K_i+U_{gi}+U_{si}+U_{qi}+W=K_f+U_{gf}+U_{sf}+U_{qf}+\Delta U_{int}$

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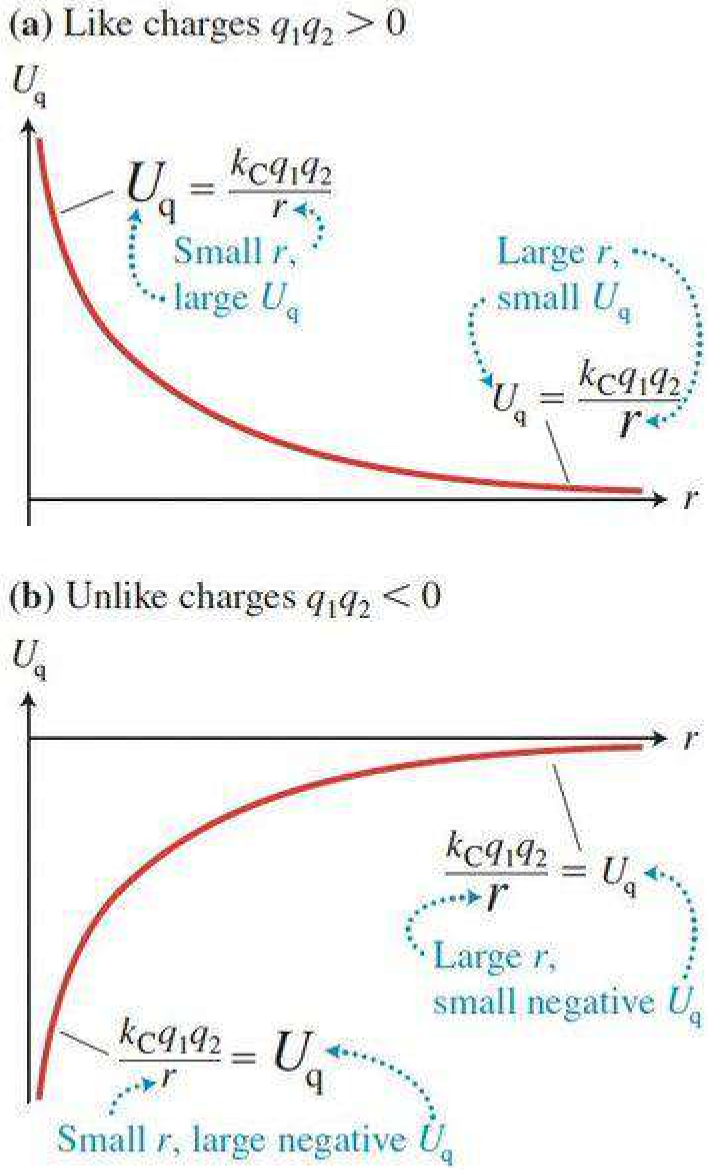
Eugenia Etkina
Admin
Top contributor
· ·
Hi all Exploring and Applying Physics people! Yesterday I posted the introductory activities for the development of the concept of electric potential energy. The activity below will allow your students to dive deeply into the concept. It requires working with the textbook too. You can get a free examination copy if you follow instructions at islephysics.net.
Here is the activity, please ask questions and post your comments!
17.5.5 READING EXERCISE
PIVOTAL
Read Section 17.5 in the textbook.
a. Compare and contrast graphs for the electric potential energy of interaction Uq of two charged objects (q1 and q2) as a function of the distance between them and for electric force between them. Consider both like-charged objects and oppositely-charged objects.
b. Evaluate the equation for Uq derived on page 519 of the textbook: Consider case 1: r = ∞ and then let r decrease for the case where q1 and q2 are both + or both –. Does the equation for Uq behave the way you think it should – consistent with Activity 17.5.1? (I posted it yesterday) Discuss.
Next, consider case 2: r = ∞ and then let r decrease for the case where q1 is + and q2 is –. Does the equation for Uq behave the way you think it should – consistent with Activity 17.5.1? Discuss.
c. Answer Review Question 17.5.
Here is the review question. (note that the students need to consider all combinations of charges):
REVIEW QUESTION 17.5 How can we reduce the magnitude of the electric potential energy of a system of two electrically charged objects?

FIGURE 17.18 The electric potential energy-versus-distance graphs for two charged objects.



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Eugenia Etkina
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Top contributor
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Hi all, we have been talking about electric potential energy. I am sharing a few conceptual questions at the end of Chapter 17 in the textbook that might help you asses student understanding.

Also, I will not post anything tomorrow as I will be driving to and from the eclipse. Wish me clear skies!
If you are going to be in the path of totality, please share your photos and thoughts. My previous experience with the total eclipse left me with the feeling of awe that is not going away. It was a true miracle and I hope to witness this natural miracle again tomorrow. To all who are going - bright sun and clear skies!

10. Two objects with charges $+q$ and $-2q$ are separated by a distance r. You slowly move one of the objects closer to the other so that the distance between them decreases by half. Considering the two objects as the system, which statements are *incorrect*?
    (a) The electric potential energy of the system doubles.
    (b) The electric potential energy of the system decreases by half.
    (c) The magnitude of the electric potential energy doubles.
    (d) The magnitude of the electric potential energy decreases by half.
11. Charged point-like objects A and B are separated by a distance d. Object A is fixed in place, while object B can be moved. Choose object A alone as the system. You slowly push object B closer to A, decreasing the distance between them to $0.3d$. Based on the given information, choose all of the correct statements.
    (a) The electric potential energy of the system increases.
    (b) The electric potential energy of the system decreases.
    (c) The electric potential energy of the system does not change.
    (d) You do positive work on the system.
    (e) You do negative work on the system.
    (f) You do zero work on the system.
12. If you move a negatively charged balloon toward a neutral dielectric wall, the electric potential energy of the balloon-wall system
    (a) increases. (b) decreases.
    (c) is constant but nonzero. (d) is constant and zero.

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Eugenia Etkina
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The eclipse was better than ever. As it was a very warm day in a cold environment (snow around, as we went to Newport, Vermont) as the Moon started covering the Sun it got noticeably cooler until it was really cold. The brightness of everything was dimming and the eerie feeling filled up the crowds. Then when the Sun was no more thousands pf spectators started cheering - screaming like crazy, and so did I. It was an unforgettable 4 minutes of a natural miracle. It was even better as next to me were standing my former students - now physics teachers who you all know very well - Danielle Buggé, Matt Blackman, and Jade Lenshoek. The drive home was exhausting - the first 90 miles we did in 9 hours, because of the insane traffic. The rest 250 were much better... On the photos taken with a telescope during the eclipse you will see a pink arch - do you know what it is? It is now on all eclipse photos.

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Eugenia Etkina
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Hi @everyone! This is the message for those who signed up for Fluids workshop on April 20th (if you have not, see your EVENTS and sign up there). We will be doing lots of experiments in the workshop. Most of them are simple and require everyday equipment. But one piece is complicated and needs to be built in advance. Please take time to make the apparatus. The instructions are at https://youtu.be/BRUWLa1EC3E.
Additionally, if you have not attended the workshops on Forces, Energy, and Gases, please review the material in the textbook (College Physics: Explore and Apply) chapters 3, 7, and 12.
I finished posting for Electric charge, Force, and Energy and will start Electric Field tomorrow.

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Eugenia Etkina
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Hi all Exploring and Applying Physics people! I am starting a series of posts about electric field. To begin I will share my experience with electric field. When I first read an American physics textbook (it was Giancoli) I was surprised that the words electric field were used for two different things - a concept of a field as an alteration of space due to the presence of electrically charged objects, and a vector physical quantity measured in N/c. In my native language these two ideas have different words - the former is indeed called an electric field and the latter is called electric field intensity. In my experience having these two different terms for two different ideas was important. This is exactly what we implemented in our textbook and in the ALG/OALG. In the Instructor Guide we discuss this new terminology. I am pasting this short discussion here but due to the nature of Facebook I cannot put vector signs above vector physical quantities, I will put it after the symbol. Here is the text:
...Before we proceed to the analysis of individual sections and activities, we should discuss the language used in this chapter. Because students have tremendous difficulties with the concept of field as “altered space” and the concept of electric potential, we have moved away from the traditional terminology. We wish to help students conceptually distinguish

between the ideas that (1) there is an altered region of space (altered by the presence of one or more electrically charged objects) with specific properties and (2) each point in this region of space can be described by several physical quantities. We will use the term field (electric or some other field) to describe an altered region of space. We call the physical quantity which is traditionally called electric field, E field (vector sign above E), and we call the quantity traditionally called electric potential, V field (and electric potential). The former is the force-like vector quantity, and the latter is the energy-like scalar quantity. We represent E field with E field vectors and E field lines (vector signs above all Es), and V field with equipotential surfaces. In summary, when charged objects are present, each point in space can be described by a vector field (E field (vector sign above E)) and a scalar field (V field).

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

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

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).

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Eugenia Etkina
Admin
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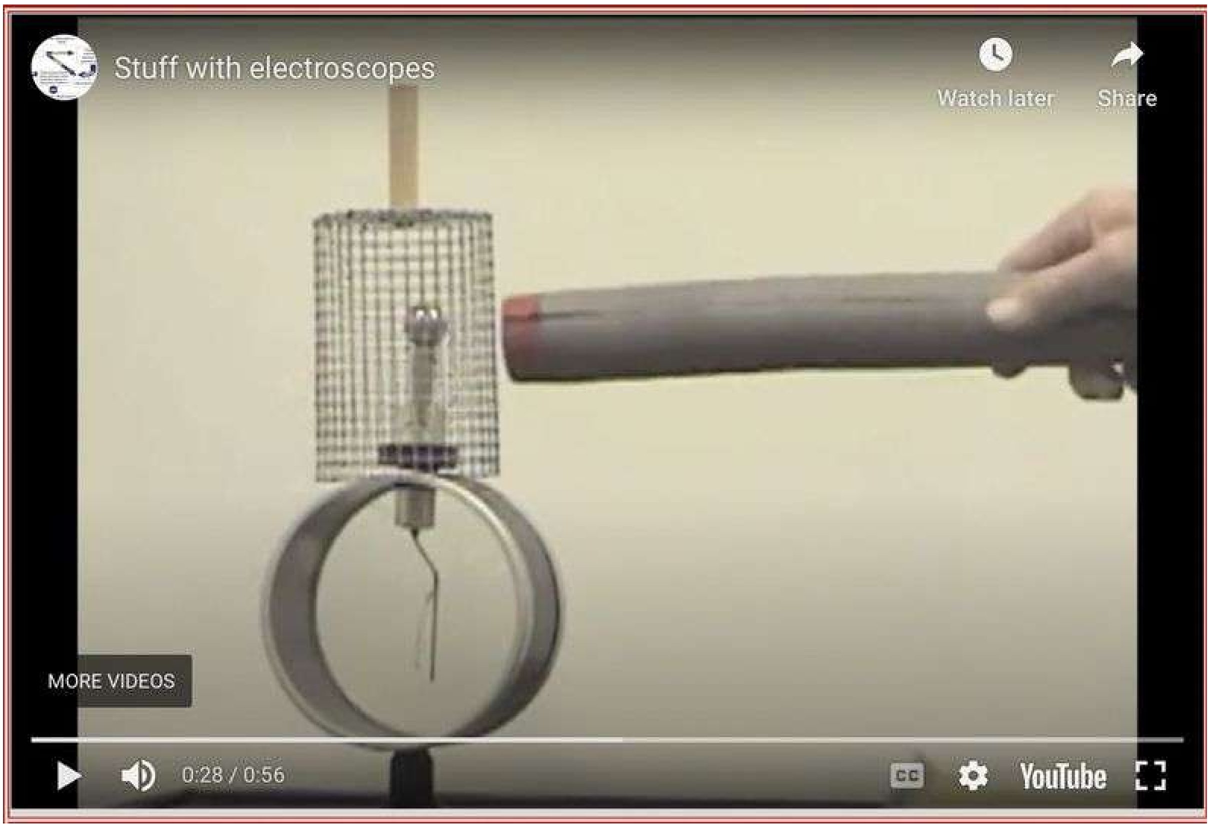
Hi all Exploring and Applying Physics people, I continue posting about electric field (Chapter 18 in the textbook and ALG/OALG - the OALG file is here, in the FILES).
Please read my post from the day before yesterday before you read this one.
As always, we start with students' physical experiences with the idea. In this case the idea is a metal construct, so teacher's help between activities 1 and 2 is needed. See activities below:
18.1 A MODEL OF THE MECHANISM FOR ELECTROSTATIC INTERACTIONS
OALG 18.1.1 OBSERVE AND EXPLAIN
Equipment: a foam tube (or a plastic rod, a plastic comb), rubbing material (felt, fur or wool), a small piece of aluminum foil on an insulating string (such as dental floss).
Conduct the following experiment: First you need to charge a foam tube and a small piece of aluminum foil on a string so they have the same charge. How will you do this? Then hold the foam tube still and slowly bring the piece of foil close to the charged foam tube. Observe what happens.

a. What happens to the piece of foil as it is brought closer to the charged foam tube? As it moves farther away?
b. Describe a possible mechanism by which the charged foam tube interacts with the charged piece of foil without touching it.
c. Read and interrogate page 536 in Section 18.1 in the textbook. What is the mechanism discussed there? How do you understand the term “electric field” and “gravitational field”?
OALG 18.1.2 OBSERVE AND EXPLAIN
WATCH EXPERIMENTS AT
HTTP://ISLEVIDEOS.NET/EXPERIMENT.PHP?TOPICID=10&EXPTID=194
A. DESCRIBE WHAT YOU OBSERVED.
B. EXPLAIN YOUR OBSERVATIONS USING THE CONCEPT OF ELECTRIC FIELD.
I am not sure why Facebook made the previous activity in caps and now the text is bolded. Very strange.
Now, about teacher's help with activity 1. Here you have what we call "time for telling". You tell the students about two approaches to the explanations of interactions at a distance. The explanation that does not involve any mechanism, and this the interactions spreads at an infinite speed and the explanation that involves some mechanism (we can call it a field) and therefore the interaction spreads at a finite speed. It is an important idea which will later help your students understand electromagnetic waves and gravitational waves too.
One more thing. The video that you see is not fo showing your student but for them to do the real experiment or at least observe you do it. The video that you see is about 22 years old. It is one of the very first videos that David Brookes and I made for our very first video website (it is still working!) and in this video you see the hands of Alan Van Heuvelen. It is a reminder of lots of contributions that Alan made to the field of PER. The magical work-energy bar charts that we use are his invention. As well as many others.



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Eugenia Etkina
Admin
Top contributor
· ·
Hi all, yesterday Marta R. Stoeckel-Rogers asked for a list of equipment for the whole year for those who are using our textbook College Physics: Explore and Apply. I posted this list some time ago, but here it is again for those who are planning equipment purchases for next year. Note that our equipment is very cheap and affordable.
Also, I am not seeing many views of my electricity posts. Is it because people are busy or this topic is not of interest? Please comment!
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Eugenia Etkina
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Interesting history - in more than a 100 years only 5 women received a Nobel prize in physics (two fo them were a mother and a daughter), but lots and lots in literature, medicine and peace...
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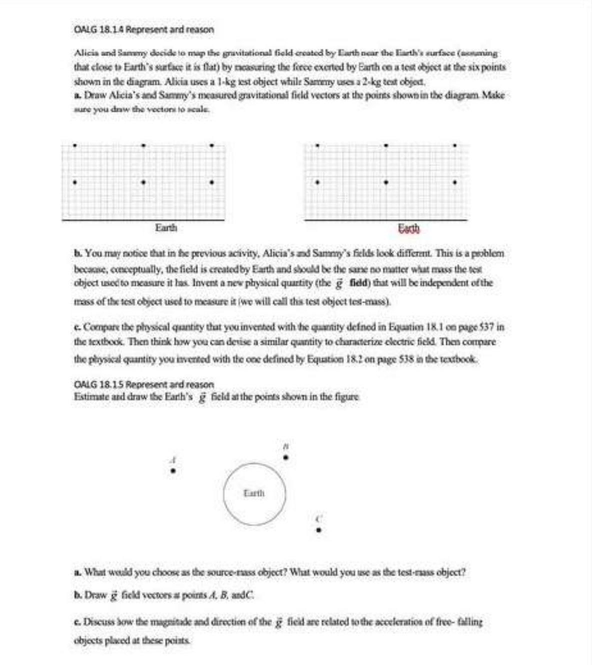
Eugenia Etkina
Admin
Top contributor
· ·
Hi all, I continue with the studies of electric field today. In my previous post about electric field (the day before yesterday) I described how our students invent a concept of electric field as a medium for transmitting interactions at a distance. Today I show how they invent the physics quantities of E-field and g-field. Do not confuse electric field with the quantity of E-field. There are other quantities characterizing electric field. The sequence of activities is attached. They are also in Chapter 18 OALG posted here in the FILES. If you read the post and downloaded the attachment, please do not forget either to like it or to comment on it to make it more visible for other group members.

Also, a reminder! If you are attending the workshop on Saturday, please see the homework in the EVENT announcement. I will post additional materials for you to bring in the announcement for the workshop in the EVENTS.



OALG 18.1.4 Represent and reason

Alicia and Sammy decide to map the gravitational field created by Earth near the Earth's surface (assuming that close to Earth's surface it is flat) by measuring the force exerted by Earth on a test object at the six points shown in the diagram. Alicia uses a 1-kg test object while Sammy uses a 2-kg test object.

a. Draw Alcia's and Sammy's measured gravitational field vectors at the points shown in the diagram. Make sure you draw the vectors to scale.

b. You may notice that in the previous activity, Alicia's and Sammy's fields look different. This is a problem because, conceptually, the field is created by Earth and should be the same no matter what mass the test object used to measure it has. Invent a new physical quantity (the $\vec{g}$ **field**) that will be independent of the mass of the test object used to measure it (we will call this test object test-mass).

c. Compare the physical quantity that you invented with the quantity defined in Equation 18.1 on page 537 in the textbook. Then think how you can devise a similar quantity to characterize electric field. Then compare the physical quantity you invented with the one defined by Equation 18.2 on page 538 in the textbook.

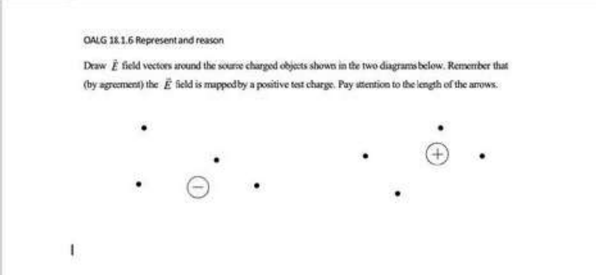
OALG 18.1.5 Represent and reason

Estimate and draw the Earth's $\vec{g}$ field at the points shown in the figure

a. What would you choose as the source-mass object? What would you use as the test-mass object?

b. Draw $\vec{g}$ field vectors at points A, B, and C.

c. Discuss how the magnitude and direction of the $\vec{g}$ field are related to the acceleration of free- falling objects placed at these points.



OALG 18.1.6 Represent and reason

Draw $\vec{E}$ field vectors around the source charged objects shown in the two diagrams below. Remember that (by agreement) the $\vec{E}$ field is mapped by a positive test charge. Pay attention to the length of the arrows.

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Eugenia Etkina
Admin
Top contributor

Hi @everyone! We had a good workshop yesterday. Thank you all those who attended. The workshop was on Static Fluids (chapter 13), the next one is on Fluids in Motion (Chapter 14). Both workshops are new. As always I am posting the link to the slides and to the recording of the zoom meeting. And the last reflection slide as well - what people have learned. I also saw several people join my zoom long after the workshop was over. I think you confused the time. The workshops always start at noon East Coast Time (this is the US East coast). Please next time, if you are not sure about the time, post a question here and I will reply. Also, those who need a PD certificate, please email me, eugenia.etkina@gse.rutgers.edu.
Link to the recording:
https://rutgers.zoom.us/.../YixAzv8NsIQeLXeXp70b... Password 5VYUK^L&
Link to the slides:
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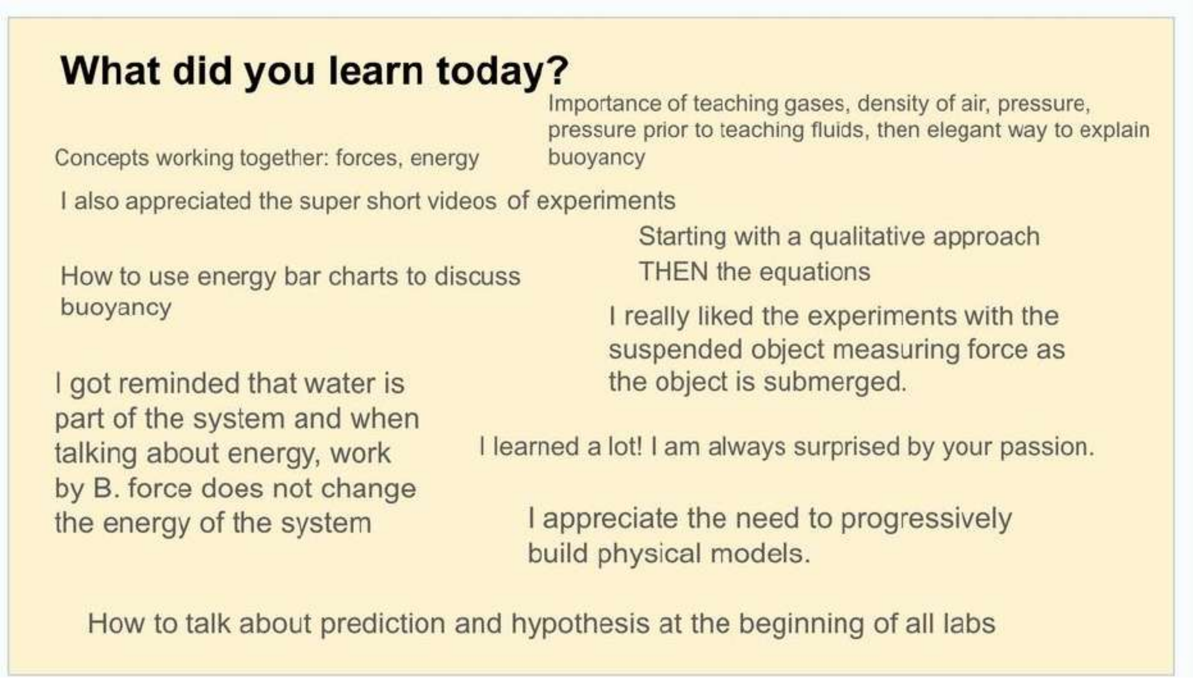

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Eugenia Etkina
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Top contributor
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Hi all Exploring and Applying Physics people, a few things today:
Let's choose the date for our Fluids in Motion workshop. My suggestions: May 18th or May 25h. The poll is below, please vote!
I will continue with the posts for Electric field. So far we discussed one physical quantity characterizing it - E field. But there is another one - V field or electric potential. The same way as E field at a point in space can be viewed as a force per unit test charge that the field would exert on a test charge placed at a particular location, the V field or electric potential at a point in space can be seen as the work per unit test charge that an external agent (you, for example) needs to do to place the unit charge at that location, or the electric potential energy per unit charge that the test charge and the field would have if you placed that test charge in that location.
Both, the E field and the V field characterize a point in space and are independent of the the test charge that we use to study them. Therefore, the definitions that I wrote above are operational definitions not cause effect relationships (E= sum of F/q test and V = Uel/q test.
For different configurations of source charges the cause-effect relationships for both quantities are different.
Now, how will the students learn what V field or electric potential is? See my post tomorrow.

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Eugenia Etkina
Admin
Top contributor
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Hi @everyone! A few things today.
Yesterday I posted a poll for the workshop on Fluids in motion and very few people viewed the post and consequently very few people voted. So, today I am tagging everyone to make sure that you have a chance to vote. I am especially asking those who attended the Static Fluids workshop to vote. As you requested this workshop, I would like to run it on the day that is convenient for you. And I just added a third option to the Fluids in motion workshop for May 11 after Gaby Scully posted that the 25th is the holiday weekend in the US, I completely forgot about it. Check out again and if you voted for one of the previous dates but can attend on the 11th, please check the 11th.
Yesterday Joseph Wachs asked if there is a book published about ISLE and a few people thought that there was no book like this. But there is a book, actually, and it was published 5 years ago - in 2019. Here is the link to the book. It is in a hard copy and in a pdf. If you don't want to buy it or have no access through your library, please email me and I will send you the pdf. https://iopscience.iop.org/book/mono/978-1-64327-780-6...
Finally, I am glad to let you know that we just finished a sequel to this book, it is called Investigative Science Learning Environment: A guide for teacher preparation and professional development. This new book is much bigger than the first one. It has 9 chapters and connects the ISLE philosophy to the development of productive habits of mind, practice and maintenance and improvement of physics teachers. I posted a lot about habits before, but in this book you will find a systematic approach to the development of these habits for those who aspire to implement the ISLE approach. The book is now in the stage of proofs and is going to be published in July. The authors are myself and Gorazd Planinsic. Several people from this group contributed to the editing process - Andrew Yolleck, Carolyn Sealfon, and Eugenio Tufino. My former students who have developed the habits described in the book shared their experiences - June Lee, Allison Daubert, Danielle Buggé and Josh Rutberg. We are infinitely grateful for their help. As soon as the book comes out, I will post the link here.
https://www.facebook.com/groups/320431092109343/posts/1607651303387309/?__cft__[0]=AZUA573I-rpgMPhHuOneueM192vN4TRg8tW53PNN-bMHwV-x3EcM9MnSSuR9lqQ4OQnVnFYisp3EIVii0-IDRGiXqt0WOryX1MjSIyb24quJNn3dea_h27VE5HopVeE0yrWVqhY-q8rSoxFolUu5VgxULHu7s5rfnvny0rWtVpc6FJvIiu-SCnnb7y0gLuH-JBzXUQwURhhuEUqP--rGsU_A&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin

Top contributor
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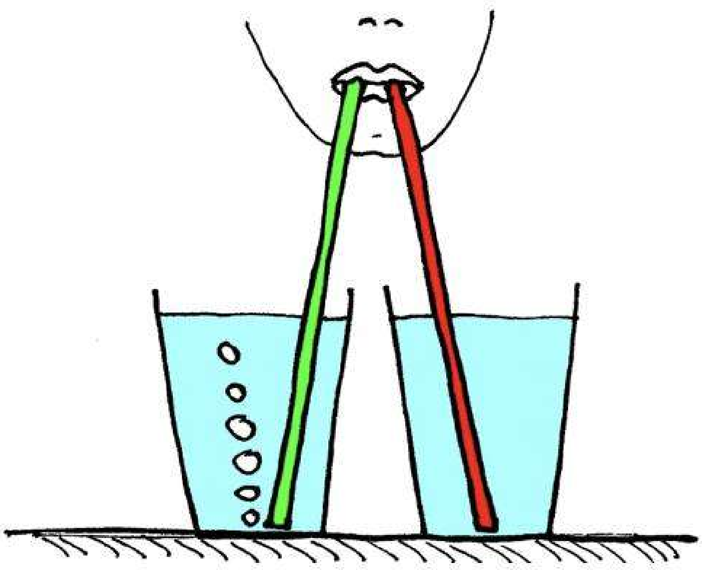
Hi all, a few things today. First, I added a third option to our dates for Fluids in motion workshop, please check it out and if this date works for you also, please mark it.
Second, I was thinking of continuing with Electric Filed posts but they have little viewership, so maybe I should build on the Static Fluids workshop and add some activities to it.
So, here is one of my most favorite activities for hydrostatic pressure - an easy mini-lab in class and an excellent homework experiment - students can do it at home and report back in class and even take videos of their experiments!
Here it is:
OALG 13.3.5 OBSERVE AND EXPLAIN
Equipment: two identical transparent containers (large plastic cups, glasses or 0.5-liter water bottles with cut tops), two identical straws, sugar.
FOR THIS EXPERIMENT, YOU WILL NEED TO PREPARE A SUGAR SOLUTION IN WATER. THE PROPORTION IS ABOUT 200 G OF SUGAR PER 1 LITER OF WATER. FOR THE EXPERIMENT, YOU ONLY NEED ABOUT 200 ML OF WATER THEREFORE LESS SUGAR (DO THE CALCULATION).
a. Prepare two identical containers. Pour tap water in one of them and sugar water solution in the other. Make sure the level of water in both containers is the same.
b. Hold the two straws in your mouth and lower their other ends into the water of the two containers so that both straws are almost touching the bottom (but are not in contact with it, see the figure below).
Start blowing into the straws until bubbles come out. In which container do the bubbles come out? Blow a little harder. Can you make the bubbles come out in the other container?
c. Explain your observations and draw graphs of pressure-vs-depth (for help, check the graphs in Conceptual Exercise 13.3 in the textbook). Why do bubbles only come out in one container and not in the other container? How can your graphs explain why you cannot make the bubbles come out of the straw in the second container?



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Eugenia Etkina
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Hi all Exploring and Applying Physics people! I did not post anything yesterday, as we had a PhD defense of one of our students (Gorazd Planinsic's and mine), Danijela Dodlek.
Danijela had a marvelous defense and her project was very useful for all teachers. Specifically, she found that while physics teachers are very good at recognizing students' correct and incorrect ideas in their written explanations of a problem situation, they have difficulties providing careful descriptive feedback to the student that would help the student build on their productive ideas. She also found that pre-service teachers who have been trained with the ISLE approach and the members of this group (who responded to the survey that was the basis of the study) were much better in recognizing students' productive ideas and building on those. Listening to the students and using their ideas as the foundation of learning is at the heart of the ISLE approach and the effect of this are clearly seen in the study. The paper about the study was published in Physical Review Physics Education Research and is very useful for learning how to provide descriptive feedback. I am attaching it.
Another thing that I wanted to mention is that we still need people to vote for the date of the Fluids in motion workshop. The votes are split so far and I need more people to vote to choose the date. We have been creating new activities for fluids in motion that have not been published anywhere, so the workshop participants will be the first to try them! Please scroll down through the posts to find the post with the poll and vote, thank you!
https://www.facebook.com/groups/320431092109343/posts/1609495449869561/?__cft__[0]=AZUKtHfLkUAIgUFjIKteHIXCZWcYZaDKteEflB4-J7rnLEk2t3CJl28m5OgrzmIGPl5Ou9-b0tJgNyE3phzUPrkgonAWIRVC9ykrXr6NJe4SWG93AvVdEHjXgwLStKUdaIcFGGx5gbTImD8DgshQ4s9fsW9B_wHqgq2lnWJ7IzDWNIT3BrS4EBfcrNlkY7-Pl4KeY57Xr7zFyf-M354p_7IFHZtaPw6yBbxYPOxwG4Wosg&__tn__=%2CO%2CP-R

Eugenia Etkina
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Hi all Exploring and Applying Physics people!
Yesterday, without any prior discussion Bor Gregorčič and I posted two papers describing teacher's responses to students' explanations. While in the study that I reported, the teachers (in-service and pre-service)responded to the explanations of real students, in Bor and colleagues' study, the teachers (professors and pre-service teachers) interacted with ChatGPTs of different "ages". The stories described in both papers are fascinating, but here, today, I wanted to focus on one idea from Bor and colleagues' study that is very relevant to teaching real students.
Remember, I posted how deceptive the "AHA" moment in our students is? We all love this moment, but if we only probe the "AHA" part a little deeper, we would almost for sure find out that that AHA relates to something else (not what we wanted the student to understand) or completely disappears the next day. This is exactly what Bor and colleagues found with their

study, only the "student" was the bot! Because of the deceptiveness of the AHA moment, a legendary physics educator Arnold Aarons recommended that we provide at least 6 exposures in different contexts for a student to actually understand and be able apply the concept (this is exactly what we do in our ISLE materials).
There are many other very useful ideas in that paper so please take time to read both papers and think of how they might affect what happens in your classroom. Good reading this weekend! I will not post anything tomorrow to give you time to read the papers.
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Eugenia Etkina
Admin
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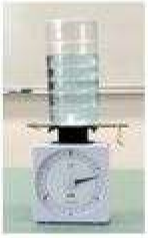
Hi all, I am continuing with Static Fluids posts to finish up the chapter. In the workshop we did not do a wonderful activity that embodies the spirit of ISLE (multiple explanations with the design of testing experiments and predictions based on those different explanations). Hypothetico-deductive reasoning is a difficult thing and needs to be practiced multiple times before one grasps the essence of it. In my physics teacher education program at Rutgers experienced teachers who were working on their masters degree would take 2 semesters to truly understand how to use it in the classroom. I am posting this example so that you can see another implementation of this reasoning in a very scaffolded environment. As I said before, Aaron Arons recommended 6 exposures in different contexts for a person to firmly "get" the idea, but for the HD reasoning I think we need over 10. So, here it is! (You can see this activity in the OALG file for chapter 13 posted here in the files).

OALG 13.6.6 Test different explanations

You place a plastic container with water on a scale and observe the reading (see the figure on the left below). Then, you hang a 1-kg object from a string and submerge it in the water so that the bottom of the object does not touch the bottom of the container (see the figure on the right below). You notice that the scale reading increases and the water level goes up. Your friends suggest the following explanations for the increase in the scale reading:



Scale reading: 620 g

Scale reading: 750 g

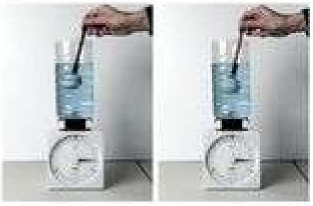
Finn: The water exerts an upward force on the submerged object. According to Newton's third law, the object consequently exerts a force on the water that is an equal in magnitude and opposite in direction (downward). This force makes the water press harder on the container and the container press harder on the scale.

Dimitry: Some mass of the immersed part of the object adds to the mass of the water. As a result, the force exerted by the container on the scale increases.

Alex: The immersed object exerts no force on the water, but it does make the water rise. The higher the level of the water, the more pressure on the bottom surface of the container. Consequently, this causes a larger the force to be exerted by the container on the scale.

While testing their explanations, your friends designed the following testing experiments:

Testing experiment 1



Testing experiment 2

Testing experiment 1: Squeeze the container to achieve the same increase in water level as when immersing the 1-kg object. Record the reading of the scale.
Testing experiment 2: Submerge in the water a ping-pong ball fixed on the end of a thin stick and record the change in the scale reading. Then, repeat the experiment with a ping-pong ball filled with sand.
a. Before reading on, make predictions for the outcome of each testing experiment based on each explanation proposed by your friends.
The outcomes of the testing experiments are as follows:
Outcome of TE1: The scale reading is 620 g (note: the cardboard "squeezers" were also on the scale in the original experiment)
Outcome of TE2: In both cases, the scale reading increases by 30 g.
b. Compare the outcomes of the testing experiments with your predictions and decide which explanation(s) you can reject and which you cannot reject.
c. Based on the explanation(s) that you were not able to reject, draw a force diagram for the water-container object. Draw another force diagram for the 1-kg object in the case when the 1-kg object is immersed in the water (as is the case in the figure on the right at the beginning of this activity).
d. Try to explain the outcome of testing experiment 1. (*Hint:* draw the forces that the water in the container exert on different parts of the container's walls.)

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Eugenia Etkina
Admin
Top contributor
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Hi @everyone! A few things today. First, my yesterday's post disappeared from the group. I wonder why... Second, I was asked to give a talk about our community at a conference and I created a short survey (3 min max) for you to fill out. Would you please do it? You will see that the questions are not just for the talk but for the improvement of our community too. Thank you for doing it. And finally, I think the workshop on Fluids in motion will be May 18th.

I will create the event announcement tomorrow and post it. Thank you again for doing the survey!
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Eugenia Etkina
Admin
Top contributor
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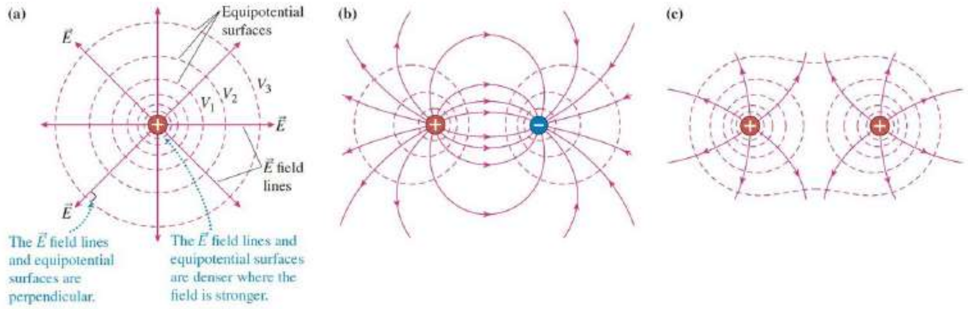
Hi all Exploring and Applying Physics people! Three things today. First, thank you for filling out the survey, almost 40 people did it so far, I will wait for a few more days to analyze the results and share them with you.
Second, I just created an event for our Workshop Teaching Fluids in motion through the ISLE approach. The workshop will be on May 18th, at 9 am US West coast time (PST), noon US East coast time (EDT) and 6 pm Central European time (CET). Please sign up so that I know how many people are coming. We have not had this workshop yet, there are no old recordings. In fact, I have never taught a workshop on Fluids in motion for teachers yet (only taught this topic for high school and college students), so it will be the first time. Let's learn together! I am reminding our new members that all workshops are free and if you need a PD certificate - you just need to email me and I will send you one.
eugenia.etkina@gse.rutgers.edu
And the third thing, I am going back to the posts about electric field. To see the beginning you need to go back for about 2-3 weeks. I stopped at the concept of V field or electric potential. I am reminding you that we use the term electric field for the region of space where if you place a test charge, a force will be exerted on it. To characterize this region of space in introductory physics we use two physical quantities - one is force-like quantity (called E field, units N/C) and energy-like (called V field or electric potential, units J/C). But non of those quantities depends on that test charge that you place in the field. The field exists without any test charges, it is created by SOURCE charges and we only use test charges to study it.
So, what does it mean to imagine what E field at point A is? Imagine placing a small positive test charge at location A and then measuring the force exerted on it - both direction and magnitude. The direction fo that force tells you the direction fo the E field, and the magnitude divided by the magnitude of the test charge tells you the magnitude of the E field.   This is rather simple. But what about the V field or electric potential?
To imagine what V field at point B (or electric potential) means, we again need a positive test charge. Only now we need to measure the work we do to place that test charge at location B and more, we need to agree that infinitely far from all source charges creating the field, the potential is zero. Now, if we need to do positive work pushing the positive test charge from infinity so it moves to to that point b at constant speed, the V field or electric potential at B is positive and equal to that work divided by the magnitude of the test charge. But if we need to pull it in the opposite direction, preventing it from flying into B at increasing speed so it does reach B at constant speed, thus doing negative work for placing it at B, then the V field or electric potential at B is negative and its magnitude again is equal to the magnitude of work we did divided by the magnitude of the test charge.
This difference between the force and the work (or between the force and the energy of the field-test charge system) is the key difference between the E field and V field (or electric

potential). But again, no test charge is needed for the electric field to exist at A or B or for it to have those two quantities describing it...
Please ask questions!

FIGURE 18.9 The equipotential surfaces and $\vec{E}$ field lines produced by (a) a positively charged point object, (b) an electric dipole, and (c) two equal-magnitude positively charged objects.



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Eugenia Etkina
Admin
Top contributor
· ·
Hi all, a few things today. First, if you plan to attend the workshop on Fluids in motion, please sign up. So far only 3 people did and we cannot have a workshop with 3 people. If there is not enough interest, we can do a different workshop on that day or run the fluids workshop in early June if the date in May is not good.
Second, although people are still responding to the survey that I posted two days ago, there are a few things that are clear from the survey: We need a better system for keeping tack of the workshops so that people can go back and look at the slides. So, I reorganized them in the workshop folder (I will post the link to it in the comments) but here I wanted to post the link to the workshop on Electric Filed that we had last year. As I have been posting on electric field for a while, I think it is good if you can access the slides and see the progression of activities. The workshops slides ARE VERY IMPORTANT IF YOU HAVE TO SAVE TIME AND ONLY HAVE YOUR STUDENTS DO THE MOST VITAL ACTIVITIES. So, here is the link to the electric Field workshop folder with the slides and all supporting documents.
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Eugenia Etkina
Admin

Top contributor
· ·

No posts today, as there were two workshops in Trieste organized by Valentina Bologna Longo and her amazing students and family. Gorazd Planinsic and I met wonderful teachers who were eager to learn different aspects of the ISLE approach. I guess, it still came out as a post
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Eugenia Etkina
Admin
Top contributor
· ·

This is one of the women that I taught about my students a lot. She was not only everything that the article says (please read as she was amazing!) but she also was a wife of a guy who invented caloric model of heat and of the guy who proved it wrong. what is a probability of that? The names of both husbands are in the article but it does not say a word about caloric... Enjoy!

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Eugenia Etkina
Admin
Top contributor
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Hi all, my last post for electric fields. These two activities have experiments that you can use for your students to solidify their understandings of the Efield and Vfield. The first experiment is very unique, the second one is not so much, but still it is a little tricky. But I did it with my students many times with good success. Please read the text of the activities - these are not just experiments. One is an observational experiment and one is a testing experiment. How is the wording different for those? How does this difference reflect the difference between the epistemic nature of the experiments?

Often, everything that happens in a physics course is divided by the students into demos and facts. We do not use these words at all not to trigger such thinking. There are no demos in ISLE and no facts. But there are observational experiments, testing experiments, applications experiments, hypotheses, predictions and assumptions. These are the words of physics. Demos and facts are not, let's help our students understand and speak this language. Right?

OALG 18.4.3 OBSERVE AND EXPLAIN

In the following video https://mediaplayer.pearsoncmg.com/.../sci-OALG-18-4-3 you see two metal plates connected to a device called a voltmeter that allows you to measure the potential difference between two points. Watch the video and explain what you observe. Answer the following questions:

a. How is it possible for the voltmeter to read positive potential difference if the experimenter only charged one plate? Hint: Note that the yellow wire in the experiment is connected to Earth.

b. Why does the experimenter move the plate using a plastic holder?

c. Why does the reading of the voltmeter increase as the plate is moved to the right although no more charges were added to it? Use an energy bar chart for help. Consider the system to be the two plates and the hand to be a part of the environment. After you draw the bar chart and explain the outcome of the experiment, think of how you could have explained it using the relationship between the E field and the V field.

OALG 18.4.4 TEST YOUR IDEAS

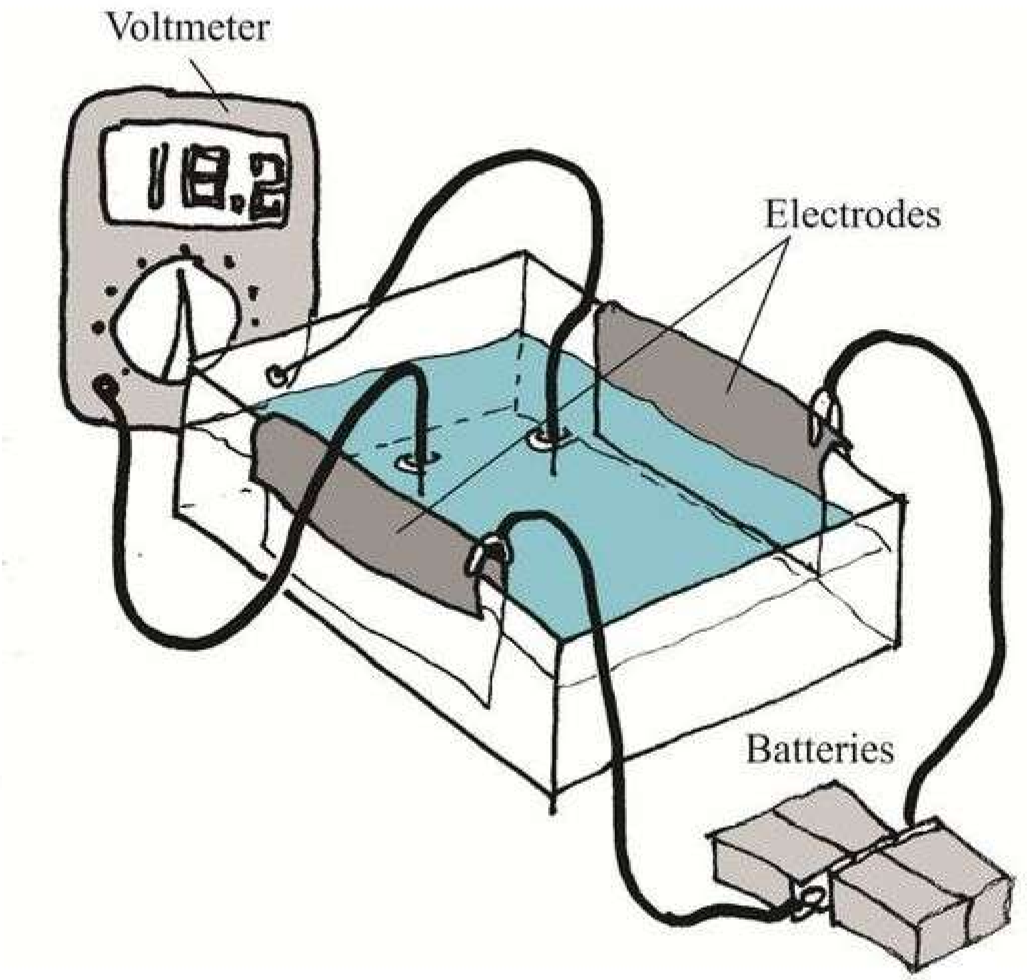
In the following video https://mediaplayer.pearsoncmg.com/.../sci-OALG-18-4-4awe use a digital voltmeter (in Activity 18.4.3 we used an analogue voltmeter) to measure the potential difference between two points. We also use a battery that creates a constant potential difference between two metal strips connected to it.

We filled the container with tap water and placed metal strips (electrodes) as shown in the figure on the right. It is possible to measure potential difference between two points by touching them with the voltmeter leads. These points can be the on the electrodes anywhere in the water.

a. Watch the video and describe in words what happens in the experiment. Then explain how you can predict the results of the experiment using your knowledge of potential difference. Discuss any additional assumptions you need to make.

b. The experiment is then modified so that the distance between the electrodes is fixed. Use your knowledge of electric potential to predict what will happen to the reading of the voltmeter when (1) the two electrodes are oriented along the line perpendicular to the metal strips and are moved along this line; (2) the two electrodes are oriented along the line parallel to the metal strips and are moved along this line, first closer to one of the strips and then closer to the middle of the container. Explain how you made your prediction.

c. Watch the experiment https://mediaplayer.pearsoncmg.com/.../sci-OALG-18-4-4band record the outcome. Did your prediction match the outcome? If not, how do you need to modify the reasoning that led you to the prediction (or some additional assumptions) to account for the outcome?



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Eugenia Etkina
Admin
Top contributor

Hi @everyone! Two things today. I am asking you again to sign up for the workshop Fluids in Motion on Saturday May 18th if you plan to attend it. most of my posts about the workshop are invisible, so I am tagging everyone to make sure everyone saw the post. Got to the EVENTS page and sign up if you plan to attend. so far we have 11 people who signed up. In my experience about a half or 2/3 of those who sign up actually attend. If we do not have enough people for the workshop, we will not run it.
The second thing is that in my post yesterday (largely invisible) I asked if I should start posting about DC circuits. Amin Rainy said that it would be good to do DC circuits. So, I am starting.
The most important thing for students' success in DC circuits is that they understand the concepts of electric potential difference and the nature of electric conductors. Creating potential difference at the ends of a conductor is a necessary condition for a continuous charge flow but it is not sufficient. Electric charges move in the electric field in the direction

that equalizes potentials, therefore we need a device or a mechanism that would maintain that potential difference for the time that we need. Understanding of this idea leads the students to the understanding of a nature of an electric circuit - the need for the device maintaining potential difference between any two points in a circuit, a conducting path, and a closed loop. Research shows that the understanding of these three conditions is the foundation of students' understanding of electric circuits. I am pasting OALG activities below that help students construct these fundamental ideas.

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?

OALG 19.1.2 OBSERVE AND EXPLAIN

Equipment: 1 D or C 1.5 V battery, a small incandescent lightbulb, 2 connecting wires.

If you have a battery, two wires, and a small lightbulb, follow instructions below.

a. Try different arrangements of these four elements to make the lightbulb glow.

b. Then, remove one wire and try to light the bulb with just a battery and one wire.

c. Draw pictures of the arrangements where the bulb lights and several where it does not. Explain how this experiment is similar to Activity 19.1.1 and how it is different.

d. Think of how an incandescent lightbulb might be constructed.

If you do not have the materials, go to https://phet.colorado.edu/.../circuit-construction-kit-dc...

Note that the simulation also uses incandescent light bulbs. They are very different from the LED bulbs that you use at home.

a. With PhET drag one light bulb, two wires, and a battery to the center of the screen. Arrange these four elements to light the bulb.

b. Now use only one wire. Can you light the bulb? How is this circuit similar to the first one? How is it different?

OALG 19.1.3 EXPLAIN

Use your observations and explanations for the previous activities to answer the following questions.

a. Summarize the conditions that are necessary for the continuous flow of electric charge in an electric circuit.

b. What properties of the devices are necessary to maintain a continuous electric charge flow through the wire? Think of such devices in your everyday experience.

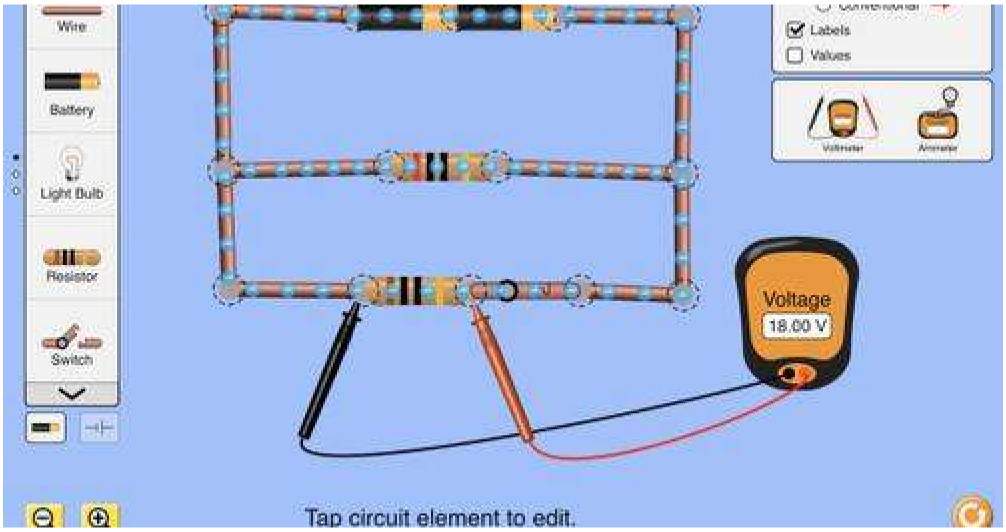
c. Construct an analogy to explain how an electric circuit works. Use the following table to help you create your analogy. Note: An analogy involves mapping between the target phenomenon (the one we are trying to understand) and some source phenomenon (that we understand and are using to compare to the target phenomenon). The source phenomenon should be some everyday experience that you are familiar with, and whose physical processes are similar to the workings of the electric circuit you’re trying to explain (this is your target phenomenon).

Source phenomenon ???

Target phenomenon (electric circuit)

Battery

Connecting wires
Lightbulb
Electric charges
Explain how your analogy works. How are the elements of your source phenomenon similar to the battery, charge flow, lightbulb, and connecting wires?
d. Compare and contrast your analogy with the material discussed in sub-sections “Making the process continuous” and “Electric current” on page 575 in the textbook.



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Eugenia Etkina
Admin
Top contributor
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This is a short clip that every teacher needs to watch. I have always been saying that every child is a born scientist and we beat this out of them in our schooling system. He is saying that every child is a born artist (actually he quotes Picasso on this). This means that every child is a born everything...
But the key here is that our educational system scares children (of all ages, including university) that making a mistake is bad. And this kills their natural curiosity, creativity and all other amazing qualities that they have. They get glassy eyes and fear. It is strange (but not strange at all actually) that the ISLE approach mitigates most of these issues by allowing students to generate their own ideas and not to be afraid to make mistakes as there is always another chance to improve.
Research shows that it is not only a person who needs to develop growth mindset, it is the environment that needs to have growth mindset for individual mindsets to prosper. ISLE provides this environment to all students. Unfortunately, when a sword of an AP exam or some other test hangs over our children, the main idea of learning is weakened and sometimes destroyed. I am not sure what to do about it. What do you think?

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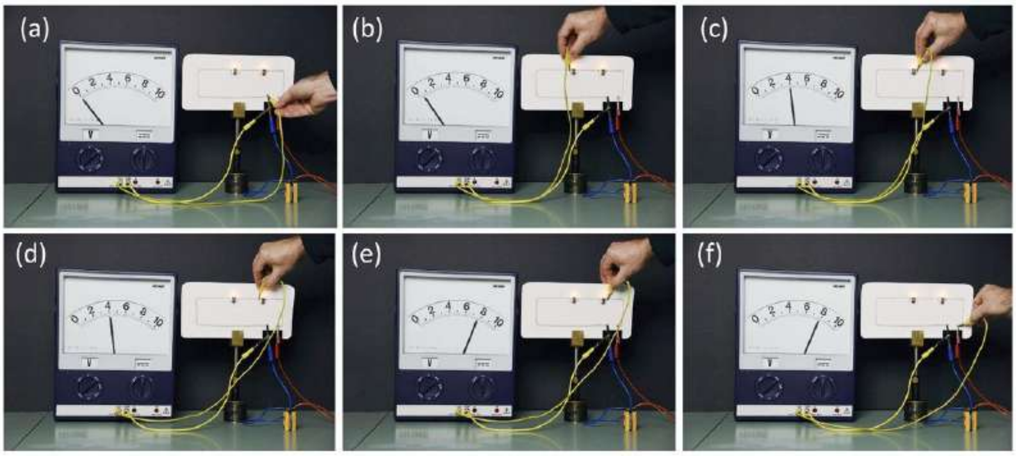
Hi all, I continue with DC circuits today (Chapter 19 in the textbook). In addition to potential difference and electric current, another physical quantity is extremely important. It's name (emf - electromotive force) is a historical artifact, as it is not a force but work per unit charge, but this term is left from the times when kinetic energy was called live force, gravitational potential energy - dead force and so on. Why is it important? Because although the unit is the same as of the potential difference or voltage, the concept behind is very different. emf characterizes the work on non-coulomb forces per unit charge, the voltage - the work of Coulomb's forces. We cannot use only Coulomb's forces in a closed circuit as they always equalize potentials (their work on a closed loop is zero) and we need to keep potential difference across conductors in the circuit for the current to exist. Here are the exercises. The text is in the textbook. Note that the idea of emf is crucial in understanding electromagnetic induction in chapter 21.
19.2.1 EXPLAIN
In Activity 19.1.2 you found that without a battery there is no continuous flow of charge in an electric circuit. How can you explain this fact?
19.2.2 OBSERVE AND DESIGN
Go to https://phet.colorado.edu/.../circuit-construction-kit-dc...and use available materials to build the three circuits according to the descriptions below.
Experiment 1 One battery, one lighted lightbulb, and two wires.
Experiment 2 Two batteries arranged so that the positive side of one touches the negative side of the other, forming a chain (in physics they are said to be in series); one lighted lightbulb; and wires.
Experiment 3
Two batteries arranged so that their positive sides are together and negative sides are together, forming a ladder (in parallel); one lighted lightbulb; and wires.
a. Draw each circuit in your notes. Observe the brightness of the lightbulb in each experiment relative to the other experiments and record your findings.
b. Explain the difference in brightness using the analogy you developed in Activity 19.1.3, or modify your analogy to explain your new findings if necessary. Sometimes your analogy won't work to explain what you found here. In that case you may need to abandon your analogy and come up with a new one.
c. Explain the difference in brightness using the language of energy.
OALG 19.2.3 OBSERVE AND FIND A PATTERN
Read and interrogate Conceptual Exercise 19.2 on page 577 in the textbook. Then, read the "Try it yourself" question. The following photos show experimental steps to help you with the question. Here, we used 2 lightbulbs instead of two motors.
a. Draw a sketch of the electric circuit used in the experiment. Carefully follow all connections.

b. Find a pattern in the reading of the voltmeter. What can you say about the changes in electric potential through the circuit?
c. Draw a graph of potential-vs-location using the graph in Conceptual Exercise as a guide. How is your graph different from the graph in the exercise? Explain.
OALG 19.2.4 READ AND INTERROGATE
Read and interrogate Section 19.2 in the textbook and then:
a. Answer Review Question 19.2.
b. Compare and contrast the physical quantities emf and potential difference (voltage).



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Eugenia Etkina
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Hi all, today is not about DC circuits. It is a story. You probably remember, that we have been working on the third edition of College Physics: Explore and Apply. Now it will be called just Physics: Explore and Apply, but this is not what the story is about.
As you all know, we have lots of videos of experiments in the textbook and the ALG/OALG. Most of them are made by Gorazd Planinsic with my humble assistance. For the new edition we are making (he is making, I am assisting and directing) lots of new videos. One of those is at the beginning of Chapter 11 - waves. The experiment needs to help students construct the idea that waves do not carry material, but carry energy. To make this video we need still water, drop a rock into it and have some light objects bounce when the wave pulse created by the dropped rock reaches them. It is easier to say than do. Where is that still water??? Being on the Adriatic coast now, we have been watching the sea for days, but it is no good - waves and wind. We tried many times but could not get good footage. So, today we are running in the morning and I see a little bay made by rocks where the sea water seemed to be still. I say: Gorazd, look - good water! He says: We need to hurry then, as the tide is coming.
So, we sprint home (about a mile), pick the camera, the tripod, and get on the bikes to rush to that place. It took us about 20 min to do this but by the time the wind was picking up.

I said: It is no good, let's go home. But Gorazd does not give up. Ever. After about 30 min of multiple takes we got that one moment that you will see on the video. It looks so easy... https://youtu.be/Dg97KtWvotc

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And this is the direct application of the idea that students construct explaining our simple video in my first post today - using this energy that a wave carries! I wonder how Facebook knew to send me this video?

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Hi all, thank you for reading about our wave-making-video adventures.
Today, I am going back to DC circuits. I am sharing two activities. The first one is crucial for your students to learn how to measure current through a resistor and voltage across it. Notice the language here - current through - means the device to measure it should have the same current passing through it, and voltage across - means the device needs to be connected across the same points. The second activity is for the students to learn what resistance is - as the ratio of voltage over current. It also help dispel a common idea related

to Ohm's law - that resistance is the slope of the line on the graph voltage vs current. While it is true for ohmic resistors, it is not true for non-ohmic resistors. Non ohmic does not mean that Ohm's law is not true for them, it only means that the ratio of voltage over current is not constant. Both activities are taken from the OALG - they use phet instead of real equipment, but they can be done with real equipment too.

OALG 19.3.2 DESIGN AN EXPERIMENT

Your goal is to build an electric circuit in which the lightbulb glows, and an ammeter measures current through the bulb, and the voltmeter measures potential difference across different elements. You will do it using the circuit construction kit at https://phet.colorado.edu/.../circuit-construction-kit-dc....

a. Think of how to assemble the elements. Read the instructions about connecting ammeters and voltmeters in a circuit provided on your desk or on p. 580 of the textbook. Then examine the materials available for you in the simulation.

b. Draw the circuit you are going to make, including the ammeter so that it measures the current through the bulb. Mark points across which you will connect the voltmeter.

c. Make the circuit and check that the bulb only glows (and the ammeter is showing a non-zero reading) when the switch is closed.

d. Collect the current and potential difference data for different positions of the voltmeter (potential difference across the battery, across the bulb, across the wires, and across the closed and open switch).

e. Record the patterns that you find.

OALG 19.4.1 DESIGN AN EXPERIMENT, FIND A PATTERN, AND EXPLAIN

Your goal is to find a relationship between the current through and potential difference across commercial resistors. Use the materials at https://phet.colorado.edu/.../circuit-construction-kit-dc...

To make a variable power supply to vary the potential difference across a resistor you can place the battery in the circuit construction place, tap on it, and at the bottom of the screen you will see that you can change its emf from 0 to 120 V.

Please address the following points when you write up your report:

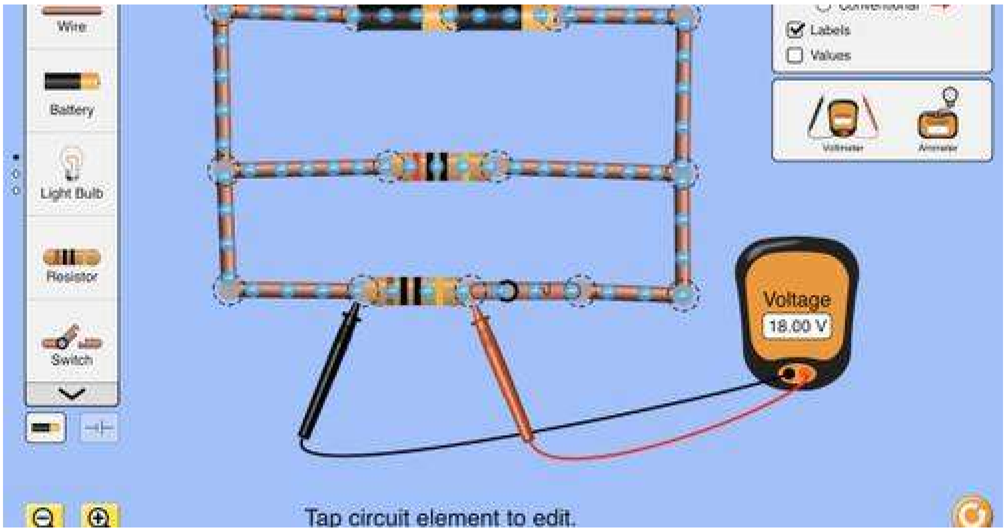
a. Describe the procedure for your investigation and describe your experimental design. Include a labeled circuit diagram.

b. What important physical quantities change during the experiment? What are the independent and dependent variables in your experiment?

c. Record your data in a table. Then calculate the ratio of potential difference across the resistor and the current through it for every potential difference reading. What can you say about the ratios if you take uncertainty into account?

d. The ratio of potential difference across the resistor and the current through it for each potential difference reading is called resistance. What can you say about the resistance of the resistor for different potential differences across it? Is the resistance of the resistor constant or is it changing?

e. Use the ohmmeter to measure the resistance of the resistor that is not connected to a circuit. Does it match your findings in part c.?



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Hi all, three things today.
Those who signed up for the Fluids in Motion workshop on Saturday at noon EDT (East Coast US time) please prepare the following equipment: 2 straws (at least one of them needs to be transparent), a transparent glass (a beaker will do), two empty soda cans and smooth surface to put them on, scissors, three sheets of printing paper, a syringe, A container with water, a bottle with holes and tacks that we used in the previous workshop.
I continue with DC circuits. First I want to remind people that we write Ohm/s law as I=delta V/R, not deltaV=IR as it is written in many sources. We chose the former way of writing it to underscore the course-effect relationship - current is the result of potential difference and a non-infinite resistance of the medium. Also, delta V - the voltage, is already potential difference, so commonly used term voltage drop does not make sense and we do not use it.
As I said yesterday, a common mistake is to think that resistance is the slope of the potential difference-vs-current graphs. It is not, resistance is the ratio of deltaV/I. Only for ohmic resistors the ratio is the same as slope of the graph. But the definition of resistance that follows from Ohm's law works for any resistor for specific current and voltage. We have a great example of a non-ohmic device (crucial for today's life) - an LED. I am attaching the screen shot of the text in the textbook. Last year we ran a 4-hour LED workshop for the group as we have a special sequence of activities to embed LEDs in many topics of the physics course (see our series of 4 papers in The Physics Teacher about LEDs, all posted here in the FILES).

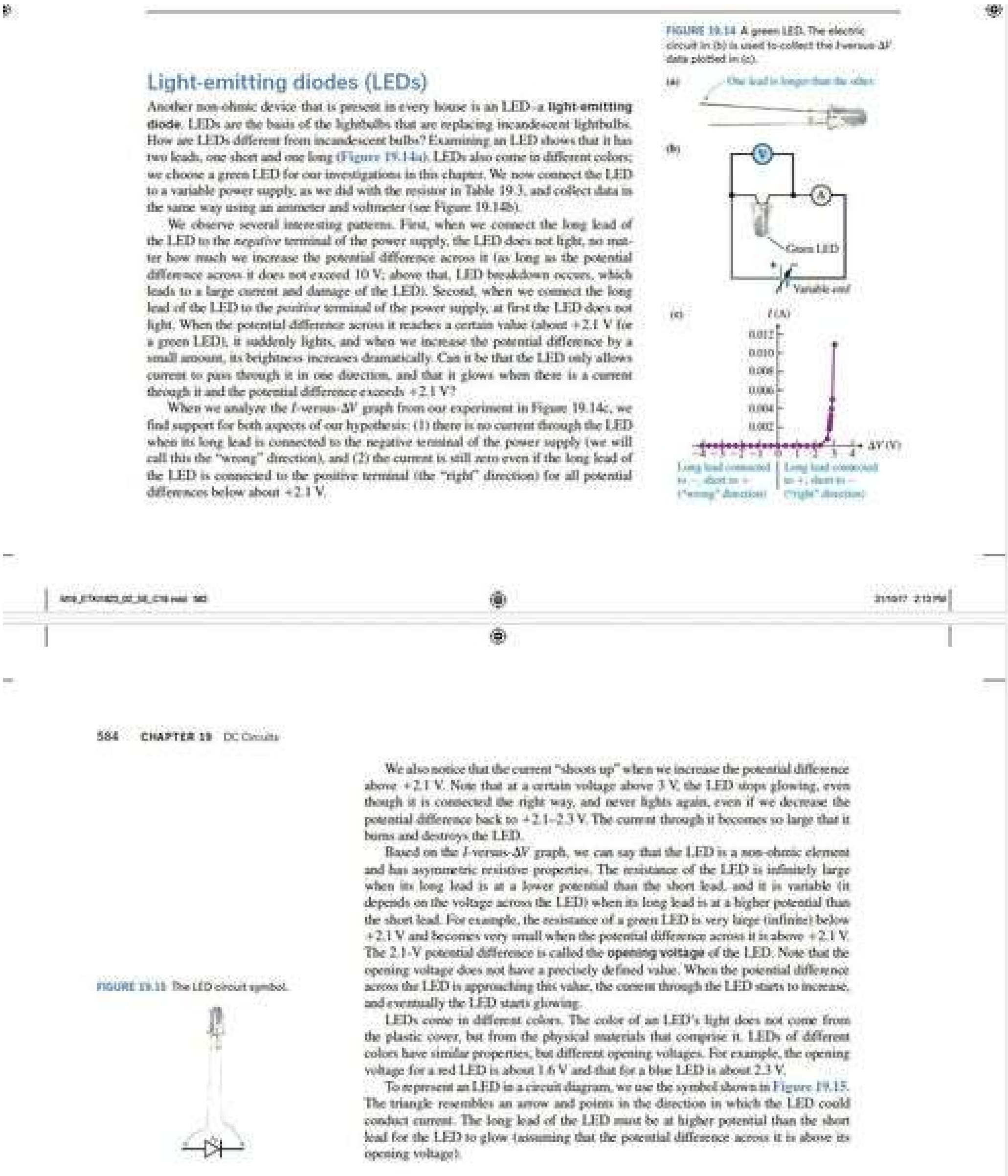

FIGURE 19.14 A green LED. The electric circuit in (b) is used to collect the I-versus-ΔV data plotted in (c).

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.

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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
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Top contributor
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Hi all, yesterday I was posting about difficulties that our students might have with the idea of Ohm's law. By the way, notice, that I never use the word "misconceptions" when I am talking about things that are difficult for the students. If you are interested WHY I NEVER use the term "misconceptions" - please ask, and I will write again as I have important, research-based reasons to do it.

But, putting the language aside, what else is difficult for the students when they have to apply Ohm's law? A open switch! They understand that when the switch is open, there is no current in the circuit (the current is zero). But does it mean that the potential difference or voltage across an open switch is zero? It is so tempting to say YES, as I= delta V/R, so if I =0, shouldn't deltaV=0 too? It would, if R were a finite number. But what if it is infinity? As it is for an open switch. What will you get when divide ANY number by infinity? You get 0. Just as what the current is. But then, what is potential difference across an open switch equal to? This is where the knowledge of electrostatics comes into play and the understanding of what an equipotential surface is. Here is the activity from the OALG that has videos of the experiments. When in class- the students can do these experiments themselves, the videos are just for you to have an idea.

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.

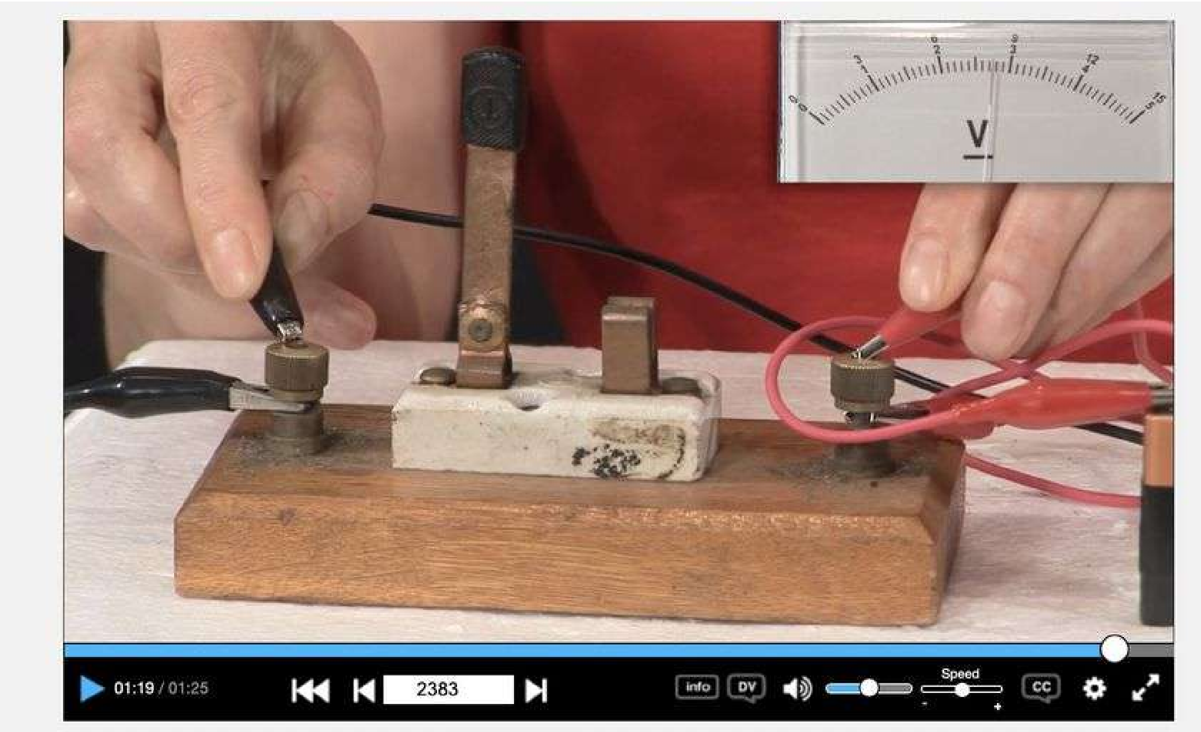
a. Draw the circuit diagram of your circuit.

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= delta V/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.



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Eugenia Etkina
Admin
Top contributor
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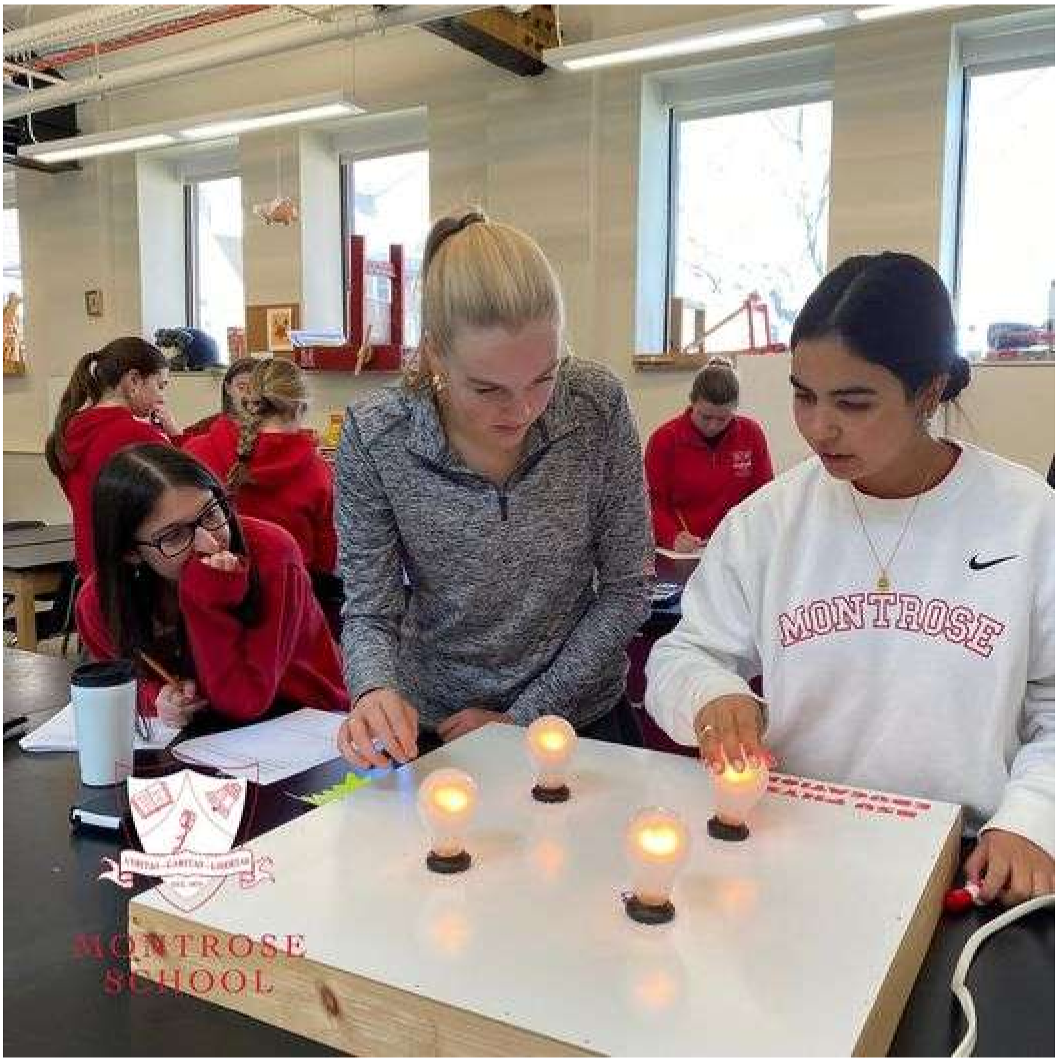
Post about Allison Daubert, one of our members and my former student. I am so proud of her!



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Although I promised not to post anything 2 days before th workshop other than the announcements, this one post from Tamah Fridman is impossible not to share. 74 minute solar eclipse. WHAT??? Indeed it was!

Watch it - it is totally amazing. It is not only about solar eclipse, it is about relative motion! Discussing it with your students during kinematics unit will make it it so much more relevant! But still - the Fluids in motion workshop is tomorrow. Only a few people signed up and I am worried that will will not have enough for high quality group work. Please join! noon EDT. The zoom link is in the announcement in EVENTS. and the materials were posted 2 days ago. The new videos we will watch and discuss will blow your mind. See you tomorrow!

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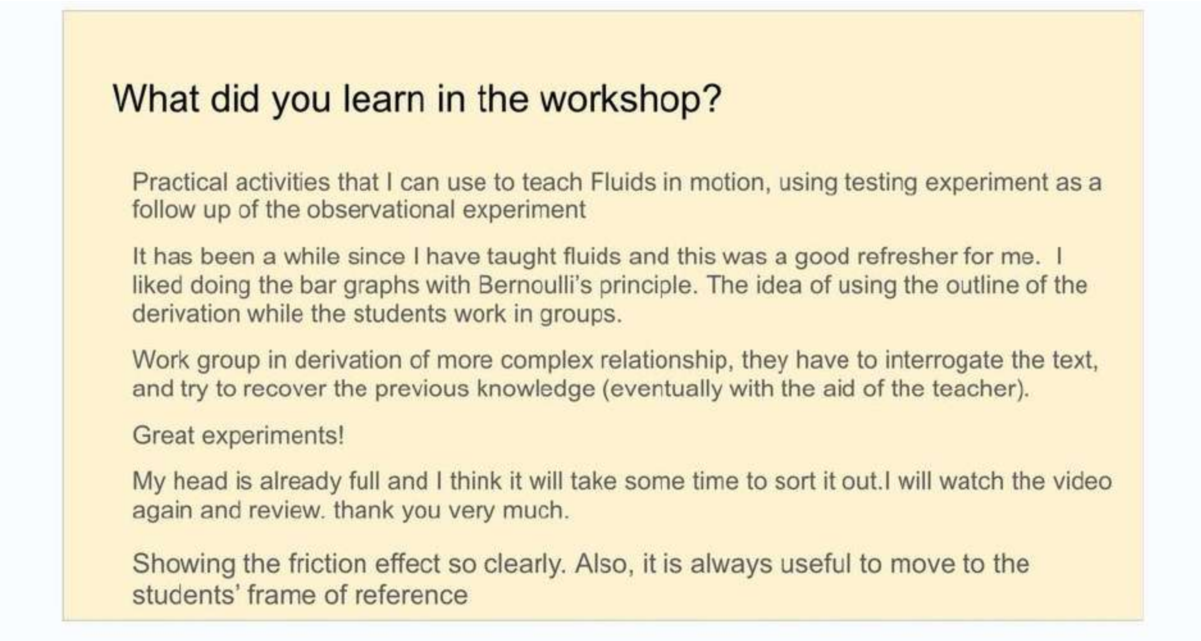
Eugenia Etkina
Admin
Top contributor

Hi @everyone! We had a wonderful workshop yesterday. It was a small group but everyone worked vigorously. Lot's of new activities and experiments that are not in the textbook yet but will be in the next edition. I am posting as always the links to the recording, the slides and the summary slide of what everyone learned.
In the workshop we discussed how to decrease surface tension at the hole of the bottle with the water jet. Laura Novak Sloma and Dorota Sawicka came up with great ideas. But what about adding some soap to the water? It will decrease surface tension, right? This is what Gorazd Planinsic is going to do and make a new video. Thank you for your ideas!
Recording of the workshop (unfortunately the first 10 minutes are not recorded as I forgot to press the button)
https://rutgers.zoom.us/.../F3G9m7XcO-uRLZy2...
Password: eqvK*ng4
Link to the slides
https://docs.google.com/.../10Oa4fLzWOW6xDQ3WyUw1.../edit...
And the reflection slide is attached.



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Eugenia Etkina
Admin
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Hi all Exploring and Applying Physics people! Over a year ago I posted that Gorazd Planinsic and I started working on a book that has a goal of helping teachers learn to use the ISLE approach. The book was supposed to be a sequel to the first book about ISLE (we wrote it together with David Brookes) that came out 5 years ago (this first book is about the approach itself, if you do not have this first book but wish t read it, please send me an email). Basically, if you wish to use ISLE with your students and develop productive habits that will help you implement it every day - this new book is for you. If you are not planning to use

ISLE but wish to have an interactive student-centered classroom - the book is also for you. If you are looking for some new physics ideas, cool experiments, and new problems - the book is for you too!

We have been working on it for almost 2 years. Many people helped up us: Carolyn Sealfon, Andrew Yolleck, and Eugenio Tufino helped edit the chapters. Bor Gregorčič wrote an interlude about AI and ISLE. Allison Daubert, Danielle Buggé, June Lee, and Josh Rutberg shared their experiences with the development of habits necessary to implement ISLE.

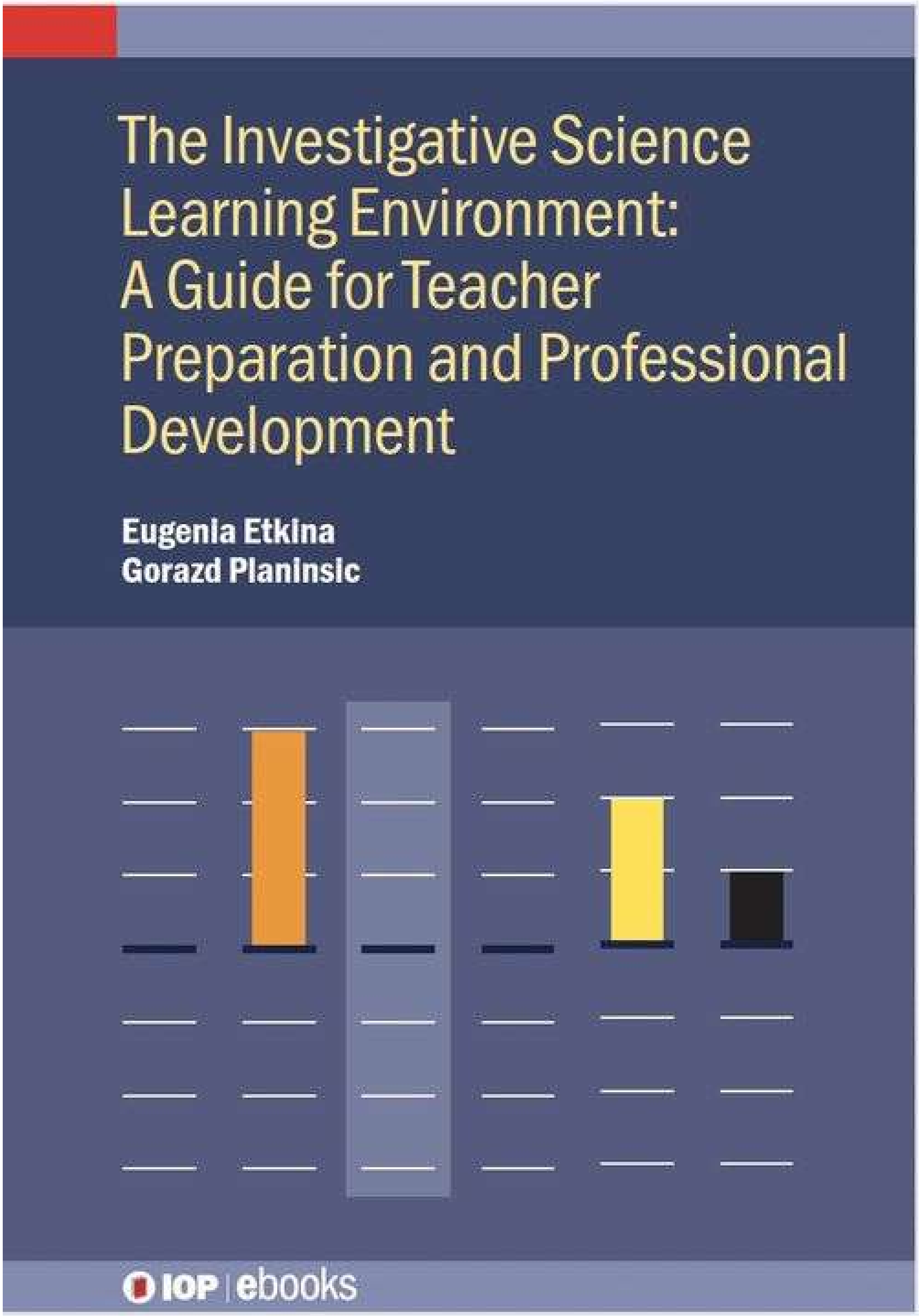
THANK YOU, THANK YOU, THANK YOU!

On Friday the book was published online. Here is the link. It should be in your university library shortly, but if you wish to start reading it today - please email me.

eugenia.etkina@gse.rutgers.edu

One more thing: the book goes together with our textbook "College Physics: Explore and Apply". If you do not have access to it, again - please email me.

https://iopscience.iop.org/book/mono/978-0-7503-5568-1



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Eugenia Etkina
Admin
Top contributor
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Hi all, two things today. The post is long, please read to the end as I have questions for everyone there. Thank you.

Welcome, people! This group is for those who are learning to use or using the Investigative Science Learning Environment approach to learning and teaching physics with their students, as well as the materials that support this method: The textbook College Physics: Explore and Apply (hence the name of the group), the Active Leanring Guide (ALG) and Online Active Learning Guide (OALG). If you do not have the textbook but wish to explore it (no pun intended), please send me an email at eugenia.etkina@gse.rutgers.edu. To start learning about ISLE and all other resources that we offer - please visit islephysics.net. to benefit from the group, check the posts daily and either like them or comment on them, and keep an eye for the workshops. Once a month, online, free. Do not hesitate to ask questions.
The second thing is that I am skipping the June workshop as we have an 8 hour Introductory workshop in July. The workshop is full. But I am asking you about August. Three choices: the workshop on how to start a school year with the ISLE approach (most of it will be in the intro workshop to ISLE in July), the workshop on kinematics (this will be the third time we will run it, we had it the previous two years), or a new workshop on DC circuits or magnetism. Please comment on your choices.
Tomorrow I will share the findings from the survey that you responded to. They are fascinating. And please read the post form yesterday if you are interested in the book about how to prepare teachers to teach with ISLE. Thank you all and welcome new members!
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Eugenia Etkina
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Hi @everyone! Thank you for all your comments about possible workshops in August. Based on your wishes, this is what we are going to do:
Those who have not attended (and will not do it this July) the Introductory 8 hour workshop for ISLE but are planning to start using the ISLE approach in the Fall, please watch the recording of the workshops for the first day of class and kinematics in the zoom subfolder of the google folder for the posts at https://drive.google.com/.../10qn...
The slide shows for all our workshops are at https://drive.google.com/.../1kiYbLqbLP7xMBhmZJBrFQgjdQwL...
All meetings/workshops folders are renamed so it is easy for you to find a specific folder. Additionally, I will start posting about the first day of class and kinematics at the end of July. So, if you follow the posts, you will have additional help. But regardless of all this, please ask questions when you have them! And read the Instructor Guide - chapter 1. The IG is posted here in the FILES. If you cannot find it, please send me an email eugenia.etkina@gse.rutgers.edu
Finally, based on your responses yesterday, we will have Magnetism workshop in August. The days to run it are Saturday 3rd or 10th. I prefer the 3rd. I will post the poll tomorrow but if you could express your preference in the comments to this post, it would be great!
Thank you!

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Eugenia Etkina
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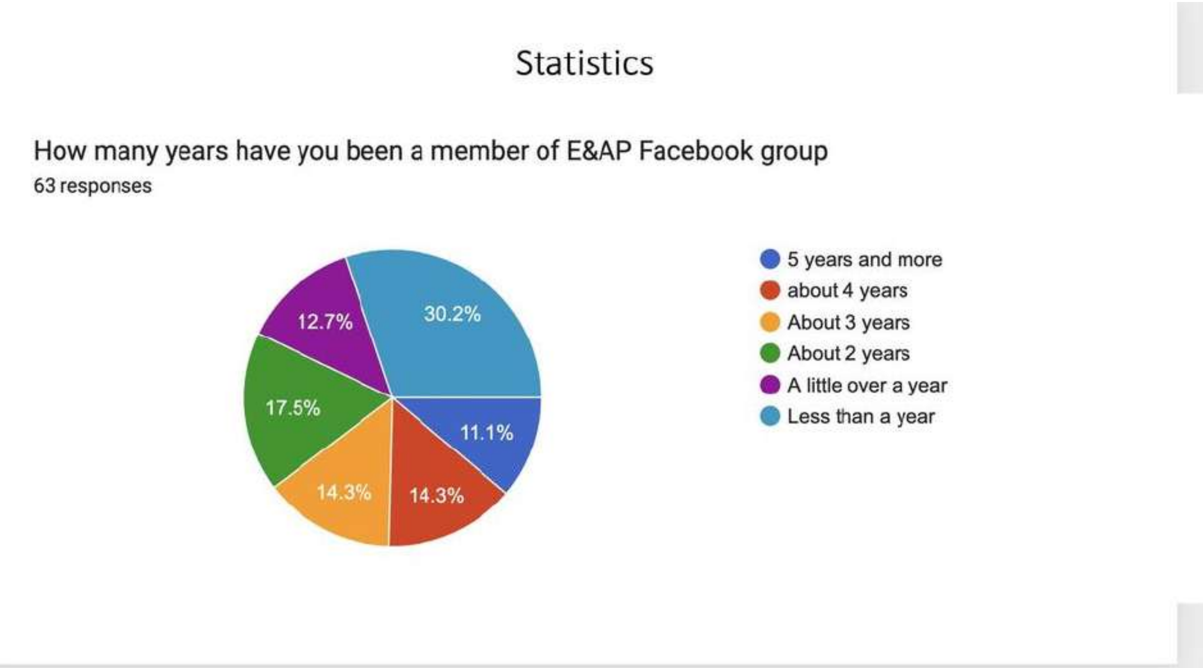
Hi all Exploring and Applying Physics people! I promised to share the results of the survey about the group. I will do it slowly, a few ideas at a time. First, thank you all 63 people who responded (I closed the survey after 2 weeks). Here is some statistics:
Who are we? 43% teach highs school physics, 30% teach AP 1, 2, or C and 24% teach college. (The rest is IB and some other small groups).
How long have people belonged to the group is in the attached slide (over 11% of the respondents have been members for over 5 years!). The countries of the participants are listed below - and this is the list that shows how world-wide we are. Look at it! 22 countries among those 63 people who responded!
USA
Canada
Mexico
Australia
Bali (Indonesia)
Vietnam
Italy
Slovenia
Croatia
Netherlands
Brazil
Ireland
Japan
China
Latvia
South Korea
South Africa
Thailand
Philippines
Sweden
Serbia
Argentina



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Admin
Top contributor
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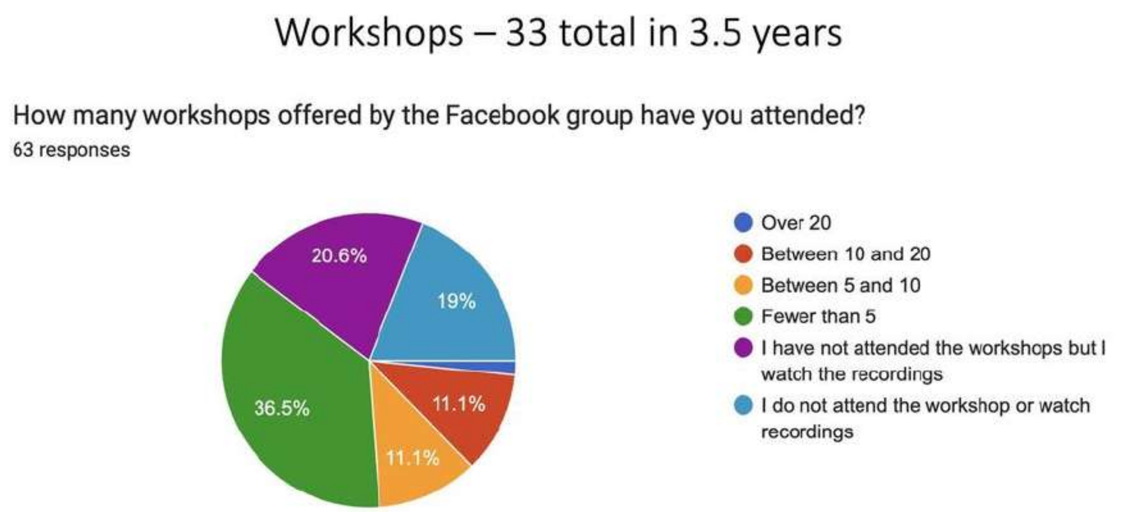
Hi all Exploring and Applying Physics people! Two things today: first I continue with DC circuits and second, I will post another finding from the survey.
Here are two labs that can be done online to help students develop the ideas of electric power. If you are doing flipped classroom approach, the students can do those epxeriments at home and then come to class to discuss their findings. They do these experiments in teams even at home. As you probably already know that I do not support traditional flipped classroom approach when students are assigned to read the textbook before they come to class - please ask me why. But doing experiments at home before they come to class is great! So, it can be a flipped classroom but different. It does not mean that I recommend that the students never read the textbook before coming to class, sometimes it is useful, but it cannot be a regular set-up. So, here are those two lab experiments (note that all of them are published on the scientific abilities website).
OBSERVATIONAL EXPERIMENT
Goal: to figure out what physical quantities affect the brightness of a bulb
Use materials at https://phet.colorado.edu/.../circuit-construction-kit-dc....
Equipment: 2 different lightbulbs, battery, connecting wires, voltmeter, ammeter.
Rubrics for self-assessment: Ability to conduct an observational experiment. Rubrics B5, B7, and B9.
In this activity you will need to use different light bulbs. In the simulation, to make different light bulbs click on the lightbulb and change its resistance. After you have created two

different lightbulbs, connect the two bulbs in series with each other and the battery, and compare their brightness.
a. Devise several explanations for why the brightness of the bulbs is different.
b. Design and implement experiments to test the explanations you came up with. Which explanation couldn't you rule out?
c. Use the explanation that you did not rule out to predict the relative brightness of the same bulbs when you connect them in parallel to the battery (if you have not done this experiment yet in part b.).
d. Explain why incandescent lightbulbs glow when there is current through them. Where does this light energy come from?
TESTING EXPERIMENT
GOAL: TO TEST THE MATHEMATICAL MODEL FOR ELECTRIC POWER
Use materials at https://phet.colorado.edu/.../circuit-construction-kit-dc....
Equipment: 2 different lightbulbs, battery, connecting wires, voltmeter, ammeter.
Rubrics for self-assessment: Ability to conduct a testing experiment. Rubrics C1, C4, C7, and C8.
a. Connect the bulbs in parallel and observe that bulb A is brighter than bulb B. Use your knowledge of electric power to explain this observation, and then predict what you will observe if you connect the bulbs in series to the same battery.
b. Perform the experiment and record the outcome. Did it match your prediction? If not, revise your explanation to account for the outcome.
2. And here is another finding from the survey - how many workshops people have attended! While it is amazing that over 10% of those who responded attended between 10 and 20 workshops, we have 20% who never attended a workshop or watched the recordings. Do you think it is a problem or is it a good small number? And I counted how many workshops we had total - 33!



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Eugenia Etkina
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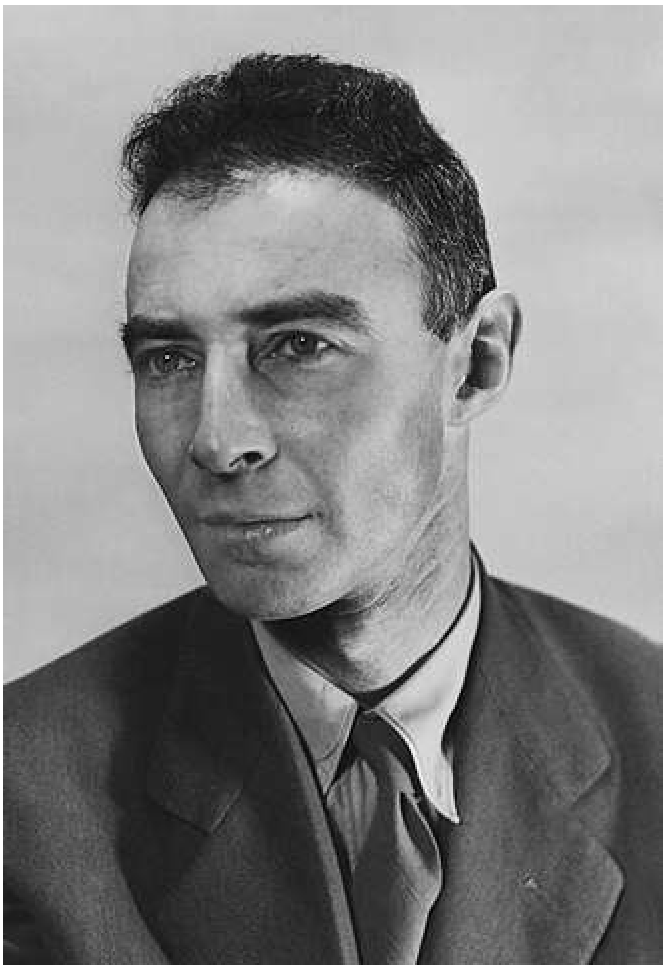
This post is out of order (not DC circuits) but is really important. Today everyone knows what black holes are. In 1978 when I was studying astrophysics it was not the case. I learned the limit of mass - 2.7 solar masses after which a remnant of a Supernova collapses to a black hole, not neutron star in my 300 level stellar astrophysics course. But I never knew who came up with this number. Watching the movie I realized who it was, and it was like, Wow, why didn't I know this before? And this is exactly what this article is about. For all of us. Enjoy!



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Eugenia Etkina
Admin
Top contributor

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Hi all Exploring and Applying Physics people! I continue with DC circuits today. In my previous post for DC circuits (on Friday) I shared activities for the development of the idea of electric power. This idea is very important if we wish to understand why we do not buy incandescent bulbs anymore. The screen shot of our textbook page is an example of an application experiment that the students need to do BEFORE they read the textbook. It is easy to do and the results are amazing. As it is an application experiment, all you need to ask them to do is to design an experiment to compare the power of two bulbs - and they will be very creative doing that. Here is the screen shot:

Power of incandescent lightbulbs and LEDs

In the last few years, LED lightbulbs have almost completely replaced incandescent lightbulbs in our homes. Why? A simple observation can give us a hint. When we touch a bright incandescent lightbulb, it is very hot; however, LED-based bulbs are not hot to touch. Therefore, we can hypothesize that traditional bulbs convert a significant fraction of the electric energy to thermal energy rather than to light, while LEDs convert most of the electric energy delivered to them to light energy. Both light energy and thermal energy leave the bulbs and LEDs through the process of radiation.

We can conduct an experiment to investigate this difference quantitatively using a variable power supply, a small incandescent lightbulb, and a white LED. Both light sources are enclosed in white ping-pong balls to ensure that the light they emit is spread evenly, making it easier to compare their brightness (Figure 19.23a). In order to compare the light sources more objectively, we will use a special device (a light sensor) that measures the brightness of both sources; its sensitivity to light is similar to that of our eyes. We will change the potential difference across the power supply until the light sensor has the same reading for both sources when placed at the surface of the ping-pong ball. (In Figure 19.23a, the LED appears to have a somewhat different color than the bulb, but despite this, their brightness as measured by the sensor is the same). The data collected in the experiment are shown in Figure 19.23b. A pattern is clearly visible from the data: the white LED needs about 10 times less electric power to emit light of the same brightness as an incandescent lightbulb. Thus the old-time incandescent lightbulb must be converting the rest (90%) of the energy into thermal energy or some other form of light that cannot be detected by our eyes. Figure 19.23c shows thermal images for both light sources: the LED is at room temperature and the bulb is much warmer. We will learn in Chapter 28 the mechanism behind the high efficiency of LEDs.

FIGURE 19.23 Comparing energy conversions for an LED versus an incandescent lightbulb.

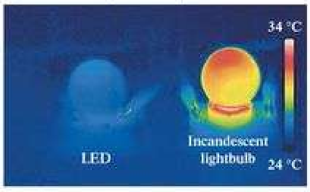
(a) Experimental setup

(b) Table of measurements taken

	LED	Incandescent lightbulb
ΔV (V)	3.1	3.6
I (A)	0.020	0.190
P (W)	0.062	0.680
B (lux)*	450	450

*Brightness of light measured at the surface of the ping-pong ball

(c) Thermal images of the experiment



Paying for electric energy

Electric power companies charge their customers according to the amount of electric potential energy that is converted into other energy forms in the devices that the customer uses. Utility companies do not use the joule. Instead, they use an energy unit called the **kilowatt-hour**. A kilowatt-hour (kW · h) is the electric potential energy that a 1000-W device transforms to other energy forms in a time interval of 1 h ($1\ kW \cdot h = 3.6 \times 10^6\ J$).

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Eugenia Etkina
Admin
Top contributor
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Hi all, I continue with DC circuits. I have been doing it for a while as we agreed to run the Magnetism workshop next, which means skipping DC circuits. That is why I am trying to go over them systematically. Please check my posts over the last 2 weeks to see the progression.
Today is the emf of the battery and its internal resistance. When the internal resistance of the battery is zero, then the emf is equal to the potential difference across it, but when the internal resistance is not zero, the potential difference across the battery is always less than the emf. The larger the current through the battery, the larger the difference between those two.

We have activities in the ALG and OALG for the students to figure out this idea.
Here is the OALG activity that they can do at home before coming to class or in class if you are teaching an online class:
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/.../circuit-construction-kit-dc...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?
e. For help, read and interrogate sub-section “Internal resistance of a battery” on page 594 in the textbook.
And here is a sequence of parallel ALG activities that they can do in class (in a lab). Notice the difference between the ALG and OALG.
19.7.8 DESIGN AN EXPERIMENT
Lab: Equipment per group: 9-V battery, 3 different lightbulbs in holders, connecting wires, ammeter, voltmeter, and/or multimeters, switch.
Working with your group-mates, design an experiment to investigate how potential difference across the 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. Describe the pattern you found. How can you explain it? Think of the emf of the battery and its internal resistance.
19.7.9 POSE YOUR OWN QUESTION
Lab: Equipment per group: whiteboard and markers, several different batteries, resistors, lightbulbs, conducting wires, ammeter, voltmeter.
You have learned that batteries have internal resistance. What questions concerning the internal resistance of a battery can you investigate using available equipment?
a.Collaborate with your group, making a shared list of questions and focus on one of them.
b.Working together, design an experiment to answer the questions.
c.Conduct the experiment and record the results.
d.What did you and your group learn about batteries in this investigation?
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Eugenia Etkina
Admin

Top contributor

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I continue posting about contributions of forgotten women to physics and science. This woman - Hypatia of Alexandria, however, not only made significant contributions to astronomy and physics but also to pedagogy! If you have never heard of her - research. I posted below a few facts that ChatGPT shared with me when I asked about her and more are in the shared article below.

Astronomy:Celestial Mechanics: Hypatia's work on astronomy involves principles that are crucial to physics. Her studies likely included the motion of celestial bodies, an area that directly relates to gravitational theory and mechanics.

Astrolabe: She improved the design and accuracy of the astrolabe, an ancient instrument used to make astronomical measurements, such as the altitudes of celestial bodies. This device was critical for understanding the heavens and contributed to the early development of observational astronomy, which is deeply connected to the physics of celestial motion.

Hydrometer:Hypatia developed an improved hydrometer, an instrument used to measure the density (or specific gravity) of liquids. This device relies on principles of buoyancy and density, which are fundamental concepts in fluid dynamics, a branch of physics.

Philosophical Context:As a Neoplatonist philosopher, Hypatia taught and wrote about the nature of reality and the cosmos, engaging with ideas that overlap with metaphysics and natural philosophy. Her philosophical inquiries would have encompassed discussions on the nature of the physical world and the underlying principles governing it.

Mathematics:Hypatia is credited with contributions to the development of algebra and geometry. She wrote commentaries on the works of Diophantus (considered the "father of algebra") and Apollonius (known for his work on conic sections), making complex mathematical concepts more accessible to students.

Teaching and Influence: Hypatia’s role as an educator and her commentaries on classical texts helped preserve and disseminate scientific knowledge from earlier Greek philosophers and mathematicians, such as Ptolemy, Euclid, and Archimedes. These works include foundational concepts that are essential to the study of physics.

Intellectual Legacy: By mentoring students and engaging in public intellectual life, Hypatia contributed to the continuity of scientific and philosophical thought. Her influence helped shape the intellectual environment of her time, fostering a culture of inquiry and rational thought that underpins the scientific method.

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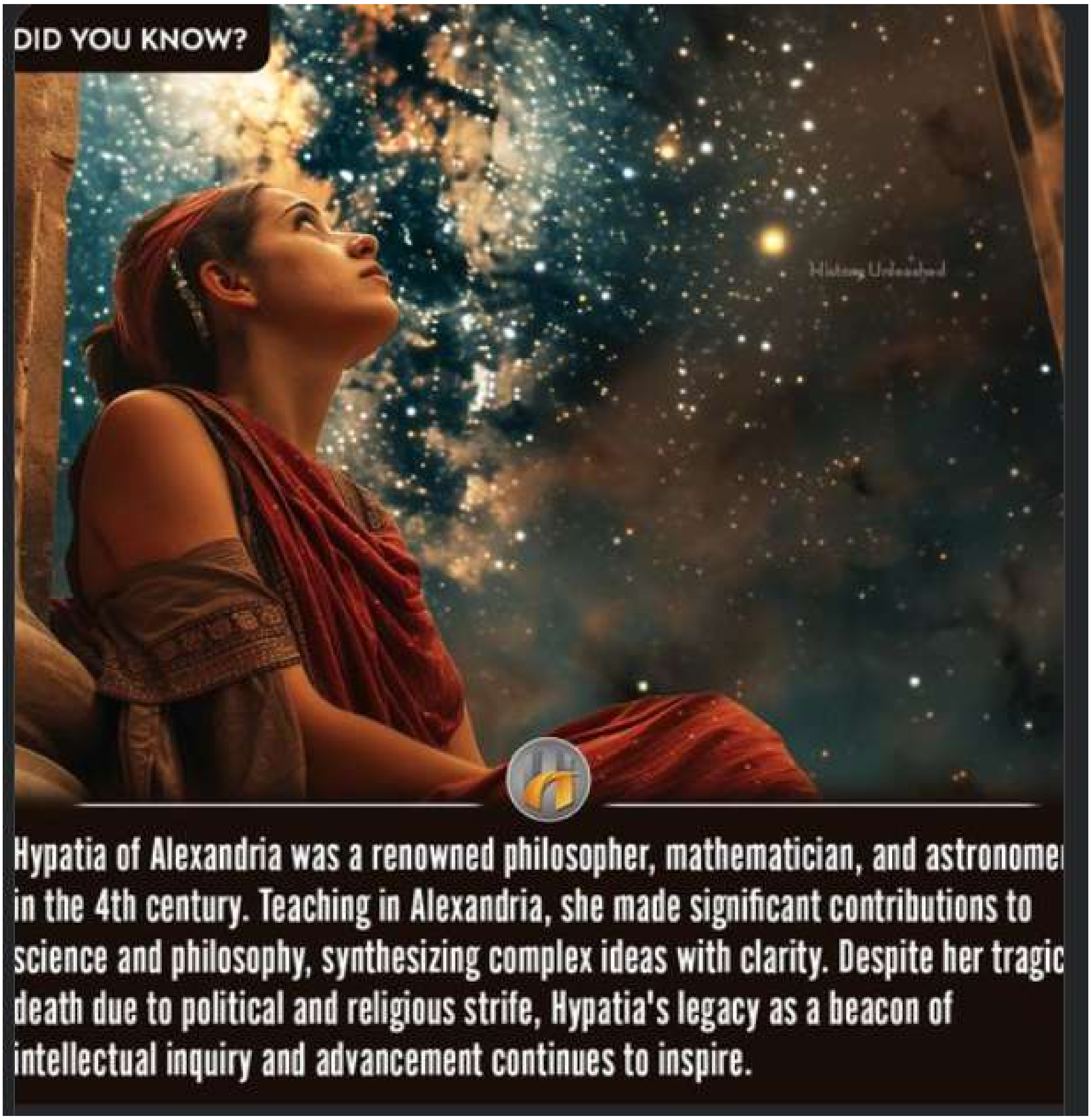

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Eugenia Etkina
Admin
Top contributor
· ·

Hi all, two things today. First I wanted to welcome our new members. We have several people who joined yesterday and today and answering the question why the joined they said that they wanted to learn about reading interrogation technique.
I posted a lot about this technique and we learn it in our introductory ISLE workshop, but as the summer workshop where we do the elaborate interrogation is full is full, let me slowly

introduce the technique here. Especially as we decided not to do the August workshop for the First days of school, but instead focus on Magnetism.
So, from tomorrow on I will systematically post what to do as the new school year starts (if you are going to implement the ISLE approach) and will focus in detail on the elaborative interrogation - a technique that teaches our students how to read scientific text.
What is important though, is that this technique is not an isolated thing, the same ways as none of our activities is an isolated thing. They all work together to help our students learn to think like physicists and there is much more to this then learning to read the text.
Or, better that, one cannot really learn how to read scientific text until they understand how physics works - epistemologically. Epistemology is the study of the elements of knowledge and how knowledge comes to be. Traditional physics teaching that is focused on students solving problems and doing cook-book experiments does not help them learn the epistemology of physics and that is why (one of the reasons) they do not know how to read scientific texts.
Well, I said enough - welcome our new members! To learn what the group is about please visit islephysics.net and read the material under every tab there, especially where there is information about the resources that we have and the textbook that follows the method.
Hmm, what was that other thing that i wanted to talk about? Oh, the date for the workshop on Magnetism. I can do it August 10 or August 24. What is your preference? Please comment! I will post the poll later, but I want to see how many people are interested in attending.
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Eugenia Etkina
Admin
Top contributor
· ·

Hi @everyone! I am starting a series of posts (a long series!) for the beginning of the school year. Consider this an asynchronous workshop. Instead of attending a 2-hour workshop on a specific day, you will need to read the posts and do the work. Your responses are very important - please post them in the comments AFTER you do the reading.
While the students will be doing various activities that I will describe, it is important that the teacher sees a big picture behind all those activities and understands why the materials are the way they are. Therefore, I will start by asking you to read the introductory chapter of the Instructor Guide. It describes how the whole system works together and lists learning goals common for ALL topics. Content specific goals are in every chapter. After you finish reading the chapter, please put your questions in the comments and I will answer every one of them.
I will make posts every other day, not every day so that you have time to do the readings and process new ideas. What do you think of this approach?
Here is the chapter to read, it is the introductory chapter of the Instructor Guide which is posted here in the FILES.
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Eugenia Etkina
Admin
Top contributor
 · ·
Hi all, no new post today as I am giving you time to work through the Introduction to the Instructor Guide posted yesterday. Joseph Wachs commented that he could access links to the scientific abilities website though the links in the document. Did you have the same issue? If you did, this website does not require any special access, you can find everything here: https://sites.google.com/.../scientificabili.../introduction Explore all the tabs and you will find lots of useful stuff! I will have a new post preparing for the upcoming school year tomorrow.
https://www.facebook.com/groups/320431092109343/posts/1631625244323248/?__cft__[0]=AZWlsY44EANrl1oQo2obOFQk2YR9TEnNgggIXiN1SUWFfrJuAEK9AwjfaJOG26KhUGFSD7Wr1E1JbPrPeUkXN3D96fWkT5EVEdmTgbVqUhb13TLvJiLf6spRp2LSk6F7bf0fPcuy7-cZs7ehNeDVvk5lZMSGqGgOlyzd6_uUBFzWPV0CEVMGM9T9GXWmTSWcjPrtjGXOTmZJc6ap4vkJS1OC&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin
Top contributor
 · ·
Hi @everyone, this is my second post about starting the school year with the ISLE approach. The first post was the Introductory chapter in the Instructor Guide to help you see what the approach is about, what is important, what the everyday goals are (same goals for every day!), and so forth. Today's post is about preparing your classroom and your mind for the kind of work that the students will be doing. Please read this post AFTER you have read the Introduction to the Instructor Guide posted the day before yesterday. It is really really important that you go in order and ask questions about every post. So far I got only one question for the IG. Hope this post will inspire more. I am putting the text here and attach the document with THE FIGURES. The photos were taken by Gorazd Planinsic in the classrooms at the university of Ljubljana. Please post your classroom photos after you read this post.
Here is the long text about important things to know and do to help your students learn physics through the ISLE approach.
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-style seating with the stage in the front, or a room with tables for 3-4 people with small whiteboards and markers on each table with no center stage? See the difference in figure 1. THIS FIGURE IS IN THE ATTACHED DOCUMENT

(a) (b)
Figure 1. (a) interactive engagement classroom; (b) traditional classroom
These settings send completely different messages to the students. The students see what is expected of them – either to watch the person on the stage or to work themselves. As the ISLE approach assumes the latter, the first routine is clear – to set up your classroom in a

way that sends a clear message to the students that learning physics is a collaborative enterprise with them at the center.

Our routine is to first set up the whiteboards. As they last for many years with good care, there is a good chance that you will only need to do this once. Here are a few suggestions:

Size: We recommend the size of approximately 50 cm x 70 cm or larger, depending on the size of the desks where your students are working. Figure 6.2 shows a simple solution, where we used a 50 cm x 70 cm whiteboard and combined two traditional school desks to make a table for a group of four students.

Material: The most important thing is that the white surface is really smooth. If you can't find panels with a suitably smooth surface, you can buy untreated panels and cover them with smooth white self-adhesive wallpaper.

Care: Insist that students clean the whiteboards after each lesson. Ink left on the boards for several days is difficult to remove. You can use a mild detergent solution or water for daily cleaning, but occasionally you will need to clean the boards with alcohol.

In addition to whiteboards, you need different color dry erase markers, an eraser or some cloth (old rags work best), and a cleaning solution for each group.

THIS FIGURE IS IN THE ATTACHED DOCUMENT

Figure 2. A whiteboard for group work and a set of colored markers.

The next step is to organize 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. It is even better if some of your students and pre-service teachers come early too and help you do this. This way, the setting up becomes a routine for them that they will replicate in their own classrooms.

The next step is to put any 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 so that the contributions of each member are clear. How do you form 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 of 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 an optimal number for all students to participate. Four is still ok, but one person might not participate. Starting with 5 members, only a few of them participate. 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 this later). With the possibility of a large variability in the group member’s preparation, we found it useful to have groups of mixed ability. Thus, as you get to know your students, try to organize the students so that the groups in each course meeting have students who are high achieving, medium achieving, 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. However, random group assignments work too if you change the groups often.

Working in groups is important in the ISLE approach. Do you remember the two intentionalities of the ISLE approach? The first is to help students learn physics by constructing knowledge that follows the processes that mirror those of practicing physicists. The second is to help students 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 community, belonging, and extend students' zone of proximal development. The problem is that not all groups are functional. What does it mean to have a functional group? A functional group is a group where 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) 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. Such hedging opens space for other members of the group to contribute. 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.

As everything else, working in a group is a skill that needs to be learned. Using hedging in your own speech to model desired behavior of your students is the first step. The next step is openly talking to your students about what makes groups effective – this knowledge will serve them long after they finish the physics class. Sharing with the students that being socially aware of other people in the group, making sure that everyone has a chance to speak, and understanding that everyone’s contributions are important is crucial for productive collaboration. People have different strengths and building on these different strengths is what makes the intellectual value of a group much higher than the sum of intellectual values of its members. When students work in groups, it is helpful to stand behind a group and listen to the tone of their conversations and watching if all members have a chance to speak and if they are trying to hedge. If you notice a problem, either talk to the whole group (“I noticed that not everyone has a chance to speak in your group, please make sure that everyone does”), or asking the most dominant group members to meet you outside of class and talk to them separately about the importance of being aware of other people in the group (“Why do you think we hedge when we make statements? Why do you think listening to other people might help you learn more?”).

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 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.

(a) (b)

Figure 1. (a) interactive engagement classroom; (b) traditional classroom

Figure 2. A whiteboard for group work and a set of colored markers.

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Eugenia Etkina
Admin
Top contributor
· ·

Hi all Exploring and Applying Physics people. I continue the series of posts for the beginning of the school year using the ISLE approach. You need ot read my two previous posts before you read this one.

THE GOAL OF THE FIRST DAY OF CLASS IN THE ISLE ENVIRONMENT IS TO ENGAGE THE STUDENTS IN THE PROCESSES THAT THEY WILL FOLLOW FOR THE REST OF THE YEAR. THESE ACTIVITIES NEED TO BE NON-THREATENING BUT AT THE SAME TIME HELP THE STUDENTS SEE THE LOGICAL PROGRESSION OF THE EXPERIMENTS AND REASONING THAT SHOULD EVENTUALLY BECOME HABITUAL FOR THEM. AT THE BEGINNING, SET THE CLASSROOM AS IT IS DESCRIBED IN MY PREVIOUS POST, LET THE STUDENTS CHOOSE THEIR GROUPS ANY WAY THEY WISH AND THEN TELL THEM THAT YOU ARE GOING TO PLAY A GAME: A MAKE-

BELIEVE GAME. I HAVE NO IDEA WHY FACEBOOK DECIDED TO CAPITALIZE THIS TEXT, BUT I THINK IT WORKS.

Imagine you come into my home and you see lots of tennis rackets. More than 10. What will you be thinking looking at those rackets? The students might say: "Why are you having all those rackets?" You say: “This is a great physics question. When you saw the rackets, how did you know that they were rackets? You have an instrument that is sensitive to them – your eyes, and you also have seen tennis rackets before. So, you conducted an accidental observational experiment. When you asked why I have all those rackets, you are trying to explain why I have them. This is the step in physics when you start constructing explanations, or hypotheses. Why can I possibly have all those rackets? In your groups, come up with at least three wild ideas explaining why I have those rackets. Let’s try with an example together. What do you think?”

The students might say that I am a tennis rackets collector. “Great”, I say: “Are there more? Put your wild ideas on the whiteboards. I give you 3 minutes for this.”

The students start talking and working and their ideas appear on the boards: I have many children. Many other people live in the house. I steal tennis rackets. I repair them. I say: “Now lift the boards and see what you came up with. There are so many explanations for the same observational experiment! Which one is correct? Should we vote? Of course not! What should we do next?” The students might say: “We just ask you.” I say: “OK, go ahead, ask me.” They say: Why do you have all those rackets?” I respond: “I am a skabenga.” WHAT??? They look at me: “What did you just say?” I repeat that I am a skabenga (this is actually a zulu word for a thief but they do not speak this language). They look puzzled. "What do you mean?" I say: “I answered your question but you cannot interpret my answer as you were not prepared for what would happen, you do not have an instrument to interpret the sound that I made. It was because your request for a new experiment – and it was an experiment to ask me - was not based on any of the hypotheses that you made and you did not expect me to answer in a foreign language. You do not have equipment to understand the outcome of the experiment. What does it mean? It means that once you have a hypothesis, you need to design a new experiment, called a testing experiment, whose outcome you can predict in advance using your hypothesis. This way, you also prepare the equipment to help you interpret the outcome as you know what it should happen IF YOUR HYPOTHESIS IS CORRECT. So, now, please go back to your boards and think of what testing experiments you can design and what equipment you need to interpret predicted outcomes, which should appear if your hypothesis is correct.”

The students go back to the boards and devise experiments. For example, if the hypothesis is that I have many children, and they go into the house and look for shoes, then they should find pairs of shoes of different sizes. Or clothes. But if the hypothesis is that I am a thief, then they do not expect to find any shoes, but they also do not expect to find any receipts for the rackets. And, they come into the house and do not find receipts. Does it prove that I am a thief? It does not disprove it but it does not prove anything as I could have been buying rackets online or have lots the receipts. However, if they do find the receipts, they can rule out the hypothesis that I am a thief. Also, to do this experiment, they need to know what the receipts actually look like to know that they found them. This shows that disporive something is much easier than proving.

We can continue this game for a few more rounds, but I think the point is clear. The testing experiments are different from observational experiments. Hypotheses are different from data. Observational experiments do not require any predictions, testing experiments require a prior hypothesis that explains some other experiment and a prediction of the outcome based on this hypothesis, not your intuition.

The point here is that the game is not scary, everyone is successful, and it is fun. The next step is another game, now, with more physics in it. It is described in the attached document and in the ALG/ OALG Chapter 1. Please read the attached document. These two activities can be done in 45 minutes and at the end the teacher shares the slide with the logical progression of experiments and reasoning that the students went through twice. It is in the Introduction for the Instructor Guide that you read 4 days ago. I will post a colorful slide tomorrow for you to download.
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Eugenia Etkina
Admin
Top contributor
· ·
Hi all, I posted a detailed description of the first day in an ISLE class and there are two issues with it. First, relatively few people saw it and only two people commented. Thank you Stephanie Hunt and Joseph Wachs! But we need more, right?
But the second issue is that nobody asked me a question that I was expecting. The question that should sound like this: This is the first day of class, we should talk about the rules not play games with the students. We should talk about the syllabus and requirements of the course. Why are you not talking about it?
Exactly, WHY AM I NOT TALKING ABOUT ANY OF THIS ON THE FIRST DAY OF CLASS? Your responses to this question will be greatly appreciated. Please write!
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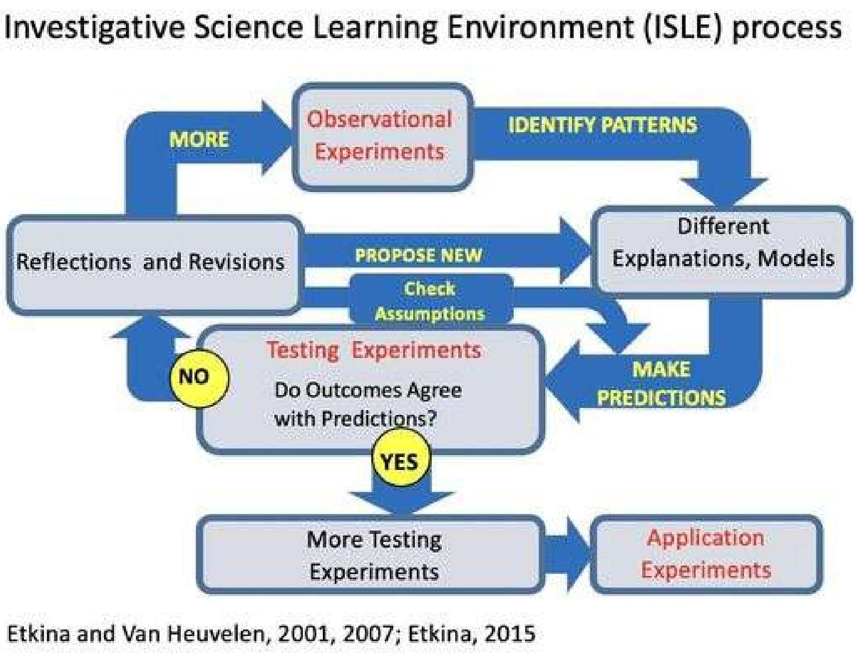
Eugenia Etkina
Admin
Top contributor
· ·
Hi all Exploring and Applying Physics people! Thank you so much for responding to my post of June 4th. I did not post anything yesterday as I was all day at a conference where I presented a talk about our community - remember the survey you filled out? After my talk we got lots of new members, I will welcome them tomorrow as today I wanted to continue with my post of June 3rd. On June 4th I asked why describing the first day of class in the ISLE approach I did not mention anything about the syllabus or the rules. We got a TON of excellent responses to that questions. Thank you, Stephanie Hunt, Joseph Wachs, James Kerr, Cynthia Hardesty, Martina Bach, Gopa Mukherjee, Dimitri Kaviani, and Joanne Aronson for contributing your ideas! All of them are absolutely correct and infinitely precious!

I strongly recommend those who missed the comments on June 4th to scroll down and read them. Today, I will add my thoughts to them.
Here they are:
Once the students play the ten rackets (or 12 cameras, or 10 bicycles game, whatever you chose) and a wet glass game (or why a balloon makes a loud sound game - see the ALG/OALG Chapter 1 posted here in the FILES) you bring them back together and ask them to reflect on the steps they took to figure out why the glass was wet (or the balloon made a loud popping sound). After the discussion you bring up the ISLE diagram (posted here) and go over what they said connecting their words to the elements of the diagram. Then you tell them that this is how physicists construct new knowledge and, as they (your students) are all physicists now, they will construct knowledge the same way. [I would make a posted of this diagram, laminate it and put it on every desk in your classroom.]
"But", you say, "there is more to physics than this poster. How did you figure out why the glass was wet? You worked together, right? And you shared your ideas with your group and the rest of the class - this is again, how physicists work - they collaborate! So, in this class you will always work together and help each other learn. Every person's mind and experience will help all of us to learn (myself included!)
There is another important thing I want to tell you (you continue). In this class I do not give grades. You "TAKE" grades. It is your decision what grade to take. I assume that everyone wants to have an A at the end. I will help you earn this A or "TAKE" this A as long as you are willing to work. First work in class as a good partner and member of the community. Second, work at home. Every assignment, be it lab report, or a quiz, or a text can be improved after you learned more. This is also how physicists work. Let's say I write a paper about my work and I send it to a journal. The editor send it to reviewers- the experts in my field who will decide whether my paper is good enough to be published. The reviewers find mistake or omissions in my paper and the journal editors sends it back to me to revise and improve. I work on it again and they review it again. If they are satisfied, the paper get published. The value of the paper is not diminished by the number of revisions I did - only the final quality matters. As long as you are willing to work to learn, I am willing to give you feedback and help. So, it is your choice! Here is the syllabus with the stuff will be working on and activities you will engage in and what work you need to do. Read it at home and come up with three questions as your homework."
In the syllabus, by the way, there are no behavior rules. I do not tell my students what will happen if they are late to class, misbehave, break equipment, or cheat. I do not tell them what will happen as I do not expect them to do any of this. But if any of this happens (it might, I live in a real world), then, and only then, I will bring it up with the class and ask them to make the rules. The same way as we create "the need to know" before starting every new concept, the behavioral stuff needs to come on the basis of the "need to know". Honestly, in my teaching life of 40 years it almost never came up. And I taught students of all ages - from 12 to 17 in middle school and high school and from 19 to 55 in college. I think it almost never came up as I expected my students to want to learn and communicated this expectation to them, I kept them busy and engaged, and showed them again and again that I cared (as you all do!) And if they lied to me, I would not have known as I believed them. I understand that it is a controversial position and it might not work for everyone but I am putting it out here so that you know who I am (you probably already do anyway .
Here is the ISLE process picture. I wanted to add that the first graphical representation of the process was done by David Brookes a long time ago and the present picture was done by Gorazd Planinsic.



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Top contributor
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Hi all, today is a welcome post for our new members. Many joined recently - the list is below and I wanted to remind these new members of our community that this group is for those who are using or interested in using the Investigative Science Learning Environment approach to learning and teaching physics (ISLE).
ISLE (see more at https://www.islephysics.net/) is an intentional curriculum approach. There are two major intentionalities of ISLE: students learn physics by practicing it and students' well being is enhanced in the process. Intentionality means that no matter what happens in the classroom - a lesson, a lab, a problem solving session, an individual conversation with a student, these two principles need to guide our decisions and actions.
Here, in the group we share strategies, activities, approaches and issues that help all of us implement ISLE. Lots of free curriculum materials are posted here in the FILES and on the ISLE website (see above). The textbook for general physics that uses the ISLE approach is called College Physics: Explore and Apply. The word College here means that it is algebra based, not calculus based.
To benefit from the group, try to check the posts as often as you can and like or comment on them to make the new post come to your feed and the make the present post visible for

more group members. Please ask questions and share your experience implementing ISLE. Welcome to our community!
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Eugenia Etkina
Admin
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Hi @everyone! I continue with the first days of school when you are using the ISLE approach. See my previous posts if you were not following or joined after I had started. We discussed two introductory activities - the tennis rackets and the wet glass. There is a third activity in the ALG/OALG that is fun and if you have time or this is the second year with the same students (AP1 and 2) or you do not like the wet glass activity, it is perfect for the first day. It is more complicated as the correct explanation is the combination of two that the students will devise, so you will need to be careful. Note, that I posted first the text for the students who learn online. For those who teach in person, the students wll need to propose and do the experiments, not watch the videos of course. I posted this version so that you can see what the experiments look like. After that I posted the ALG text of the activity - this is what you need to use when you are teaching in person.
I am also pasting the text and also the NEXT very important activity that the students need to do if you have the textbook. If not, the poster with the ISLE process elements will serve the same purpose. I posted it two days ago. Please download and save. The second activity today is necessary to prepare your students for learning how to interrogate the text. Do not skip it!
Here we go:
OALG 1.1.3 OBSERVE, EXPLAIN AND TEST YOUR IDEAS
Equipment: air balloons, needle, additional materials to test your ideas.
For this experiment you will need an air balloon and a sharp needle. If you have a balloon, inflate it and then pop the balloon using the needle. If you do not have the balloon, watch the video https://mediaplayer.pearsoncmg.com/.../sci-OALG-1-1-3a
a. Describe what happened when you popped the balloon (or when the person in the video popped the balloon).
b. What makes the sound so loud? Think of several explanations using only simple words.
c. Elana and Rob proposed the following explanations: Elana said that the air escaping the balloon made the loud sound and Rob said that the breaking rubber of the balloon made the loud sound. Did you come up with similar explanations? How can you test them? Describe the experiments that you would like to conduct.
Elana and Rob came up with the following testing experiments. Predict their outcomes (specifically, whether you will hear the loud sound) using each explanation that they devised separately (what does the air hypothesis predict? What does the rubber hypothesis predict?):
1. Fill the balloon with water and pop it with the needle.
2. Take a plastic bag, inflate it and pop it with the needle.
3. Take a piece of rubber from the first popped balloon, stretch it and pop it with the needle.

d. Watch the experiments (TE1: https://mediaplayer.pearsoncmg.com/.../sci-OALG-1-1-3b, TE2: https://mediaplayer.pearsoncmg.com/.../sci-OALG-1-1-3c, TE3: https://mediaplayer.pearsoncmg.com/.../sci-OALG-1-1-3d) and compare the outcomes with the predictions. What are your judgments of Elana's and Rob's explanations for the causes of the loud sound of the popped balloon?
e. After Elana and Rob examined the original popped balloon they realized that they missed a piece of evidence. Below is the photo of the original popped balloon.
They saw that it exploded into a few separate pieces (not one piece with a small hole). Now, they came up with a new explanation: it is not just the air or just the rubber that makes the loud sound, but the rapid expansion of air through large opening that appears in the balloon due to the elastic rubber. How can they test this new explanation? They propose to take an inflated plastic bag and hit it with a palm so that the plastic bag suddenly tears. If their improved explanation is correct, it should produce a much louder sound than the bag that was just poked with the needle. Watch the video of the experiment https://mediaplayer.pearsoncmg.com/.../sci-OALG-1-1-3e and compare the outcome to the prediction. With this new evidence, what is your new judgement as to which explanation best explains the loud sound of a popped balloon?
SEAME ACTIVITY FOR TEACHING IN PERSON:
1.1.3 POPPING THE BALLOON
Class:Equipment per class: rubber balloons, needle, plastic bags (thin plastic bags for vegetables and fruits work best), access to water (tap), bucket for catching water. Optional: small embroidery hoop (about 12 cm diameter)
A teacher is holding a fully inflated balloon. The teacher asks the students to observe carefully while she pops the balloon using a needle.
a. Describe what happened when the teacher popped the balloon.
b. What makes the sound so loud? Work in your groups to propose several explanations using only simple words.
c. Propose testing experiments that you can run to test the proposed explanations. Try to propose as many as you can.
d. For each testing experiment, make prediction for its outcome based on each explanation that you proposed in b. Indicate any assumptions that you made when making predictions. (Note: The best testing experiments are those that give different predictions for different explanations).
d. Perform testing experiments that you proposed in b. (if necessary, ask teacher for additional equipment).
e. Compare the outcomes of the testing experiments with the predictions that you made in c. What can you say about the explanations under test now? Can you reject or revise some explanations? Do not forget to include the assumptions when making any judgements. Can you verify some assumptions?
This is the activity to slowly get your students to interrogate scientific texts. It is only present in the OALG.
OALG 1.1.4 Represent and reason
a. Examine Figure 1.3 in the textbook and match the elements of reasoning to the steps you took to figure out answers to each of the activities above. Specifically:
What were the observational experiments?
Patterns? Hypotheses (explanations)?
Testing experiments? Predictions?
Outcomes?
How did you arrive at a judgment?
Were there any application experiments?

b. After you identify the elements, read Section 1.1 in Chapter 1 in the textbook and compare your answers to the answers to the tennis racket activity in the text.
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Hi all Exploring and Applying Physics people! I continue with my posts for the beginning of the school year. Once the students do the tennis rackets activity, the wet glass activity, and the activity identifying ISLE elements in both (SEE MY PREVIOUS POSTS), the next step for them is to identify elements of scientific practice in a new context. This activity is in the OALG only and not in the ALG (download chapter 1 here in the FILES). Please read it carefully and match the sentences with the elements of the ISLE process. This activity is the preparation for learning how to interrogate scientific text.
OALG 1.1.5 IDENTIFYING THE ELEMENTS OF A 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 on 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 the 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 a prediction of the outcome of the testing experiment
Making assumptions
Describing the outcome of the testing experiment
Making a 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.
Please like the post or comment on it to make it more visible for other group members.
Thank you.

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Eugenia Etkina
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Hi @everyone! I continue posting about the first week of class with ISLE but I am seeing that the number of people who view the posts is decreasing despite the fact that the number of members in the group is increasing. I am afraid that it is because few people like or comment the posts and this makes posts not visible for more members. Thus I am asking you for help - please like or comment.
Yesterday I posted an activity where students have to identify ISLE elements in a scientific text. But what do these elements mean? I am posting the definitions of the most common ISLE terms that the students will encounter during the year. As always the rule is to introduce the word only AFTER the students have experience with the concept and have and image of it. See The introduction to the Instructor Guide that I posted a week ago. This treatment of new words is one of the most important aspects of ISLE.
Shared language in the ISLE approach
by Eugenia Etkina and David Brookes
Observational experiment is an experiment where you investigate a phenomenon by collecting qualitative or quantitative data without specific expectations of the outcome. No predictions are made of the outcome of an observational experiment. We can call observational experiments “hypotheses generating experiments”.
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 the reasons for something that 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 sum of the forces 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. A hypothesis can be disproved by a series of testing experiments (see below). It can turn out to be wrong.
Model is a simplified version of an object, a system, a phenomenon or a process. A scientist creating the model decides what features to neglect. A particle model of an object neglects its size, a model of ideal gas neglects the sizes of its particles and the interactions at a distance between them, a model of a free fall neglects interactions of falling objects with air, a model of energy constancy of an isolated system neglects interactions of this system with the environment. Models can be conceptual or mathematical. In a way explanations, models, and hypothesis all belong to the same group of concepts – mental constructions describing or explaining physical phenomena. In many cases the terms models/hypotheses/explanations are synonyms.
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.
Testing experiment is an experiment whose outcome you should be able to predict using the hypothesis being tested. We can call these experiments “hypotheses testing experiments”. A testing experiment test 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).
Here an important note is in order: A hypothesis can be disproved by a series of testing experiments. It can turn out to be wrong. A prediction, however, is only wrong when it does not follow from the hypothesis being tested. If the outcome of the testing experiment does not match the prediction, it does not mean that the prediction is wrong. It only means that the hypothesis on which the prediction was based is wrong or some assumptions were overlooked. In this case the prediction is said not to match the outcome of the testing experiment.
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.
Application experiment is an experiment with the goal of solving a practical problem or determining the value of some physical quantity using the relations/models that have not been disproved by multiple testing experiments. We can call application experiments “Multiple hypothesis applying experiments”.
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. Interactions of the environment objects with the system cannot be neglected. External objects exert forces on the system, do work on the system, exert impulse and so forth. Internal objects cannot do any of these things.
The terms below were already defined in chapter 4, but we are repeating them here so that you have them al together.
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.
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, s 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, 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).

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Eugenia Etkina
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Hi all, thank you so much for responding to my request yesterday. Your "likes" and comments made it 3 times more visible than the previous posts. THANK YOU!
I completely understand that many of you are still teaching and do not have time/energy to process the long posts that I make. But downloading them in the logical progression does not take much time. If you do it - you will be able to review them when you have the time. The first post about starting the next school year was on May 30th, so you can go from there. I am not posting anything new today to give you time to download the posts and maybe read and post questions.
Tomorrow I will start a series about teaching students to read science texts. Some think that students do not need to read the textbook if we engage them in active learning (which ISLE does, of course). But this is a mistake in my opinion. A skill of reading and processing scientific text is vitally important for the success in the future (as well as our duties as citizens). Therefore, it is our responsibility to help our students read scientific texts and learn from them. This reading is very different from reading fiction and if we do not teach our students how to do it, they will not learn which happens to them now. So, tomorrow, it HOW TO HELP OUR STUDENTS LEARN TO READ SCIENTIFIC TEXTS. Stay tuned! And please like or comment Thank you!

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Eugenia Etkina
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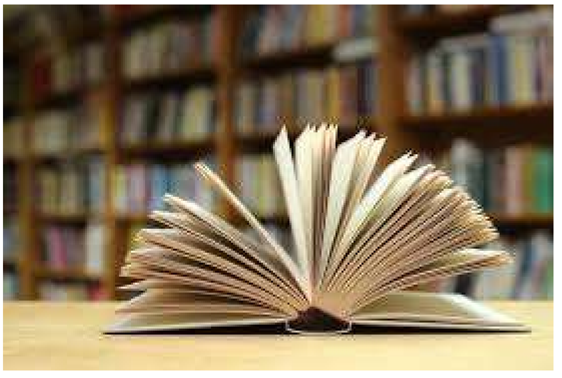
Hi all Exploring and Applying Physics people! Thank you for responding to my please to "like" or comment on the posts. This is making posts much more visible. Please do not stop! Today I start a series of 3 posts concerning reading. Textbook reading. Please be patient and save all three posts. I do not want to make one long post as if you miss it, then it is hard ot find. So, here is the start:
As we discussed above, one of the goals of the ISLE approach is to help students experience learning physics similar to how physicists construct knowledge. A crucial part of functioning as a physicist or any scientist is reading scientific texts. Although evidence suggests that the ability to effectively read science texts is important, students enrolled in STEM courses do not regularly read science texts (Podolefsky and Finkelstein 2006). In one survey of life science and engineering majors (Stelzer et al. 2009), the researchers found that 70 percent of students never or rarely read texts. A study of students enrolled in introductory physics courses found that while 97 percent of the students report buying the text, fewer than 40 percent of those students regularly read it. Studies in other content areas have yielded similar results, finding that less than 30 percent of students regularly complete reading assignments. This lack of consistent reading can be detrimental not only to the students' learning in school, but also to their success out of school.
Why don't students read the textbook even if they spent money on it? We can see three reasons here. The first one is the textbooks are written in a way that does not help students learn. The second one is that the students do not know how to READ textbooks. They usually approach a textbook as they approach fiction, thinking that just by reading a sentence after a sentence they can learn new ideas and solve problems. But reading is just one part of the brain learning cycle (Kolb 1984 and Zull 2002). According to brain research, the learning process starts with sensory input. It then proceeds to the reflection of this input and the subsequent formulation of a hypothesis that explains the input by connecting it to existing knowledge. Finally, the hypothesis explaining the input needs to be tested through the engagement of the learner in active testing of the hypothesis which involves motor functions (it can be talking, writing, performing an experiment, etc.). Based on this process, reading involves sensory input. However, if after this input the reader does not reflect on the read sentence and does not try to place it in the set of knowledge that they already possess by making connections, does not hypothesize what this read sentence or paragraph can mean, and does not talk to other people about it, or write it, then the read information does not become "knowledge" or "understanding". Therefore, if we wish the students to learn something from reading the textbook, they need to learn to go through the above processes. The third reason for the students not reading textbooks might lie in the use of internet and social media. Research points to the reduced attention span and inability to concentrate of those who spend a lot of time on online social networks (Paul et al. 2012). To benefit from textbook reading, one needs to invest significant time and mental energy. The lack of this time and inability to focus on the same content for a prolonged time might also contribute to the lack of textbook reading. However, this reason might not be that important as even before the expansion of social media our students did not read textbooks much.
To help students develop abilities to comprehend and think critically about their reading, we need to teach them to read scientific text the same way we teach them how to design experiments, collect and analyze data, solve problems, etc.

How do we do it? See my post tomorrow. Thank you for reading, you know what to do next.



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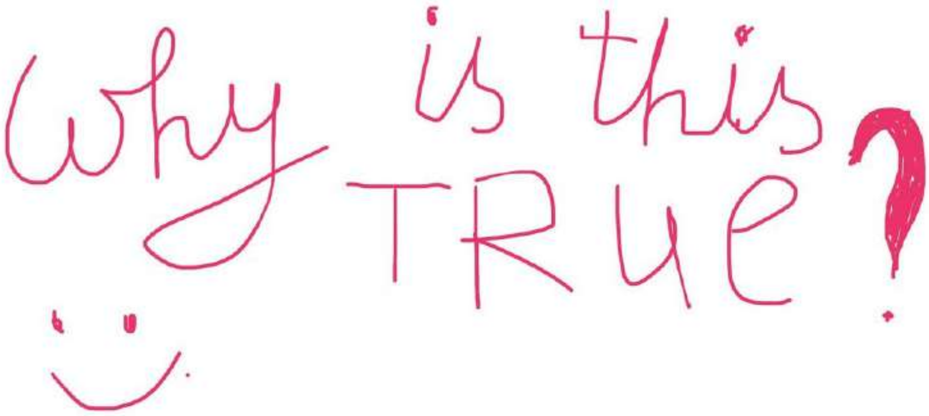
Hi all Exploring and Applying Physics people! Yesterday (June 13) I started a series of posts about teaching students to read scientific texts. Thank you all for commenting on the post. Your comments indicated how important this part of our teaching is and how it is currently missing from our work. Today is my next post. Will not post anything tomorrow to let everyone catch up.
Here is goes:
To help students develop abilities to comprehend and think critically about their reading, we need to teach them to read scientific text the same way we teach them how to design experiments, collect and analyze data, solve problems, etc. One method that was found effective to achieve this goal is called Elaborative Interrogation (Smith et al. 2009). Elaborative interrogation is a reading strategy in which students are prompted to read the text and then answer a “Why is this true?” question based on the reading. The results of interrogation studies are encouraging, as the method shows increased comprehension over more traditional comprehension techniques such as rereading. Two studies examined the reason for the effectiveness of this method and both came to a similar conclusion. The “Why” questions help focus students’ attention on the relevant information within the text, which reduces the cognitive load of irrelevant information. But the reduction of cognitive load is not the only benefit of the Elaborative Interrogation approach. If you think of what is happening in our brain when we ask ourselves “Why is this true?”, you will see that the steps resemble Kolb’s learning cycle. To answer this question, the reader needs to first think of what this “this” is – reflective observation. Then they need to figure out how this new piece of information relates to what they already know to answer the question why this is true – making a hypothesis. Finally, if the assignment requires the student to write an answer to the question as a part of the homework assignment or class activity, then they engage in active testing as motor function is involved.
While it might seem that Elaborative Interrogation is just another technique that we, as teachers, need to learn, in fact, there is nothing new to it. All experts, when reading scientific papers, interrogate them. They ask themselves the following questions: How do the authors know this? What is the evidence? What is the uncertainty in the evidence? How does this new idea fit into my previous knowledge? How can we test this new idea? And so forth (to ask these questions a student must know how scientific knowledge is constructed - thus the ISLE process). These are interrogation questions and when we ask them, we go through the Kolb’s cycle again and again (read about Kolb's cycle in the post form June 13). How can we teach our students to do the same? See my post on Sunday to answer this question.
If you finished reading the post, PLEASE CLICK LIKE OR COMMENT ON IT TO MAKE IT MORE VISIBLE FOR OUR GROUP MEMBERS AND TO ENSURE THAT THE NEXT POST COMES INTO YOUR FEED. THANK YOU.



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Eugenia Etkina
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Hi all, today is the WELCOME NEW MEMBER POST! I will continue with reading interrogation tomorrow as promised.
Dear new members! Welcome to our community - a community of physics teachers of all levels who are implementing or learning to implement the Investigative Science Learning Environment approach to learning and teaching physics (see islephysics.net to learn about ISLE and all the resources that we offer). Here, please check the files here as there is a ton of resources of all kinds posted here too. We have monthly workshops online, the next one is in August as July is taken by a workshop that is already closed (it is an introductory 8 hour 2-day workshop for ISLE). Monthly workshops are thematic. All workshops are online, free and video recorded. To benefit from the group, try to check the posts daily and like them or comment on them to help Facebook notify you about the next post. For now, just scroll down and see what we have been talking about in the last 2 weeks. This time will be well spent, I promise! Welcome!
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Hi @everyone! I continue with Elaborative Interrogation reading strategy. I described it in my post of June 14, and today I am showing how I do teach my students. It is called "Reading aloud with students". I chose an example from Chapter 17 - electric Charge, Force and Energy, but you can try on any example. I will paste an activity from OALG Chapter 1 after my example.

Ask the students to open a page in their textbook (it needs to be the same page for the whole class) and read a paragraph. Then you model how to interrogate each sentence in the paragraph. For example, here is a paragraph from the textbook College Physics: Explore and Apply (Chapter 17, p 506):

“We now understand why rubbed objects acquire opposite charges. Two objects start as neutral—the total electric charge of each is zero. During rubbing, one object gains electrons and becomes negatively charged. The other loses an equal number of electrons and with this deficiency of electrons becomes positively charged. Sometimes when you rub two objects against each other, no transfer of electrons occurs. When the electrons in both materials are bound equally strongly to their respective atoms, no transfer occurs during rubbing.”

Now I show how to “read it aloud” with your students to help them learn how to interrogate this text. The original text is in Italics and the interrogation progression - what you say as the teacher - in a regular font.

We now understand why rubbed objects acquire opposite charges. When did we learn that? Oh, right, we did experiments when we saw that when you rub the foam stick with fur, this fur attracts that stick and repels the stick rubbed with plastic. Assuming that the stick rubbed with fur is negatively charged, and the stick rubbed with plastic is positively charged, then the fur should be positively charged. I guess the sentence makes sense. It is true.

Two objects start as neutral—the total electric charge of each is zero. That is right, zero does not mean the absence of charge as I remember though. Maybe a neutral object already has both charges inside, but they cancel each other? Not sure the sentence is true, but I will go on.

During rubbing, one object gains electrons and becomes negatively charged. The other loses an equal number of electrons and with this deficiency of electrons becomes positively charged. We just studied that atoms are made of positive nuclei and negative electrons and only electrons are mobile. When we charge objects by rubbing, then it is possible that some of the electrons of one object jump onto the second object. Then the first object that lost electrons is now positive and the object on which the electrons jumped is negative. But the total charge is still zero as we did not create or destroy any electrons. It looks like this sentence is true.

Sometimes when you rub two objects against each other, no transfer of electrons occurs. Hmm, this does not make any sense. Does this sentence contradict the previous sentence? When the electrons in both materials are bound equally strongly to their respective atoms, no transfer occurs during rubbing. Oh, I see now. If the electrons are bound equally strongly in both objects, then nobody can pull electrons from this other object. Then it means that for charging by rubbing to work, the electrons in the two rubbing objects need to be bound differently to their nuclei. However, if I think about it, it does not make sense. It is very hard to imagine that all electrons are bound equally strong to an object. So, maybe, if the electrons are bound approximately equally strongly in both objects, each object takes about the same number of electrons from the other object. Therefore, the total number of electrons on each object practically does not change. I wonder which one is more correct…

The process described above takes about 5-7 minutes in class, but it is extremely important as it shows how you think. When we talk about cognitive apprenticeship, the most difficult part of it is to make the thinking of an expert visible to a novice so that the novice can use it as an example. Thinking aloud when reading the text achieves this goal. The next step is to engage the students in the same activity for a couple of examples and then to assign reading and interrogation for homework. But how do you know that the students did indeed interrogate the text at home? One way to do it is to explicitly assign interrogation questions as homework and then put them on quizzes and tests. In the textbook, College Physics: Explore and Apply, each section ends with an interrogation question, the answer to which can be found in the text of the section. Allison Daubert shared with me her excellent strategy for engaging her students in Elaborative Interrogation reading. Allison Daubert, please share with the group! Below I al posting an activity from Chapter 1 OALG (posted here in the FILES) that achieves the same goal as my example above:

OALG 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, p. . 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 expenses change 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 expressions 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 expenses 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 a 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 texts. They continuously interrogate every sentence by 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. If the sentence does not make sense, they read the next one to check whether that sentence helps them 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.

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Eugenia Etkina
Admin
Top contributor
· ·

Hi all, I finished posting about the first days of class in the ISLE classroom. Should I start kinematics? As we will not have a workshop on kinematics this summer, but do magnetism in August, what do you think? Kinematics? Or more of the general ideas that are applicable for every topic? Such as reflection, homework, questioning techniques, group work, etc. Please express your interests! Thank you!
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Eugenia Etkina
Admin
Top contributor

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Hi all those who will need to teach fluids. Oliver Moose, Tara Frazier Sloan, and Keri McKenzie asked to share information about Fluid workshops we had in April and May.
Here are the links to the slides and workshop documents:
https://drive.google.com/.../1JN3YuiFEgQjy0E0aRAKvhz12tnK...
https://drive.google.com/.../1JN3YuiFEgQjy0E0aRAKvhz12tnK...
And to zoom recording for static fluids
https://www.youtube.com/watch_popup?v=J_3yy_2J2w4&ab_channel=HrvojeMilolo%C5%BEa
and fluids in motion
https://rutgers.zoom.us/.../F3G9m7XcO-uRLZy2... Password: eqvK*ng4 somehow I could not find it in the archive, Hrvoje Miloloža, do you know why?
I also wanted to make a few comments for fluids in motion topic as we have been working on a new edition of our textbook and modified some stuff. I will do it later when you are closer to teaching fluids next year.

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Eugenia Etkina
Admin
Top contributor
· ·

Hi @everyone! Yesterday I asked if I should post about teaching kinematics or provide some general notes about different aspects of ISLE methodology that are applicable to all topics. You overwhelmingly voted for the latter and gave a comprehensive list of issues that need to be discussed. I am starting these discussions today.
The issue that I want to start with is present in every unit of any physics curriculum and might explain why physics is considered to be one of the most difficult subjects. Read on. Warning: long post.
Every physicist and every physics teacher has had the same experience. When somebody asks you" What do you do?" and you reply: “I do physics research or I teach physics”, the response is almost identical no matter where you are or who is the person asking the question. The response is usually full of respect: “Wow, physics! You must be smart. It is so difficult! It has so much math! I never took physics.” Or, “I took physics but I hated it.” There are minor variations in the responses but they all communicate the same fear of physics and the admiration for those who are brave enough to do it.
Why? What is it about physics that makes it universally considered to be one of the most difficult subjects accessible for only the brightest? One reason can be the way we teach it. We start by using abstract words and we attach abstract mathematical relations to those abstract words. However, the studies of the brain tell us that to learn something, one first needs to have an image of it (Zull, 2002, Dehaene 2021). Imagine that we tell you that we are learning about malum today. A malum can be green, yellow or red. It can be hard or soft. Some malums can be sweet and some can be sour. Will you know what malum is? Probably

not. But if I show you a picture of one malum (see the screen shot attached to this post), you will know exactly what malum is (we used Latin language here).
I (Eugenia) can only solve a physics problem if I can imagine what is going on. I can see moving pulleys and ice skaters doing their rotations but for the life of me, I cannot figure out the rules of baseball. So, any problem involving baseball is impossible for me to solve. Why? The quantities in the problem have no meaning for me. I cannot visualize them.
How does the ISLE approach deal with this problem of lacking concrete images to help students bridge abstract words and abstract symbolic representations used in the practice of physics? It links these abstract ways of describing the world to more concrete descriptions. ISLE students learn to represent physical processes in multiple ways and learn to move from one representation to another in any direction. This moving back and forth between representations helps them make connections between concrete ways of representing a process (pictures and diagrams) that create images in their brains and more abstract ways of representing the same processes (graphs and equations). In fact, in our textbook College Physics: Explore and Apply the first half of every chapter does not have any mathematical representations. Instead, we focus on descriptions and videos of experiments, sketches, and graphical representations specific to physics (such as motion diagrams, force diagrams, energy bar charts, etc.). This approach helps students construct their personal understanding and qualitative image of the concept and feel comfortable with it before using abstract mathematics. In a way, using representations other than mathematics not only addresses the first intentionality of the ISLE approach (help students learn physics by practicing it) but also the second intentionality (improve student motivation, self-confidence and persistence). Graphical representations in physics play a crucial role. We can think of the Feynman diagrams as an example. Quantum electrodynamics (QED) was largely inaccessible for many physicists before Richard Feynman invented a graphical representation that allowed the physicists to keep track of particles and interactions. Galileo took pages of his book Two new sciences(1638) to explain how to derive the quadratic dependence of distance on time for the objects moving at constant acceleration, while if we use the graphical representation of mean speed theorem invented in the 14th century by the Calculators of the Merton College (a group of thinkers at Oxford) and proved by Nicolas Oresme, we can do it using one graph[1].
Representations also help students group information in bigger units (the process called chunking, see Gobet & Simon 1998) which allows them to process larger amounts of information at once. The mind can supposedly hold five to seven chunks of information. Experts with years of experience group many small ideas together in one of these chunks. Thus, their seven chunks are actually much bigger. Each chunk for a novice is small. This makes it difficult for novices to develop understanding about a whole process with these few small chunks stored in their mind. They must go back multiple times to the problem statement. It seems less fatiguing to solve the problem by finding an equation that seems appropriate and plugging the known information into that equation—the infamous plug-and-chug problem solving strategy.
Thus, constructing a sketch of the process, for example, allows a student to see the problem situation without having to rely on storing the information in their mind. They can then focus on using a more expert-like strategy to solve the problem. In such an expert strategy, graphical representations serve as bridges between the abstract words describing the problem situation and the mathematical equations that are needed to get the numerical answer.
In other words, the different representations serve as tools that allow us to solve problems and develop new knowledge more easily – similar to having tools in construction. We teach students what “hammers” and “saws” they can use to build their “physics house”. Below I

show you an example of using graphical representations in dynamics and helping students learn how to check consistency of representations.

The teacher is catching a vertically falling medicine ball. The ball has a blinking LED attached to it and you can see the traces of light indicating that the ball's speed is decreasing after it gets in contact with the teacher's hands. Part (b) of the figure shows the motion diagram for the ball during the contact with the hands. Part (c) shows the force diagram for the ball. We choose the ball as our system of interest and put a dot on the right of the motion diagram to represent the system. We then find all objects with which the system object interacts (either directly touching or without the direct contact if there is a long-range force like the gravitational force that the Earth exerts on the object). Then we use this sketch and the identified system to construct a new representation that is called a force diagram or a free-body diagram (we actually prefer the word force diagram to the free body diagram as when external forces are exerted on an object, it is not free). We then use the diagram to write Newton's second law in component form. (The method that we use is based on work by Heller and Reif and further developed by Etkina and Van Heuvelen in the first edition of College Physics.)

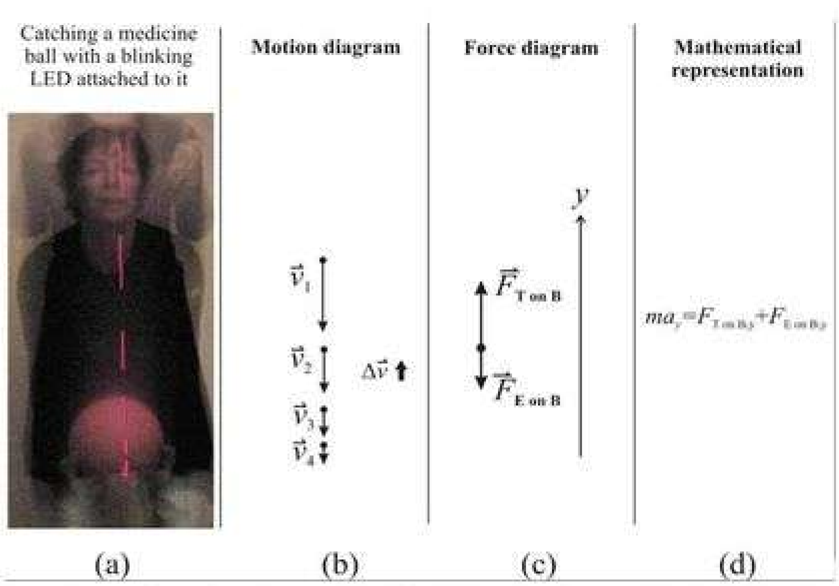
Now let's go back to the force diagram representing the forces exerted on the medicine ball as you are catching it. How long should the force arrows on the force diagram be? There are two very important ideas at this moment. First, the relative lengths of the force arrows should be approximately consistent with the magnitudes of the forces (if the information is known). And here is where the motion diagram helps. If the student constructs the motion diagram next to the force diagram, then the velocity change arrow on the motion diagram will indicate the direction of the sum of the forces. The direction of the sum of the forces will help the students to adjust the lengths of the force arrows on the force diagram. This step helps students develop the habit of evaluating the consistency of the diagrams and also helps them decide what lengths the force arrows should be. Students need to practice constructing force diagrams and matching them with the motion diagrams before they start solving quantitative problems. We provide examples of such activities in the textbook and ALG/OALG.

Next students use the force diagram to help write Newton's second law in component form. Having the force diagram as an intermediate reasoning step helps students avoid mistakes such as calculating the force that the hands exert on an accelerating medicine ball by setting ma sub y equal to the force exerted by the teacher (F teacher on ball and neglecting the gravitational force that the Earth exerts on the ball.

Once the students have learned to construct these different representations, they need to learn to use them to evaluate their work. For example, is the velocity change arrow in the motion diagram in the same direction as the sum of the forces in the force diagram? Have all of the forces been included in the application of Newton's second law in component form? Students need to practice converting from one representation to another—for example, from equations to a force diagram or to a word description of a problem. In the textbook multiple representations are integral to the problem-solving strategy. The problem-solving strategy has 4 steps: Sketch and Translate, Simply and Diagram, Represent Mathematically, and Solve and Evaluate. All 4 steps are related to different representations. See textbook Chapter 3 for the examples.

[1] The mean speed theorem says that a uniformly accelerated object starting from zero initial velocity travels the same distance as the object with the constant velocity equal to the half of the final velocity of the accelerated object. Oresme proved it using a trapezoid with base being the time of travel and the sides being initial and final velocity.

Malum.



(a) a photo of Eugenia catching the medicine ball; b) motion diagram for the ball; c) force diagram; d) mathematical representation.

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Eugenia Etkina
Admin
Top contributor

Hi all, no new post today, I want to give you time to process the one from yesterday (it is a long one!) and also to scroll down through the previous posts to make a list of procedures for the first week of class. Tomorrow is a new big post! Make sure you like this one so that the one tomorrow comes to your feed. And please comment, comment, comment! Thank you

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Eugenia Etkina
Admin
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· ·
Hi my people Exploring and Applying Physics! I continue with the "general stuff" as you requested.
Today my post is about three important skills that are vital for the implementation of the ISLE approach: monitoring group work without interfering, running whole class discussion, and withholding validation. These three skills are vital for the implementation of the ISLE approach. The students need time to work on the activities and when we interrupt them asking questions, they lose their train of thought and try to follow ours. Therefore, it is extremely important not to ask leading questions when the students are working collaboratively on the activities but carefully watch what is going on. If you feel that the students are stuck, try to ask a question that will help them fall back on something that they know, so that they make the conceptual leap themselves, thus using their brain connections and building on them.
While it is important to let students figure out things on their own, how do you keep the activities on time then? The time that each activity takes, depends on how much guidance/scaffolding the teacher provides (I will post more about it tomorrow). Therefore, sometimes it is trade-off between prompting the class with leading questions or cutting "critical" activities. While our interruptions hurt student learning, it is a true challenge of trying to implement ISLE at scale.
During class discussions, there is always a moment when a student responds to another student, this is the most precious moment as it might give rise to the conversation among the students, which is our ultimate goal. If you withhold validation, and they figure out the issue themselves, this "self-figuring" not only will help them better remember what happened but also will contribute to the development of self-efficacy – they did it themselves!
How do you withhold validation in practice? The technique is called "reflective toss" and I learned it from Jim Minstrell. When a student asks a question, you do not answer it but toss it back to the class – What do you, people, think? (notice that I did not say "guys", in fact the word guys when talking to the students should be banned from our vernacular). Wait for somebody else to reply, or if no one does, let them discuss it briefly in groups. This creates a habit of thinking for themselves, not waiting for you to answer. But when the answer comes from a student, you do not say whether it is correct, but keeping a poker face ask the class again: "What do you, people, think?" The students need to get used to the fact that you are not the ultimate authority, that they can figure out things on their own with some help. Of course, sometimes, a question requires a direct answer, usually when it is about some routine procedure. So, being flexible here is important.
Look at the dynamic in the photo that I posed. These are the students in the ISLE class - they are figuring out stuff on their own and you do not even see the teacher in front of the class when they exercise authority. Not standing in front of the class is also very important for showing that you are not the authority but a guide. You might think that these little details are not important, but remember, ISLE IS THE INTENTIONAL APPROACH TO CURRICULUM DESIGN. Intentionality means that EVERYTHING that you or students do in the classroom serves the main goals of the curriculum approach. For ISLE these goals are: students learn physics by practicing it and students' well being is enhanced by their

experiences in the course (motivation, self efficacy, growth mindset, the sense of belonging, etc.). So everything that you do (including where you stand during class discussions) should be serving these goals. Does it make sense?
Finally, these skills are followed by the skills of facilitating cognitive reflection. These reflections (what did you learn? How did you learn it? What remained unclear? What was the most difficult part? What helped you learn?) can be a part of a whole class discussion, group reflections or a homework assignment. I will post more about reflections in a separate post.

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Dear NEW MEMBERS, please visit islephysics.net to learn about the ISLE approach (Investigative Science Learning Environment) to learning and teaching physics group. ISLE philosophy is the foundation of everything that we do here. The website will help you see what resources we have and how to use them. Here we pist every day about different aspects of ISLE as well as about teaching specific topics through the ISLE approach. We have monthly online free 2 hour workshops and there are lots of materials posted here in the FILES. To benefit from the group, try to check the post daily and like or comment on them to make sure that he next post comes to your feed. Now, just start scrolling through the recent posts. I recommend going back a month to see what has been happening and how to start a school year if you are going to try ISLE with your students. Welcome!
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Eugenia Etkina
Admin
Top contributor
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Hi @everyone! Today my post is about group work. I posted about it many times, but here, in a very long post (THIS IS A WARNING!) Hang on, it will take time to read.

I already posted that in the classroom your students will be working in groups at those tables, each holding a marker of a different color in their hands so that the contributions of each member are clear. How do you form 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 of 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 an optimal number for all students to participate. Four is still ok, but one person might not participate. Starting with 5 members, only a few of them participate. 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 this later). With the possibility of a large variability in the group member's preparation, we found it useful to have groups of mixed ability. Thus, as you get to know your students, try to organize the students so that the groups in each course meeting have students who are high achieving, medium achieving, 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. but randomly formed groups that change often also work.

Working in groups is important in the ISLE approach. Do you remember the two intentionalities of the ISLE approach? The first is to help students learn physics by constructing knowledge that follows the processes that mirror those of practicing physicists. The second is to help students 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 community, belonging, and extend students' zone of proximal development. The problem is that not all groups are functional.

What does it mean to have a functional group? A functional group is a group where 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) 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. Such hedging opens space for other members of the group to contribute. 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.

As everything else, working in a group is a skill that needs to be learned. Using hedging in your own speech to model desired behavior of your students is the first step. The next step is openly talking to your students about what makes groups effective – this knowledge will serve them long after they finish the physics class. Sharing with the students that being socially aware of other people in the group, making sure that everyone has a chance to speak, and understanding that everyone’s contributions are important is crucial for productive collaboration. People have different strengths and building on these different strengths is what makes the intellectual value of a group much higher than the sum of intellectual values of its members. When students work in groups, it is helpful to stand behind a group and listen to the tone of their conversations and watching if all members have a chance to speak and if they are trying to hedge. If you notice a problem, either talk to the whole group (“I noticed that not everyone has a chance to speak in your group, please make sure that everyone does”), or asking the most dominant group members to meet you outside of class and talk to them separately about the importance of being aware of other people in the group (“Why do you think we hedge when we make statements? Why do you think listening to other people might help you learn more?”).

It is also important to watch whether everyone in a group has a chance to speak and whether everyone's suggestions are respected. If you notice lack of those two, talk to the group members about developing those two skills.

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 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 (see my Friday's post on withdrawing validation) 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 (this is TIME FOR TELLING). 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 (or copy them as class notes. People asked me about note taking - this is a good moment for note taking).

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.

If you finished reading this long post, you know what do next   Thank you for doing it!

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Eugenia Etkina
Admin
Top contributor
· ·

Hi all! Thank you for checking the posts every day, liking them, and commenting - it makes a huge difference! Thank you!
As I promised, I post long posts every other day to give you time to read and process them. On the "off" days I either welcome new members, put announcements, or post something short.
Today is a post about a photo here. These are the former students, now physics teachers, and present students in the ISLE-based physics education program at the University of Ljubljana. (The empty seat is mine as I am taking the picture). They are the students of Gorazd Planinsic, Andreja Sarlah, and Sergej Faletic. They have this summer picnic every year, as a community. It is great to see how more experienced teachers share their stories with the future teachers, how all conversations are about students and improvement in their ISLE teaching. The same way the students need a community to learn, the teachers need a community to prosper and be happy. That is why we have our community. Have a great day, my people, I will have a long post tomorrow. (The photo posted with permission, several people in it are the members of our group).

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Eugenia Etkina
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· ·

Hi all Exploring and Applying Physics people! I continue my general posts - general meaning that they apply to all topics when you are using the ISLE method. Today is about REFLECTION.
The word reflection is common in educational practice. We can think of reflection as an act of looking back in order to process experiences, or a way of thinking about one's own

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 certain experiments trigger productive thinking in my students and other experiments 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.

Is there an explanation as to why reflection is important? YES! Indeed, our knowledge of how the brain works provides two mechanisms for the importance of reflection for learning. First, 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 just been formed. This activation makes the circuits stronger and thus more easily accessible later (reflection improves memory). But there is more to the role of reflection, oral or written, in learning. According to Kolb's brain cycle (Kolb, 1984), 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 our 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 performing the actual testing experiments that are a part of the ISLE process). 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. Think of what happened in class that helped you learn those things." 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 it difficult to add to what was already said, so next time they will raise their hands first.

If you have too many students in the course to have individual reflections, you could have group reflections. Give 2-3 minutes to your students who have been working in groups during class to write what they have learned (same questions) on their whiteboard and then ask them to share. Each group says one thing from each category on their whiteboard and the reflection goes from group to group until all new things are said. Group reflections are also very helpful when you have students that are (for various reasons) shy or not accustomed to reflecting. Implementing regular group reflections helps them to break the ice and learn how to reflect, so that you can later proceed with individual reflections.

You can do 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?

But there is more here. 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?
This homework 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 and when they can articulate how they learned something by connecting experiments and reasoning, they have higher learning gains compared to those students who think that they have learned from listening to the teacher of from pure observations of experiments (May and Etkina 2002). Similarly, when they asked higher level questions (how to? And why? Instead of what?) they have higher learning gains (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 the solutions to the problems involve checking the units, doing extreme (or limiting) case analysis (White et al. 2023), considering how reasonable the result is and how consistent it is with different representations used to analyze and solve the problem. The important next step is to go back and fix the solution if any of these techniques show a mistake. How can we help our students develop such habits and what routines can we use in this process? We need to model it and to reflect on when we assess our own solutions. How do you catch mistakes that you 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 value of g to be 9.6 + - 0.2 m/s/s. Is it correct?" Although the students wrote the findings with 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. To determine some unknown quantity, students are required to design two independent experiments. For those experiments, reflection is crucial as it helps the students compare the results obtained from two different experiments. Only by comparing the findings from two experiments including experimental uncertainties can they 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. All rubrics are posted at https://sites.google.com/site/scientificabilities/

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Eugenia Etkina
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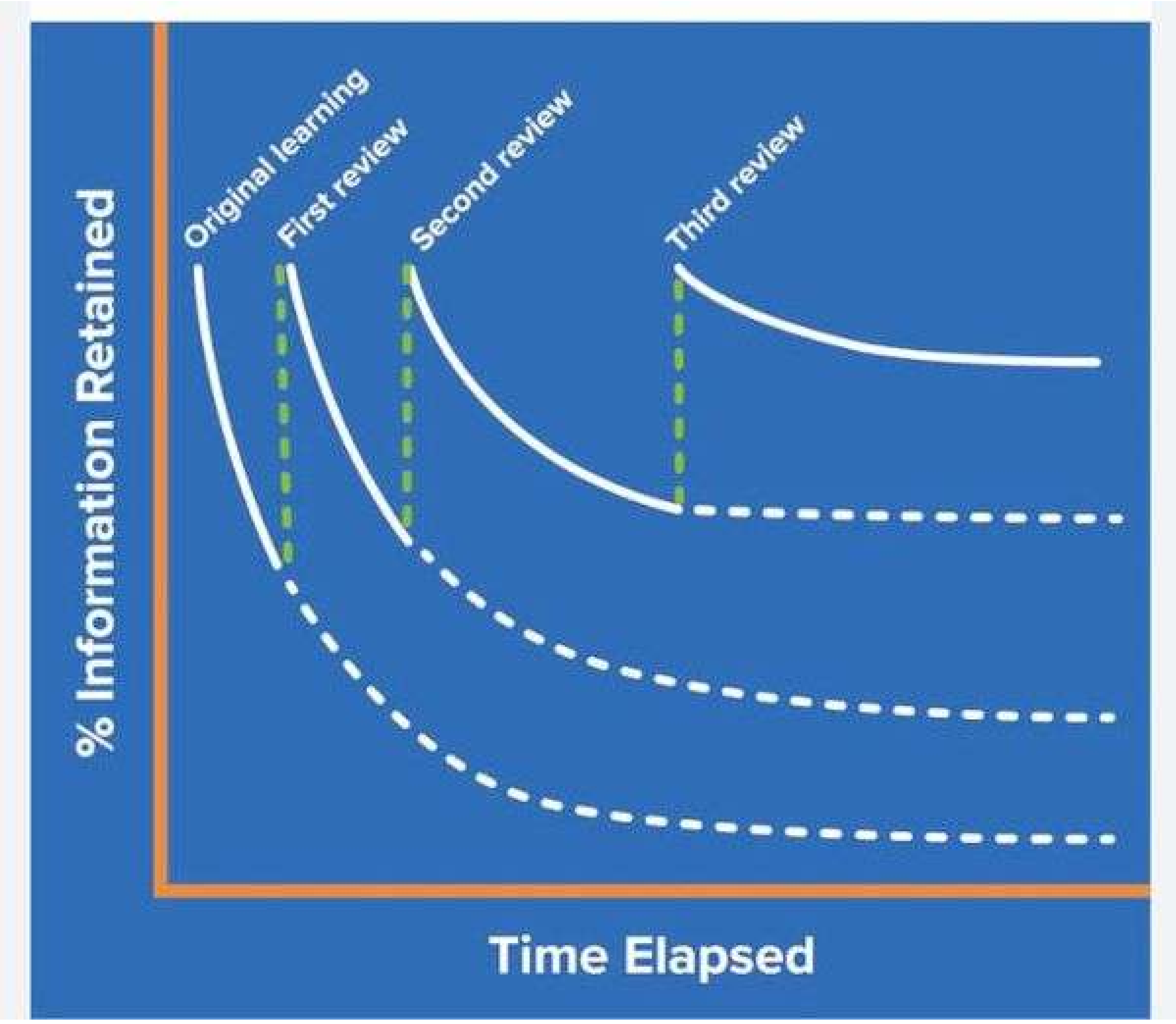
Ho @everyone! I continue my "general" posts. Today is the post about homework - assign or not to assign? Read on.
Homework is probably one of the most contentious issues in education. Some studies show that assigning homework does not improve student learning, some argue that the students need to rest at home, some say that even if they assign homework, very few students do it. There are lots of arguments against assigning homework. What are the arguments in favor of assigning homework? We list them below.
Argument 1: Homework teaches people to 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, during the first 10 hours) a person forgets about 70% of what they learned (see attached screenshot). However, if they review the material within this time, their memory brings up the new knowledge to the same level. Repeated review drastically reduces the amount of forgotten information.
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 their 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 helps learn to interrogate scientific text. There is a great deal of research (Podolefsky and Finkelstein 2006) 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 next section). However, to practice this reading strategy, the students need different amounts of time as everyone reads at their own pace.
Based on the above, we have enough arguments in favor of assigning 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 the next section in this chapter). 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 for 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 the latter assignment requires team work, thus it should be assigned to teams of students (2 or 3) 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 homework (or see them online if the students submit online), reading every single one of them and providing feedback is a time and effort consuming approach. How can we save time providing feedback? There are multiple options.
For the homework, which serves 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 not take more than 5 minutes. If a person did the homework, the time should be enough to complete the quiz. But if the person did not do the homework, then 5 minutes will not be enough. We discussed above how to grade these quizzes and how to provide feedback. Another way to provide feedback is to have a group activity in class the next day that mirrors the homework and then provide feedback in that moment to the class as a whole. You could also post the solutions to the assigned problems a day after the homework is due and 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 regardless of whether they complete the homework. So, why bother do it at home?
For the homework that prepares the students for the next lesson, the feedback is provided when you continue the activities through sharing in class. But in this case, there is no accountability – if the homework was to collect data from an experiment, 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 lose 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 effort, for completion, for clarity, but not for correctness. The bottom line is that the grade should not 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 finished reading the post, you know what to do now Thank you for doing it!



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Eugenia Etkina
Admin
Top contributor
· ·
We have many people joining our group every day. We welcome them all!

Dear NEW MEMBERS, please visit islephysics.net to learn about the ISLE approach (Investigative Science Learning Environment) to learning and teaching physics group. ISLE philosophy is the foundation of everything that we do here. The website will help you see what resources we have and how to use them. Here we pist every day about different aspects of ISLE as well as about teaching specific topics through the ISLE approach. We have monthly online free 2 hour workshops and there are lots of materials posted here in the FILES. To benefit from the group, try to check the post daily and like or comment on them to make sure that he next post comes to your feed. Now, just start scrolling through the recent posts. I recommend going back a month to see what has been happening and how to start a school year if you are going to try ISLE with your students. Welcome!
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Eugenia Etkina
Admin
Top contributor
· ·
Hi @everyone! I continue posting general ideas about teaching physics through the ISLE approach. This time it is about questioning. As it is a long story, I will split it into two and post only one half today. Here we go! Oh, one more thing. I am not attaching any images to this post to see whether without images people will respond.
Questioning techniques
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. We will call one group

“closed questions” and the other group “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?
· What is acceleration?
· What is the definition of acceleration?
· What is the unit of acceleration?
· What does it mean that the acceleration is negative/positive?
All these questions assume confidence in those who answer and the existence of one right answer. These are closed questions.
How can we 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 can you help her agree with your point of view?
· David says that an object with an acceleration of 5 m/s/s speeds up and an object with an 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 another example of an object that has a 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 (and will) participate.
In general, it is a good rule of thumb to avoid starting questions with: What is …? Who knows …?
If you read to the end, you know what to do next. Thank you!!
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Eugenia Etkina
Admin
Top contributor
· ·
Hi all Exploring and Applying Physics people! I continue with questions.

Let's say we asked a good question How to elicit answers to it? 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 have a chance to participate and try not to miss girls holding their hands (as you know, they are often invisible). Give students 10 to 15 seconds to respond, let them see that you really mean it. 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 your thoughts about…. What are your ideas? How can we explain…? How can we test…? How would you approach…? How do you know…? What is your image of…? How can we convince A in…? Tell me more about... Who can add to…? Any ideas about how we can explain…? Any ideas how we can test…?
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 is to make sure to ask this question: "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 agree? Sometimes, when one student answers a question, the others do not listen or do not understand. Asking "Do you agree?" to the whole class with 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?" a Reflective Toss by Jim Minstrell that we talked about a few days ago) When somebody in the class responds, stay back until the discussion between the students starts. Open questions encourage or trigger discussions, closed questions do not.
Did you finish reading the post?   You know what to do next.
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Eugenia Etkina
Admin

Level 3 contributor
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Hi @everyone! I am starting a series of posts (a long series!) for the beginning of the school year. Consider this an asynchronous workshop. Instead of attending a 2-hour workshop on a specific day, you will need to read the posts and do the work. Your responses are very important - please post them in the comments AFTER you do the reading.
While the students will be doing various activities that I will describe, it is important that the teacher sees a big picture behind all those activities and understands why the materials are the way they are. Therefore, I will start by asking you to read the introductory chapter of the Instructor Guide. It describes how the whole system works together and lists learning goals

common for ALL topics. Content specific goals are in every chapter. After you finish reading the chapter, please put your questions in the comments and I will answer every one of them. I will make posts every other day, not every day so that you have time to do the readings and process new ideas. What do you think of this approach?
Here is the chapter to read, it is the introductory chapter of the Instructor Guide which is posted here in the FILES.
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Eugenia Etkina
Admin

Level 3 contributor

Hi @everyone! Today is my last post about questions. We talked about teachers asking good questions, teachers responding to students' questions and answers, but we did not talk about the most important, crucial part! Here it 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 teaching practice we only 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 free fall - would you know that you are not standing on Earth? So, bottom line, asking good questions is as important, if not MORE important than giving good answers.
When I was teaching high school, on the first day of class, I would tell my students 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. And during my teaching 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 was important to follow as it created a natural "need to know" and led to more learning. 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 (the 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 is conducive to generating or producing insightful and valuable questions.

Below we give a 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?

Which variable is independent and which is dependent?

Model/explanation/hypothesis development questions:

How do I start thinking about making a mathematical model for the pattern?

How do I know if it is a good idea to linearize data to find the pattern?

How do I go about finding a mechanism?

How do I know that my explanation is correct?

Testing experiment questions:

How do I design an experiment to test the model/explanation/hypothesis?

How do I know if this is a good testing experiment?

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 will give me the outcome that will allow me to differentiate between the two hypotheses that I have?

Were there any additional assumptions that I made when I made the prediction? How can I validate them?

How do I determine the uncertainty of my result?

How do I know if my experiment ruled out the hypothesis/model/explanation?

We can go on to 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 questions start with HOW ("How do I know …?", (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 questions starting with the WHY, those are in fact the questions that have the HOW in them, however (and this is the reason to avoid "Why" questions) "Why" questions question the purpose of the phenomenon, not how it happens. And often the answer is anthropomorphic (Anthropomorphism is the attribution of human traits, emotions, or intentions to non-human entities. It is an innate tendency of human mind). 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. The 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 such questions (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 [see ISLE-based 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 et al. 2003). Those who asked questions that we described above as "good" had significantly higher learning gains than those who focused on "what" type of questions.
If you read to the end, you know what to do next! Thank you for doing it!
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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi all, I continue today with the general ideas important to the implementation fo the ISLE approach. I am starting a long series of posts about the reasoning processes employed in physics as the first intentionality of ISLE is to help students learn physics by practicing it. But practicing WHAT? Here is post #1. It is a long one, pleas be patient.
START of POST
In order to implement the ISLE approach, a teacher needs to habitually think like a physicist. 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 knowledge is constructed, then the habit of treating physics as a process 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 independent 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, interactions,
· physical quantities and their relationships,
· measuring instruments,
· physics devices,
· testing experiments,
· predictions of the outcomes of testing experiments,
· application experiments, and
· 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.
Physical phenomena and physical objects
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. When we observe physical

phenomena, we conduct observational experiments with no expectations of the outcome. The goal of doing such experiments is to identify some pattern, which we will later model or explain. These observational experiments can be qualitative or quantitative, involve some measuring instruments or be done with our direct senses. When the students observe phenomena, it is important to ask the following questions:

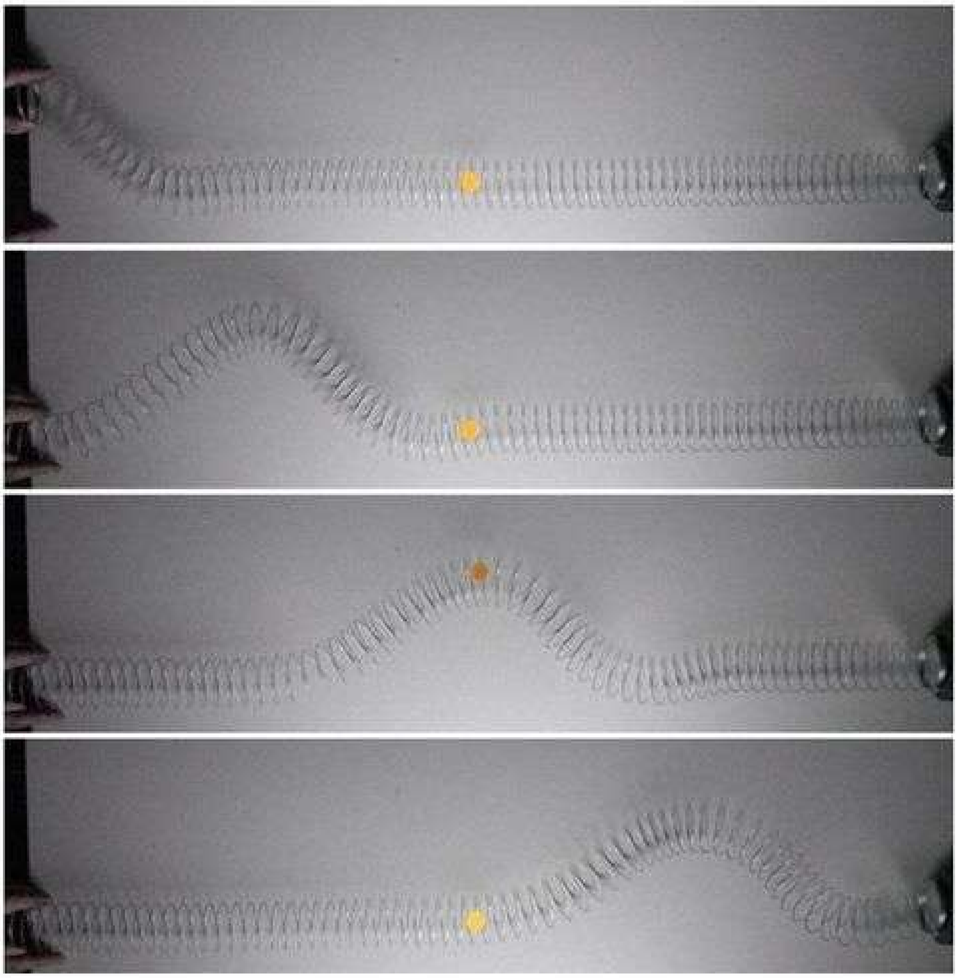
· What did you observe?
· What data can you collect?
· How can you represent the data to find patterns?
· What are the important patterns?
· What patterns can we explain?

Here is an example of a physical phenomenon (see video https://youtu.be/gT5_KYmOgKs attached figure of four successive photos of a traveling transversal pulse on a Slinky.

· The students observe the disturbance that they created and how it travels along the Slinky (a helical spring toy). They also observe each coil moving up and down while the disturbance propagates to the right.
· There are many patterns that they can find by varying different parameters. They can collect data concerning the speed of the propagation of the disturbance in various situations. They can change how the spring is taut, they can attach lead beads or small magnets to a spring, and they can also change the amplitude of the disturbance and measure the speeds.
· They can explain the propagation qualitatively by the interactions of the coils and use this explanation to account for different speeds for different conditions.

To help students conduct observational experiments with the ISLE approach, we have developed relevant self-assessment rubrics. They can be found at https://sites.google.com/site/scientificabilities/rubrics (Rubric B).

If you finished reading to the end, you know what to do next



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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi all, yesterday I started a series of posts about physics reasoning. The first one was about the elements of physics knowledge and the first element - physical phenomena. Today is the next element - models. Read on - long post again.
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 (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). 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 (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 (for example, F=Gm1m2/r^2). 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, object, or system are you trying to simplify?
· What are your simplifications?
· How can you justify these simplifying assumptions? When is the model applicable?
· Is the model qualitative (if yes, is it causal or mechanistic?) or quantitative?
· What experiments can you conduct to test (and possibly reject) 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
(1) the particles are identical point-like objects that have mass but negligible size,
(2) they interact with each other and with the walls of the container only during collisions but not at a distance, and
(3) their motion obeys Newton's laws.
· As the interactions of microscopic particles decrease dramatically when the distance between them is larger than their sizes, we can estimate that, 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 (in describing the mechanism) and quantitative because it allows for using Newton's laws to derive the expression for the pressure that an ideal gas exerts on the walls of the container p=1/3nm0v^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 12 of our textbook College Physics: Explore and Apply..
· The model is limited to rarefied gases. For example, a student should be able to realize that the ideal gas law cannot be used to solve the following problem (College Physics: Explore and Apply, page 382): "A 5000-l cylinder is filled with nitrogen gas at and 300 K and closed with a movable piston. The gas is slowly compressed at constant temperature to a final volume of 5. Determine the final pressure of the gas."
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 or a system 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.
If you read to the end you know what to do next - Comment or like to make the post more visible for other group members! Thank you!

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Eugenia Etkina is feeling thankful.
Admin

Level 3 contributor
· ·

Hi all, I see that my latest posts do not have many views, so I am not posting anything today to let you catch up with the posts on physics reasoning. The next one is tomorrow!
Thank you all who signed up for the Magnetism workshop. It is great to see the names of the "regulars" and some new names. We welcome everybody who wishes to teach physics through the ISLE approach!

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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi @everyone! I continue with the elements of physics knowledge today. We discussed physical phenomena and models (see my previous posts). Today are two other elements - physical quantities and measuring instrucments. Here we go! Long post again
Physical quantities
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.
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 (cannot do arrows here, but you know what I mean, F, v, etc.). 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 K). Mass is a scalar quantity as are temperature and kinetic energy. Scalar quantities can be positive or negative.
It is important to recognize the difference between the operational definition of a physical quantity(a=delta v/delta t) and the cause-effect relationship (a=sum of F/m) – see causal explanations in the models post. 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 the time interval, the change in velocity doubles). A cause-effect relationship tells us what the quantity depends on as we can change the variables independently (the mass of an object can be double 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/drive/folders/1bYPf4GzCTtETFT7C9tz4g791MQpTQbdb. When the students are developing a new physical quantity, it is important to ask them the following questions:

· What phenomenon or model does this quantity describe?
· How do you define the quantity operationally?
· What are the units of the quantity?
· How do you know if this quantity depends on other known quantities? How doesthis quantity depend on other known quantities?
· How can we test this relation experimentally?
· How do we determine the quantity: can we measure it directly or do we need to calculate it using other measurable quantities?

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 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. Depending on the , we can talk about instantaneous acceleration or average acceleration.
· The units of acceleration are .
· 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, sum of F/m and similar for other components. We can test this cause-effect relationship using an Atwood machine setup (see video https://youtu.be/sUQPlAGbyMo) and predict how far the object on the left side will move in the first second after letting go of the object on the table.
· We can "measure" the quantity using a simple accelerometer (I will not post the picture as I can only attach one per post, it is a small sphere on a circular gutter, students use a force diagram for the sphere to derive the equation for its acceleration).

To help student answer the above questions, we have developed self-assessment rubrics. https://sites.google.com/site/scientificabilities/rubrics (Rubric G)

Measuring instruments

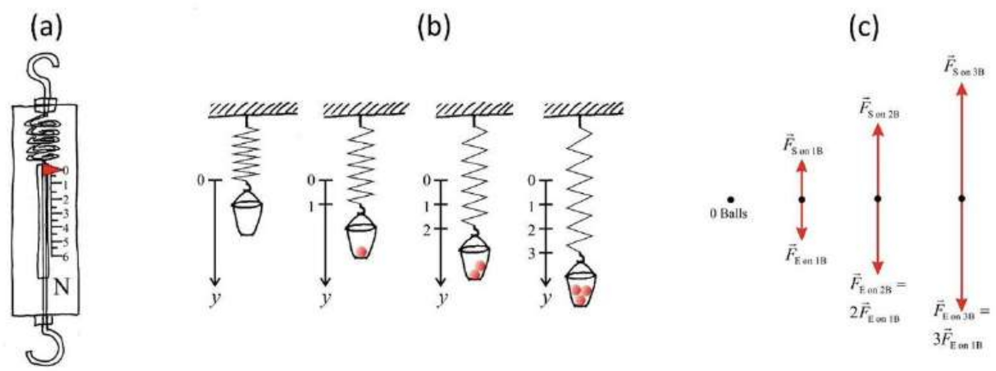
We use measuring instruments to measure physical quantities (such as a meterstick, a clock, an ammeter, etc.). Some quantities can be measured directly using an appropriate device (time, length, electric current) and some can only be calculated using directly measurable physical quantities (kinetic energy, 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 allow us to measure?
· What are the physics principles behind the operation of the instrument?
· What are the rules of operation of the instrument?
· What are the safety procedures (if applicable)?

Below is an example of the analysis of a measuring instrument such as a spring scale to determine unknown forces. (See below).

· 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 (the spring needs to obey Hooke's law). The scale is 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 exert 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 to the force that Earth exerts on the object.
· To have an accurate measurement of an unknown force (in our example, the unknown force is the force that Earth exerts on the object), the scale and the object must 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.
· Do not use the scale for any force larger than the largest force that can be seen on the instrument.
If you read ot the end, you know what to do next, thank you!



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Eugenia Etkina
Admin

Level 3 contributor
 · ·
Hi all, Adm Cohen yesterday asked in experiments in AP labs are observational, testing or application experiments. I think most of them are application, but some are observational and testing, you need to read the text carefully to figure it out. Please give examples, so that we can discuss. also, Adm Cohen said that they could not access the uncertainty document on the scientific abilities website. I am posting it here again, it will be the second copy in the FILES. Please download and save!

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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi @everyone! I continue with the elements of physics as science. We discussed phenomena/observational experiments, models, physical quantities, and physics devices. If you missed those posts, please scroll back and read before you read this one. This post about testing experiments as an element of physics.

Testing experiments

These are experiments specifically designed to test a model, hypothesis, and/or explanation. Testing experiments are different from observational experiments. However, testing experiments also involve physical phenomena as we predict the experiment's outcome using the explanation under test before conducting the experiment. An example of such a testing experiment can be the famous Galileo's inclined plane experiment when he was testing his hypothesis that all objects fall at constant acceleration (that he defined as the change of speed over the change in time) without air resistance.

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

· What is the model, hypothesis, and/or explanation to be tested?

· Brainstorm possible experiments whose outcome you can predict using the model, hypothesis, and/or explanation 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 your thought process.

· What additional simplifying assumptions are you making in your predictions?

· How might these assumptions affect the predicted outcome – will they make the result smaller or larger than expected?

· After you conducted the testing experiment, how do you know whether the prediction and outcome match or do not match?

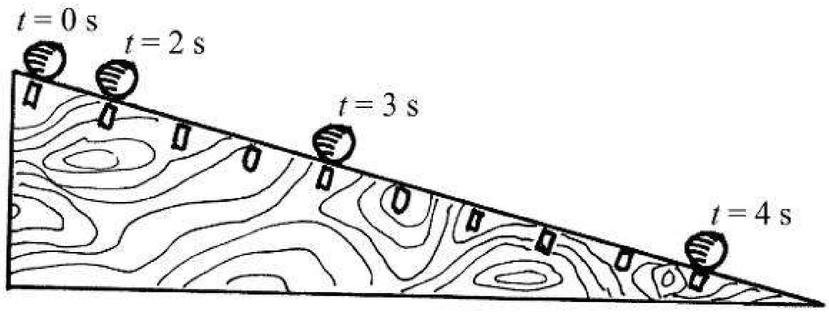
· What is your judgment about the model, hypothesis, and/or explanation under test?

We will analyze Galileo's inclined plane experiment as an example.

Galileo was testing his hypothesis that when objects fall freely from rest, their speed increases in direct proportion to time, in other words v= at. 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 handheld 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 was correct. 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 1/2at^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 a distance of d during the first second, in two seconds it would cover a distance of 4d, in 3 seconds it would cover a distance of 9d and so forth (see the attached figure).

Galileo could measure these distances and compare them to those that he predicted before running this testing experiment. He also assumed that the motion of a rolling ball down an 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 a motion detector to obtain a

position vs time graph or design an indirect experiment with a string and lead beads (fishing weights). Before running the experiment, students can predict that the sound pulses produced by the falling beads that hit the ground will be separated by equal time intervals. You can see the outcome of the experiment at https://youtu.be/FY0pmUDHXKU.
This is how to make this experiment work: Fix lead beads on an 8-m string at the following distances from one end of the string: 0 cm, 20 cm, 80 cm, 180 cm, 320 cm, 500 cm, and 720 cm. Hold the string from a window so that the bead at 0 cm is touching the ground. Release the string and listen to (and record) the sound produced by the lead beads hitting the ground. You can make the sound louder by letting the beads fall on a metal plate.
To help students learn to design testing experiments, we have developed a set of rubrics that can be found at https://sites.google.com/site/scientificabilities/rubrics (Rubric C).
If you finished reading to the end, you know what to do next! Please do not skip this step!
Thank you!



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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi @everyone! I continue with the posts about elements of physics. Understanding those is a part of learning the epistemology of physics - what knowledge is and how it is constructed. Understanding these elements helps students see the coherence of physics, its structure, instead of thinking about it as a collection of facts to memorize. If you missed my previous posts for this topic, scroll down day by day to see all of them.
Today the post is about TWO elements - predictions and application experiments. The word prediction is misused in education. It is being confused with the word hypothesis and often referred MISTAKENLY to as a guess. While hypothesis is a guess explaining some phenomenon, a prediction is ABSOLUTELY NEVER EVER, NEVER EVER A GUESS. Please read on to see why. Warning: long post.
Predictions
What we have in mind are 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. A

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 example of Galileo that I posted 2 days ago, the hypothesis being tested was that the velocity of the objects is proportional to the time of fall. For the same experiment, the prediction that was based off of this hypothesis was that 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://sites.google.com/site/scientificabilities/rubrics (Rubric C).

Application experiments

These experiments are different from observational and testing experiments because, to design them, one needs to put several tested models together to achieve a specific goal. Application experiments 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 the results consistent with each or not? How do you know?

The following example shows what students do when they conduct application experiments (full text of the lab and relevant rubrics are at https://drive.google.com/.../1wSTN5mYDzBFGN...) The lab is called Newton's laws and circular motion.

Title: Application Experiment: Coefficient of friction between the shoe and the floor tile

Brainstorm two independent experiments to determine the maximum coefficient of static friction between your shoe and the sample of floor tile provided. Once you have done this, call your TA over and discuss your experiments with them.

Available equipment: Shoe of your choice, spring scale, ruler, protractor, floor tile, tape, string, digital balance, and an assortment of objects of different asses.

Include the following in your report (a-g are for each experiment; h-i are for after you have performed both experiments):

a) Describe your experimental procedure. Include a sketch of your experimental design. Explain what steps you will take to minimize experimental uncertainty.

b) Decide what assumptions about the objects, interactions, and processes you need to make to solve the problem. How might these assumptions affect the result? Be specific. Considering each of the relevant assumptions, separately evaluate the effect that making each assumption will have on the results. For example, evaluate how the coefficient of static friction will change if you pull the shoe at an angle of 50° above the horizontal, rather than exactly horizontally.

c) Draw a force diagram for the shoe (recall your assumptions). Include an appropriate set of coordinate axes. Use the force diagram to devise a mathematical procedure to determine the coefficient of static friction.
d) What are the sources of experimental uncertainty? Which measurement is the most uncertain? How did you decide?
e) One of the assumptions you have likely made is that the coefficient of friction does not depend on the normal force that the surface exerts on the shoe (it's okay if you didn't come up with that on your own). In order to determine if this assumption is reasonable, perform a quick experiment on the side to evaluate the assumption. Decide if the assumption is or is not reasonable. Explain how you made your decision.
f) Give two different methods for measuring an angle with the available equipment. Which method is likely to provide a result with less uncertainty? Explain your reasoning.
g) Perform the experiment and record your observations in an appropriate format. What is the outcome of the experiment?
h) When finished with both experiments, compare the two values you obtained for the coefficient of static friction. Taking into account experimental uncertainties and the assumptions you made, decide if these two values are consistent or not. If they are not consistent, explain possible reasons for how this could have happened.
i) Describe the shortcomings you noticed in the experiments. Suggest specific improvements.
The self-assessment rubrics to help students develop abilities necessary to design, conduct, and interpret application experiments can be found at https://sites.google.com/site/scientificabilities/rubrics (Rubric D).
If you read to the end, you know what to do next. Thank you!
https://www.facebook.com/groups/320431092109343/posts/1658307218321717/?__cft__[0]=AZVnJM784B2gAC2dL69Mfw-bx08-TMO_f0vWqtGM1uig1yVkyVwQ9ZIoTPs7cqteYwZP1bvQ49FNzCP-TWXOGqwhVnLSS5I0oBfSTjVRzUuSubB3kK474VF_8UGMuG5o6ZU_iOSGFdzfhR7RIogm-GKvr1KDwFPnjEETFaWoxKyKwnd7ID8Cs31keGgqLmhqMTGIMYO-W-dGaMuG4t3yzMWJ&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi all Exploring and Applying Physics people! Today is my last post about the elements of physics. Tomorrow I will start discussing how physicists use these elements to construct knowledge in physics. If you just joined the group or have not checked posts for a while, please scroll back for about 2 weeks to see the progression of the posts on this subject. The last element is extremely important and often overlooked in our teaching practice.
Assumptions
Assumptions, as they are understood by physicists, are the things that we choose to ignore (air resistance, roughness of surfaces, mass of pulleys, rotation and velocity of Earth, etc.). The ISLE approach activities encourage students to articulate 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 the prediction larger or smaller that the experimental outcome. Evaluating the effects of additional assumptions is crucial for testing models and

hypotheses. To learn more about assumptions, read the following document written by D.T. Brookes at https://docs.google.com/.../0By53x8SYAF1lbVN5Sk9P.../edit...
In all my posts about elements of physics as knowledge, I referenced scientific abilities rubrics to help students navigate the elements of physics. The rubrics can be seen as specific tools for helping students operate with most of those elements effectively. In our first book on the ISLE approach (Etkina et al. 2019), all of Chapter V was dedicated to the abilities and rubrics. The work on Rubrics is described in several papers (Etkina et al. 2006, 2008, 2009, 2010; Bugge and Etkina 2016, 2020). The rubrics are available at https://sites.google.com/site/scientificabilities/rubrics. The rubrics help students design observational, testing, and application experiments; to develop explanations/hypotheses, to make predictions, to collect data and determine physical quantities, to evaluate assumptions and uncertainties, and to communicate.
The scientific abilities rubrics were developed by the Rutgers Physics Education Group in 2004 (a team of 9 people) long before NGSS an AP recognized the value of scientific practices in the learning of physics and they have been THE FIRST rigorous, tested and validated tool for the assessment of student engagement in such practices. Now, 20 years later they remain as relevant and comprehensive as they were then. Please use them.
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Eugenia Etkina
Admin

Level 3 contributor
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Hi @everyone! Two things today: first, yesterday I posted about the last element of physics knowledge - assumptions - and fewer than 3% of the group viewed it. So, please scroll down to yesterday's post to see it.
Second, tomorrow and the day after tomorrow - July 17 and 18 is the introductory ISLE workshop, 8 hours long. The leaders are Danielle Buggé, Carolyn Sealfon, Andrew Yolleck and I. As a few people who signed up for the workshop notified me that they cannot attend, we have a small number of open spots. The workshop requires homework using our textbook as well as preparing some equipment. If you have the textbook (there is no time to provide it to you) and are interested in doing the work and attending the workshop, please email me ASAP at eugenia.etkina@gse.rutgers.edu.
I will not post anything till July 19th. Please read last month's posts. They will help you implement ISLE from the beginning of the year and also help understand why we do things they way we do. Thank you.
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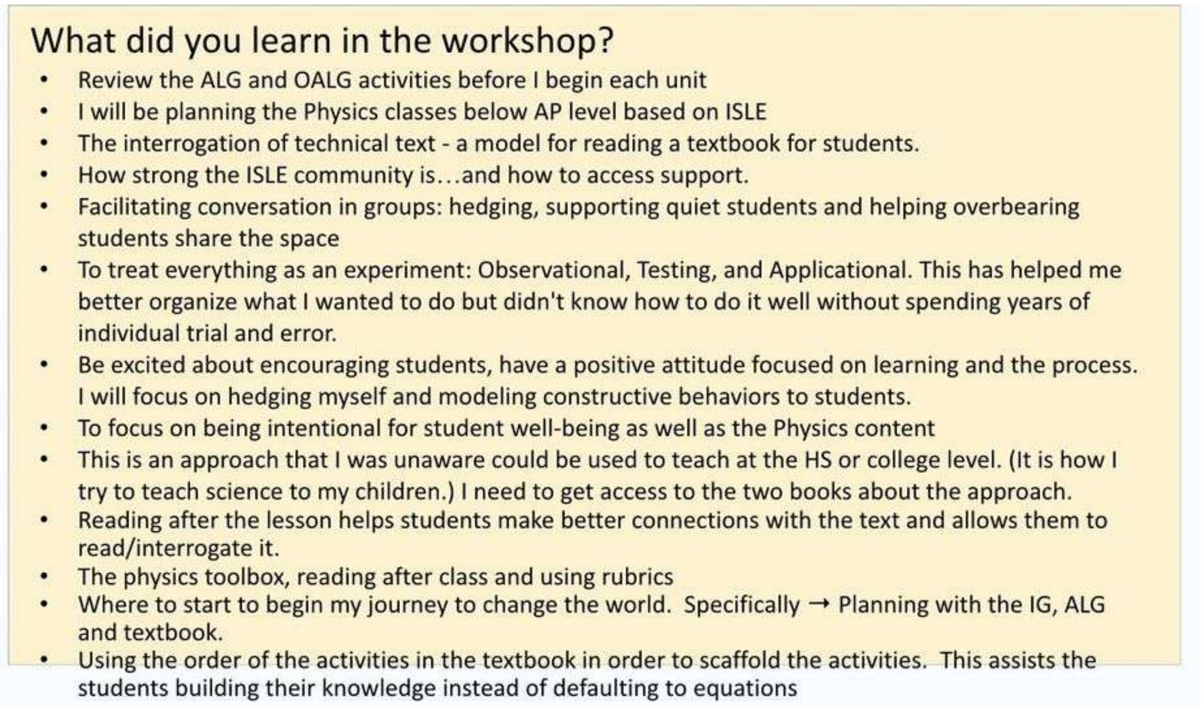
Eugenia Etkina
Admin

Level 3 contributor

Hi @everyone! We finished our 2-day 8-hour introductory ISLE workshop. Thank you all our participants who persevered during 4 hour zooms working actively on the activities and participating in discussions. Thank you Carolyn Sealfon, Danielle Buggé, and Andrew Yolleck for co-leading the workshop and Jade Lenshoek and Gregor Brumec who joined us to answer participants' questions. I am posting the link to the slides and to the recordings of the two days of the workshop and the reflection slide.
Link to the slides:
https://docs.google.com/presentation/d/1NmjhPT9zCF6GRe6iNMT2I1UPh7MeHMGODcI7D1dQOK0/edit?usp=sharing
Day 1 recording
https://rutgers.zoom.us/rec/share/IRVPI3KxqUa5iAzZaiAcx6ZidFbTNRuKNh9tz1cUnEgHIA7EBb5bMsQJxm1-H9oF.dX3Vj2xXgi5JsISb Password: m47Pz#Zq
Day 2 recording
https://rutgers.zoom.us/rec/share/L7vewXkCJE6wHqPSvk1zTmt0Lw-okbbG-TpymYMyCb7I_oq-4coN5cG9-nwEXqoR.qK-HECa2DTttn261 Password: R#?iq*2n



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Eugenia Etkina
Admin

Level 3 contributor

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Hi all, I continue with the development of physics habits of mind - or how to think like a physicist. I went over the structural elements of physics. But how are those connected to produce physics patters of reasoning? Read on!

How are the elements of physics connected to the physicist habits of mind?

When a physicist encounters a new phenomenon or reads a research paper, they habitually ask themselves the questions that I showed in my previous posts for each of the elements. Perhaps they do not ask all of the questions at once, but all of them eventually. It would be great if we, as physics teachers not only ask themselves these questions habitually, but engage the students in answering these questions when they encounter new ideas in the course. This practice might prevent students from seeing physics as collection of facts and instead allow them to see the above elements as the building blocks of physics, similar to the bricks, windows, banisters, toilets, sinks, etc. as building blocks of a house. One way to do it is to make posters in the classrooms with the questions to be answered about each element and when the students encounter a specific element, focus on the questions and the similarity of all representatives of such element (this is what I did when I was teaching high school). For example, when the students learn a new physical quantity, they should habitually ask themselves its operational definition, units, the instrument to measure it and so forth.

We can think of the elements discussed above as the building blocks of physics. How do physicists put them together or use them to develop the huge body of knowledge that our students need to learn? In their paper introducing the habits framework, Etkina, Gregorcic and Vokos (Etkina et al. 2017) give the following examples of reasoning used by physicists: “inductive (experiment-based) and ‘spherical cow’ reasoning, analogical reasoning, establishing causality, questioning claims, quickly assessing coherence of suggested ideas with the rest of the physics body of knowledge, and being able to spontaneously think of an experiment to test an idea when it is proposed (hypothetico-deductive reasoning) (page 010107-7).” I will elaborate on some of these examples

Inductive reasoning

In physics, inductive reasoning means finding patterns in the experimental data, constructing models and/or explanations of collected data, and making generalizations and extrapolations based on data (Copi et al. 2006). This type of reasoning is crucial for the implementation of the ISLE approach as observational experiments, their analysis, and inference of patterns is the first step in the student construction of any concept.

An example of inductive reasoning could be moving a magnet with respect to a coil connected to a galvanometer and deducing the pattern inductively.

Activity for the students:

Observational experiment Your group has the following equipment: a whiteboard, markers, a coil with several turns, a bar magnet, and an analogue galvanometer (see ALG or OALG Chapter 21).

a. Examine the equipment that you have on your desk. The galvanometer registers current through the coil. It needs to be connected directly to the coil (note, there is no battery). Now that you have connected the galvanometer to the coil, work with your group members to find out what you can do to make the galvanometer register a current through the coil. Once you figure out one way, look for other ways 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.

The students conduct a series of experiments and find that for certain motions the current is induced through the coil, but for other motions and when the magnet is at rest with respect to the coil, there is no current through the coil.

This finding is a pattern, but it can be generalized to form a hypothesis. The generalization (hypothesis) would be that one needs to have relative motion between a coil and a magnet to induce a current in the coil. We can think of this hypothesis as a causal explanation. It connects the cause (motion of a magnet) to the effect (the appearance of the induced current).

This was a qualitative example. To see how we can help students develop quantitative inductive reasoning, I use an example from electrostatics. Imagine that your students are investigating interactions of electrically charged objects. You do not have equipment for them to collect quantitative data, so you offer them the following activity, which helps them to construct Coulomb's law.

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 is attached 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.

As you can see from the above examples, inductive reasoning is used for the analysis of the observational experiments. The elements of physics used in inductive reasoning are the phenomena (observational experiments), physical quantities, and models/explanations/hypotheses. Sometimes two other elements are used too - measuring instruments and physics devices, but those are not always necessary.

We have developed specific language for the prompts that would elicit students' qualitative and quantitative descriptions of phenomena. Although we listed some of them when discussing phenomena/observational experiments, some prompts are new:

· Describe what you observe using simple language that a 5-year-old will understand.
· Describe what you observed without trying to explain.
· Describe the experimental set-up with words and with a sketch.
· Decide what is/are the independent variable(s) and what is the dependent variable.
Represent the data graphically.
· Find a pattern in the graph.
· Represent the pattern mathematically.
· Devise an explanation for the pattern (or devise a hypothesis explaining the pattern).

When students collect data, there is an issue of experimental uncertainty. I will come back to this issue in later posts.

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

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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi all Exploring and Applying Physics people! I continue with the types of reasoning that physicists use to connect logically the elements of physics that I discussed before. Two days ago I posted about inductive reasoning, today is the THE SPHERICAL COW REASONING. Read on!

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#:~:text=Originating%20in%20theoretical%20physics%2C%20the,the%20model's%20application%20to%20reality)
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, the curvature of Earth's surface, the dependence of g on the distance from the center of Earth and so forth. We teach them that Newton's laws are only applicable in inertial reference frames while being on a rotating and revolving Earth means that we, as observers, are clearly in a non-inertial reference frame. We do it as the effects of the above factors are small compared to the main factors affecting the phenomena and, if ignored, we still arrive at predictions supported by the experiments. The problem is that our students (and even teachers) will very often not be aware that a particular approach ignores some factor. A great example is the formulation of Newton's first law in most American introductory textbooks. Here are two examples:

· If the net force on an object is zero, the object does not accelerate and the velocity of the object remains constant. If the object is at rest, it remains at rest; if it is in motion, it continues in motion in a straight line at constant speed. (Stewart et al., 2019).

· Every object continues in its state of rest, or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it (Hewitt, 2014)

This wording leads the students to believe that both statements are always true. But if an observer is accelerating themselves, then this law does not work.
We teach our students Newton's laws while 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 are 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 is not accelerating 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 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 is infinitely more important.
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Eugenia Etkina
Admin

Level 3 contributor

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Hi all Exploring and Applying Physics people! I continue with the types of reasoning processes that physicists use. We discussed inductive reasoning and spherical cow reasoning. Today is another super important type.

Analogical reasoning

Analogical reasoning is often used when we wish to explain a new phenomenon using something that we know by using the word “like”. An analogy is a cognitive device and should not be confused with a 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 an analogy, but we speak about time as we would speak about money.

When we make analogies, we are trying to understand or explain some new phenomenon using our knowledge of a familiar phenomenon. The new phenomenon is called a “target” and the known phenomenon is called a “base”. In a way, making an analogy is mapping the objects and their relationships in a target to the known objects and their relationships between objects in the base (Glynn et al. 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 and 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, a battery provides a constant voltage for a wide range of resistances including the case when the resistance is infinite (an open switch). The pressure difference provided by the pump on the other hand strongly depends on the resistance of the system to flow and it increases significantly when the flow is stopped (a closed valve). The electrical resistance of the wires is inversely proportional to the cross-sectional area of the wire while the resistance of the tube to liquid flow is inversely proportional to the square of the cross-sectional area of the tube (Poiseuille law).
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. This is because 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 and Etkina 2007). 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 or mechanism to something that they already know.

For example, in the case of explaining how a disturbance can propagate along a string, my students came 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.

If you finished reading the post, you know what to do next! Thank you!
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Eugenia Etkina
Admin

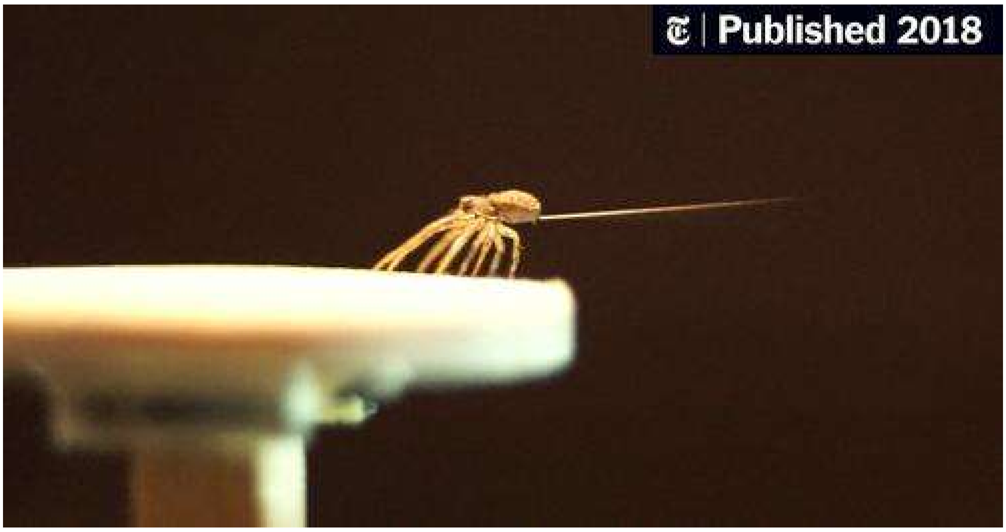
Level 3 contributor
· ·

Hi @everyone! I continue with the types of reasoning that physicists use and that we need to engage in our students. All of the types that I posted before (inductive, spherical cow and analogical) are present in the process through which students learn physics in ISLE. Now, the most important type! Long post, though...
Hypothetico-deductive reasoning
According to Encyclopedia Britannica (https://www.britannica.com/.../hypothetico-deductive-method), “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 stars using Albert Einstein’s newly proposed general relativity. 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 method is used in the ISLE process when we make predictions of the outcomes of the testing experiment using a hypothesis under test and then make a 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 being larger or smaller than predicted?
· How can you validate your assumptions?
· After you conducted the experiment, what is your judgement about the hypothesis?
In the textbook College Physics: Explore and Apply there are multiple examples of hypothetico-deductive reasoning. In our recent workshop we used an example in Chapter 22 when we showed how the students test a hypothesis that each point of an extended source emits one ray of light. In this example, the reasoning was as follows (see the slides for the workshop that I posted on July 19):
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 poked in it], 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 only one ray] is [not true and rejected].
How can we help our students develop H-D reasoning? As is the case with 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 with teachers:
· 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 by 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 the logical flow of hypothetico-deductive reasoning 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 teachers and students practice such reasoning (see their brief description in the section below). 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 the elements of physics.
Below is an example of such an activity (the solutions are italicized):
SPIDERS CAN FLY (adapted from (Yong 2018))
Match the sentences with the elements of scientific reasoning (see table below) by writing the number that you find at the beginning of the sentence into the corresponding row in the table.
Elements of scientific reasoning
Sentence numbers
Observations, collecting data, identifying patterns
1, 4, 10
Proposing a hypothesis, explanations, models
3, 5, 11

Making assumptions
2
Designing/proposing testing experiments
6
Prediction for the outcome of the testing experiment
7
Outcome of the testing experiment
8
Making judgments
9

(1) On October 31, 1832, Charles Darwin walked onto the deck of his ship and realized that thousands of tiny red spiders had boarded the ship. (2) The ship was 60 miles offshore, so the creatures must have floated over from the Argentinian mainland. Spiders have no wings, so how can they be taken into the air? (3) For a while, it was commonly believed that the spider silk catches on the wind, dragging the spider with it. (4) But then scientists noticed that spiders only “fly” during light winds. (5) An alternative idea was first proposed in the early 1800s: spiders fly by electrostatic repulsion. Recently, Erica Morley and Daniel Robert from University of Bristol tested the idea with actual spiders. (6) They decided to put the spiders on vertical strips of cardboard in the center of a plastic box in which they could generate electric fields similar in strengths to what the spiders experience outdoors. (7) If the electrostatic repulsion idea was correct, they expected to see some spiders taking off when switching the electric field on. (When they conducted the experiment, many of the spiders actually managed to take off, despite being in closed boxes with no airflow within them. (9) Based on this result, scientists agreed that electrostatic repulsion plays an important role in spider flying. (10) However, researchers from Technical University of Berlin recently showed that spiders prepare for flight by raising their front legs into the wind. (11) Therefore, it seems that the complete explanation for the phenomenon might include a combination of electrostatic repulsion and the motion of air



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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi all, today is my last post about physics reasoning that we wish our students to develop. Starting tomorrow I will go over examples of different types of reasoning in EVERY chapter of the textbook and ALG/OALG - not all at once, of course, but chapter by chapter. Here is goes - please "like" and comment!

Theory

You have probably been wondering why I never mentioned the word “theory” in our discussions of the elements of physics or physics models of reasoning. I provide an explanation below.

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:

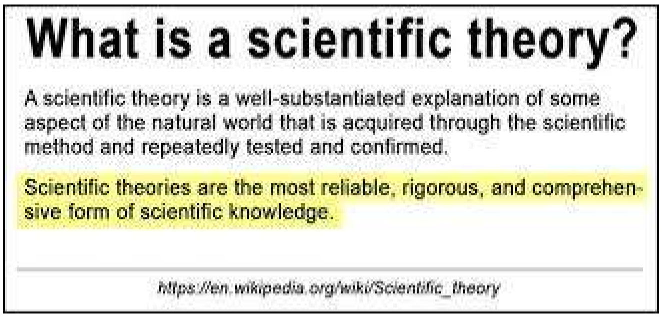
· Newtonian Theory, which explains the wide range of mechanical phenomena involving macroscopic objects at speeds much smaller that the speed of light; has its own set of physical quantities, conceptual and mathematical models which were tested in numerous experiments, measuring instruments and physics 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”.
Note: if you google scientific theory and look for images, you will see how many wrong interpretations of this word exist on the internet. Be aware!
Now, that you finished reading, you know what to do next! Thank you!



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Eugenia Etkina
Admin

Level 3 contributor

Hi all Exploring and Applying Physics people! I have been posting for a while about the structural elements of physics and the way physicists put them together to create new knowledge. We teach out students to do the same. Not only we do it on the first day, but we continue through the year. I promised yesterday to show how different types of reasoning are developed through the course of the year. The first one is hypothetico-deductive reasoning and it starts on day one. See activities in the OALG Chapter 1 and the guidance for the teacher in the Instructor Guide. Here is the text in the textbook that introduces students to this type of reasoning AFTER they did the activities together in class. Chapter 1. Do not miss!

A simple example will help you understand some processes that physicists follow when they study the world. Imagine that you walk into the house of your acquaintance Bob and see 10 tennis rackets of different quality and sizes. This is an **observational experiment**. During an observational experiment a scientist collects data that seem important. Sometimes it is an accidental or unplanned experiment. The scientist has no prior expectation of the outcome. In this case the number of tennis rackets and their quality and sizes represent the data. Having so many tennis rackets seems unusual to you, so you try to explain the data you collected (or, in other words, to explain why Bob has so many rackets) by devising several hypotheses. A **hypothesis** is an explanation that usually is based on some mechanism that is behind what is going on, or it can be a mathematical model describing the phenomenon. One hypothesis is that Bob has lots of children and they all play tennis. A second hypothesis is that Bob makes his living by fixing tennis rackets. A third hypothesis is that he is a thief who steals tennis rackets.

How do you decide which hypothesis is correct? You may reason: if Bob has many children who play tennis, and I walk around the house checking the sizes of clothes that I find, then I will find clothes of different sizes. Checking the clothing sizes is a new experiment, called a **testing experiment**. A testing experiment is different from an observational experiment. In a testing experiment, a specific hypothesis is being "put on trial." This hypothesis is used to construct a clear expectation of the outcome of the experiment. This clear expectation (based on the hypothesis being tested) is called a **prediction**. So you conduct the testing experiment by walking around the house checking the closets. You do find clothes of different sizes. This is the **outcome** of your testing experiment. Does it mean for absolute certain that Bob has the rackets

TIP Notice the difference between a hypothesis and a prediction. A hypothesis is an idea that explains why or how something that you observe happens. A prediction is a statement of what should happen in a particular experiment if the hypothesis being tested were true. The prediction is based on the hypothesis and cannot be made without a specific experiment in mind.

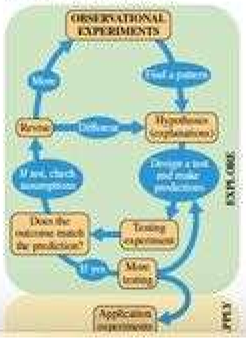
because all of his children play tennis? No; he could still be a racket repairman or a thief. Therefore, if the outcome of the testing experiment matches the prediction based on your hypothesis, you cannot say that you proved the hypothesis. All you can say is that you failed to disprove it. However, if you walk around the house and do not find any children's clothes, you can say with more confidence that the number of rackets in the house is not due to Bob having lots of children who play tennis. Still, this conclusion would only be valid if you made an **assumption**: Bob's children live in the house and wear clothes of different sizes. Generally, in order to reject a hypothesis you need to check the additional assumptions you made and determine if they are reasonable.

Imagine you have rejected the first hypothesis (you didn't find any children's clothes). Next you wish to test the hypothesis that Bob is a thief. This is your reasoning: *If* Bob is a thief (the hypothesis), *and* I walk around the house checking every drawer (the testing experiment), *then* I will not find any receipts for the tennis rackets (the prediction). You perform the experiment and you find no receipts. Does it mean that Bob is a thief? He might just be a disorganized father of many children or a busy repairman. However, if you find all of the receipts, you can say with more confidence that he is not a thief (but he could still be a repairman). Thus it is possible to disprove (rule out) a hypothesis, but it is not possible to prove it once and for all. The process that you went through to create and test your hypotheses is depicted in Figure 1.3. At the end of your investigation you might be left with a hypothesis that you failed to disprove. As a physicist you would now have some confidence in this hypothesis and start using it for practical applications.

Using this textbook you will learn physics by following a process similar to that described above. The section "How to use this book to learn physics" at the end of this chapter will explain how to master this process.

Physicists use words and the language of mathematics to express ideas about the world. But they also represent these ideas and the world itself in other ways—sketches, diagrams, and even cut-out paper models (James Watson made a paper model of DNA when trying to determine its structure). In physics, however, the ultimate goal is to understand the mechanisms behind physical phenomena and to devise mathematical models that allow for quantitative predictions of new phenomena. Thus, a big part of

FIGURE 1.3 Science is a cyclical process for creating and testing knowledge.



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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi all Exploring and Applying Physics people! Now that we finished a series of posts about the types of reasoning that we wish our students to develop, I will start slowly posting about teaching kinematics - the first unit. Please scroll down to see my posts abut starting the school year - the first 3 days of school. After that, comes kinematics. (Actually, you can also start with geometrical optics - Chapter 22, as those two topics do not build on any prior physics). Please check posts daily to see the progression.
Here is my recommendation for preparing for kinematics:

First study the goals that we put for the unit in the Instructor Guide to see whether you agree with them. Then, read the textbook chapter and go over example problems. Then check out chapter activities in the ALG/OALG and finally work though the end of chapter problems. Both the IG and OALG provide suggestions on what to assign for homework and tests. We recommend daily formative assessments in the form of one question quizzes to make sure that every students is on board. So, I start with the goals for the kinematics unit as they are listed in the Instructor Guide (the Guide is posted here in the FILES). note, that those are kinematics specific goals, the general science process goals (scientific abilities-based goals) are outlined in the Introduction to the Instructor Guide.

After studying kinematics

Students should be able to:

1. “Read and write” with motion diagrams (students can interpret a given diagram and draw a diagram for a given scenario).
2. “Read and write” with motion graphs; reading in this context means being able to interpret a graph, to write a mathematical function for the motion on the graph, to find the slope of the graph and the area between the graph and the time axis; writing in this context means being given a function for any kinematics quantity and using it to draw all three graphs (position-versus-time, velocity–versus-time, and acceleration-versus-time).
3. “Read and write” with vectors.
4. Find consistency or inconsistency between different representations of motion.
5. Operate with average quantities and differentiate between the quantity and its change; velocity and velocity change for example).
6. Compare and contrast displacement, velocity, and acceleration, and solve problems involving these quantities.
7. Compare and contrast position, displacement, distance, and path length, and solve problems involving these quantities.
8. Explain where the equations for position as a function of time for motion at constant velocity and at constant acceleration come from.
9. Explain the meaning of the term “reference frame” and analyze the same motion using different reference frames.

How do your goals compare to ours? How do you think one can assess student achievement of these goals?

If you finished reading, you know what to do next   Thank you!

The photo is of the students of Danielle Buggé working on a kinematics activity.

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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi @everyone! recently my posts are having fewer views but a lot more people "like" and comment. I am not sure why it is happening, that is why I am tagging everyone to see if it makes a difference in how many people view the post.
Yesterday I started posting about kinematics - Chapter 2 in College Physics: Explore and Apply. I shared the goals as they are listed in the Instructor Guide. Today, I am focusing on the first fundamental idea in studying motion - the fact that motion is relative. Relative to what? To the observer! Everything in motion depends on the observer. The phenomenon itself looks different for different observers, the quantities describing motion also depend on the observer. But most importantly, as we learn in chapter 3, THE MIST IMPORTANT LAWS OF PHYSICS DEPEND ON THE OBSERVER! I am talking about Newton's laws, which are only valid for very specific observers. So, in order to understand Newton's laws, one needs to learn the importance of specifying the observer when studying ANY motion. Here is an activity in OALG Chapter 2 that helps students do it and a parallel set of activities in the ALG.
OALG activity
OALG 2.1.1 Describe
Watch the video of cars moving on a street https://mediaplayer.pearsoncmg.com/.../_fr.../sci-OALG-2-1-1.

Use the arrow keys on your keyboard to play the video frame by frame. Notice the yellow and red cars and a pedestrian in the pink dress on the street (see photo below).
a.Describe how a passenger in the yellow car sees the motion of the driver of the yellow car, the driver of the red car, the pedestrian on the sidewalk.
b.How does the pedestrian describe the motion of the driver of the yellow car?
c.Why would the passenger in the yellow car and the pedestrian disagree about the motion of the driver of the yellow car?
d. Based on your answers in parts a. through c., explain what it means when someone says an object is “moving” and what it means when we say “motion is relative”.
e. To help with the answer to part d. Read and interrogate Section 2.1 Chapter 2 text on page 14 (up to Modeling motion) in the textbook .
ALG Activities
2.1.1 Describe
Class:Equipment per group: none.
Each member of your group plays a role in the story described below. Assign roles and discuss the answers to the questions. Then get up and enact the story for the rest of the class.
Story: A person sits in the passenger seat of a car that is traveling along a street. Describe the person’s motion as seen by each of the following observers:
a. another person sitting in the backseat of the car;
b. a pedestrian standing on the sidewalk as the car passes; and
c. the driver of a second car moving in the same direction and passing the first car.
2.1.2 Describe
Class:Equipment per group: none.
Each member of your group plays a role in the story. Assign roles and discuss the answers to the questions. Then get up and enact the story for the rest of the class.
Story: A person stands near a bus stop. Describe the standing person’s motion as seen by the following observers:
a. a person sitting in an approaching bus;
b. a person riding in a car moving away from the bus stop; and
c. another person standing at the bus stop.
2.1.3 Explain
Class:Equipment per group: none.
Discuss with your group members your analyses for Activities 2.1.1 and 2.1.2 and answer the questions that follow. Did you agree on your answers? If not, what were the contentious points?
a. Do any observers say that the person sitting in the passenger seat of the car in Activity 2.1.1 was moving? Explain.
b. Do any observers say that the person sitting in the passenger seat of the car in Activity 2.1.1 was not moving? Explain.
c. Do any observers say that the person standing near a bus stop in Activity 2.1.2 was moving?
d. Do any observers say that the person standing near a bus stop in Activity 2.1.2 was not moving?
e. Based on your answers in parts a. through d., explain what it means when someone says an object is “moving.” List all explanations on the board and discuss which is the most comprehensive.
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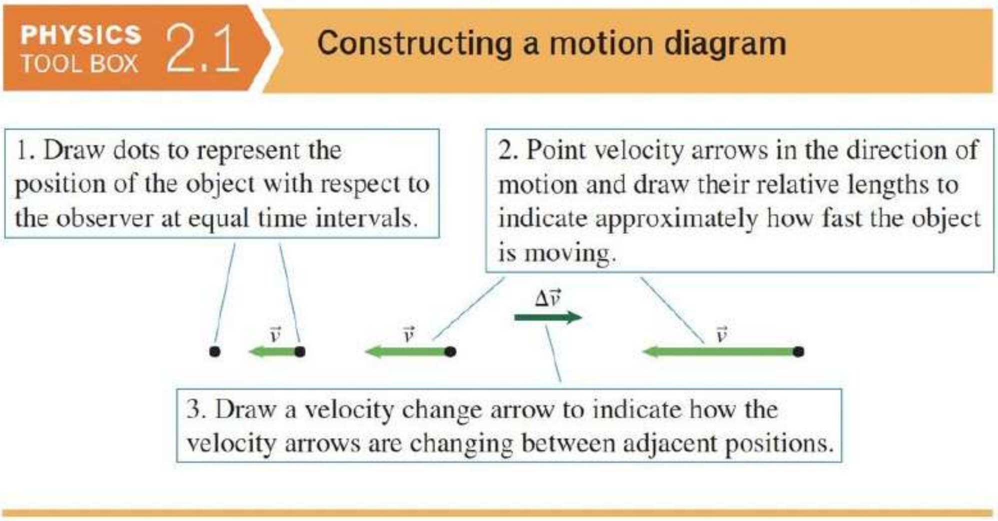
Eugenia Etkina
Admin

Level 3 contributor
· ·
Hi all Exploring and Applying Physics people! I continue with kinematics. Warning- there will be no post tomorrow as I will be traveling all day.
Now, kinematics... You probably noticed that in all chapters of our textbook as well as in the ALG/OALG the first several sections have no algebra. They are purely conceptual and only use simple experiments and graphical representations. It is a deliberate effort to help our students to have images of physical phenomena that math describes later and to build confidence tat they can succeed in physics. When we hit our students with algebra before they construct concepts, those who did not develop algebraic reasoning robustly "fall off" and start thinking that they cannot learn physics. Therefore, after constructing the idea of a refenrece frame and the importance of defining the observer when describing motion, we help our students construct the first physics representation - a motion diagram - that is essential not only for kinematic, but most importantly, for applying Newton's second law to analyze force-related situations. See activities in the ALG/OALG (I am pasting only ALG activities here, as the OALG Chapter 2 is posted here in the FILES) that help students construct the first graphical representation in their learnign of physics - the motion diagram. Note that the most crucial part of the diagram is the velocity change vector.
2.2.1 Observe
PIVOTAL Lab or class: Equipment per group: metronome (download a metronome app.) or any device to keep track of time in seconds, low-speed battery-operated car, sugar packets (or any other marking device), meter stick (or any other length-measuring device), whiteboard and markers.
This activity requires collaboration and coordination of all group members. Set a metronome to about one beat per second. Person 1 turns on a battery-operated toy car and releases it to roll across the floor. Person 2 places sugar packets on the floor at the points where the car is located at every blip of the metronome (instead of sugar packets you can use anything else that will allow you to mark the floor where the car was every second, be creative!). Do not try to put the sugar packets where the car was just released. After about 5 to 7 blips, stop the car and draw a sketch showing the locations of the sugar packets as dots. Discuss with the group members how you can use the dots to describe the motion of the car. After you come to a consensus, draw your representations on the board and share it with the class. [If you do not have a toy car, you can use a hard ball such as a billiard ball or bowling ball that you roll on a smooth floor.]
2.2.3 Observe
PIVOTAL Lab or class: Equipment per group: metronome or any device to keep track of time in seconds, any light/soft rubber ball or under-inflated basket ball, sugar packets (or any other marking device), meter stick (or any other length-measuring device), whiteboard and markers.
This activity requires collaboration and coordination of all group members. One group member sets a metronome to 1-second intervals. Another person places a flexible ball such as a hollow rubber ball at rest on the floor (The ball should be flexible enough to change shape a little when on a surface.) This person abruptly pushes on the ball once with a ruler

so that the ball rolls away from the ruler, moving with considerable speed. The third group member moves beside the ball and places sugar packets on the floor to indicate positions of the ball every second after the ruler no longer touches the ball. Discuss together: describe the motion of the ball in simple words, draw a sketch representing the sugar packets with dots, and describe the relative distance between the packets. How does the distance between the packets correspond to the observed motion of the ball?
2.2.4 Explain
Class: Equipment per group: none.
Examine Figure 2.2 in the textbook. Explain the changes in the light traces of the LED in each experiment. In particular:
a.What can the length of the light trace tell you about the motion of the cart?
b.If each subsequent light trace gets shorter, what does that tell you about the motion of the cart?
c.If each subsequent light trace gets longer, what does that tell you about the motion of the cart?



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Eugenia Etkina
Admin

Level 3 contributor
· ·

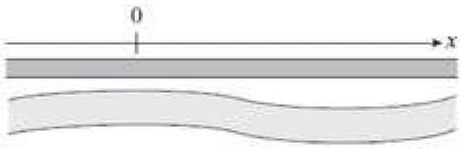
Hi all, I am back to posting and will continue with kinematics. So far we discussed to important ideas: the relativity of motion and the motion diagram. Once the students have constructed those, they are ready for mathematical description of motion. Here I will skip the section on vectors (2.3) and physical quantities (2.4) in the textbook, please read those before you continue this post. We start with the motion of constant speed but the approach

to the invention of the concept of velocity is very similar to the process through which the students invent the concept of acceleration.
We start with collecting position-vs-time data for objects moving at constant speed, then graphing it and then analyzing the slopes of the graphs. The students can collect these data using cars that move at constant speed. It is good to have cars of two different speeds so that they can see how the slopes of the graphs correspond ot real objects. Once the students analyze the slopes, we can give the slope the name - velocity. This way velocity is not displacement over time but the slope of velocity vs time graph. The slope can be positive or negative - which corresponds to the direction of motion relative to the chosen positive direction. Here the students see a different meaning of the negative sign compared to mathematics- direction.
Here are ALG activities but please read the textbook to know how to approach them. (The students need to read the textbook AFTER they do the activities, but the teachers should read BEFORE).
2.6.1 Represent mathematically
PIVOTAL Class: Equipment per group: whiteboard and markers.
Work together with your group members to answer the following questions:
a. Examine the graphs you drew in Activity 2.5.1c. (I pasted the screenshot of 2.5.1 below) Write two function expressions x (t) for the graphs. Consider your labeling system: how can you distinguish the function for your bike from the function for your friend's bike?
b. What are the physical meanings of the slope of each function and the intercepts? What common name can you use for the slope? Explain the meanings of positive or negative values for these quantities.
c. Compare and contrast how we write linear functions in mathematics to how you just wrote the position-versus-time functions for motion. What is the same between them? What is different?
2.6.2 Test your idea
PIVOTAL Lab: Equipment per group: whiteboard and markers, metronome or any device to keep track of seconds, 2 battery-operated toy cars that move with different speeds, sugar packets (or any other marking device), meter stick or ideally a longer tape measure.
Work with your group members on the following assignments. Make sure that your group keeps detailed records of the experiments so that another group from your class can repeat the experiments and get the same results.
a. For car A, design an experiment to decide if the car moves with constant velocity. If it does, determine the magnitude of the velocity (the car's speed).
b. For car B, use the same equipment and method to decide if this car moves with constant velocity. If it does, determine the magnitude of the velocity (the car's speed).
c. Predict where the cars will meet if you simultaneously release them from 2.0 m apart moving straight toward each other. List all assumptions that you made about how the cars move. If the assumptions were not valid, how would your prediction change?
d. Decide how you will record the data. How will you represent the data? In your representation, mark the predicted value for the meeting location. Perform the experiment and collect data.
e. Did the outcome match your prediction? How many times do you need to conduct the experiment to be able to say for sure whether the outcome of the experiment matches the prediction or not? Write the result of the experiment (meeting location) accounting for the discrepancies in the meeting location in different repetitions of the experiment.
If you finished reading the post, you know what to do next. Thank you!

2.5.1 Observe and describe

PIVOTAL Class: *Equipment per group:* whiteboard and markers, meter stick.

Imagine that you and your friend ride bicycles along a straight path beside a river. A coordinate axis is shown alongside the path.



The table indicates your position along the path at different clock readings.

Clock reading t (s)	Your position x (m)	Your friend's position
$t_0 = 0$	$x_0 = 640$	$x_0 = 640$
$t_1 = 20$	$x_1 = 500$	$x_1 = 490$
$t_2 = 40$	$x_2 = 360$	$x_2 = 340$
$t_3 = 60$	$x_3 = 220$	$x_3 = 190$
$t_4 = 80$	$x_4 = 80$	$x_4 = 40$
$t_5 = 100$	$x_5 = -60$	$x_5 = -110$
$t_6 = 120$	$x_6 = -200$	$x_6 = -260$

a. Work with your group members to write everything you can about the bike rides and indicate any pattern in the data. What was happening at the clock reading of zero?

b. Draw motion diagrams for both bikes.

c. Construct position-versus-clock-reading graphs for both bike trips using the same coordinate axes in which x is a dependent variable and t is an independent variable. Compare and contrast the graphs – how do the graph lines represent the differences in the bikes' motions? Check with other groups – are their graphs the same or different from the graph of your group?

d. Discuss with your group members how the motion diagrams in part b. correspond to the graphs. How do you need to position the motion diagrams with respect to the graph axes so that it helps you visualize the motions?

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Eugenia Etkina
Admin

Level 3 contributor
· ·

I will hold off posting new stuff today to let everyone catch up with how the students invent the physical quantity of velocity. But, I wanted to add an important note here.
When we define velocity as the slope of x-vs-t graph, we are dividing something in meters by something in seconds, a new quantity arises, that is neither meters nor seconds. It is a different concept of division compared to mathematics where division is a continuous subtraction fo the same quantity. This is a huge difference between math and physics. UNITS make this difference. Have a discussion with them about it.

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1RLtFP_muDNemq9FShwLuwiIUF7gsl7qBnU3gv5mn_5qfe7AhfWZCefrQ5b0k-hIO-b-ojqumGSK9dVpRibMNAxCSfejBSLDy5DBzPz0r-K8RHh1Q7Gxy8RiKvwbcqdwcBCmonDjPE7WSYbHYMOz1B32sRqO97nBl6iPvqSwxDTjgq7J&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi @everyone! I continue with kinematics. Imagine that your students invented the concept of velocity as I described in the post two days ago and are confident applying this concept to the actual motion. They also learned how to find the position of an object moving at constant velocity at any clock reading (see ALG activities for that and the textbook). Today I am sharing one of my most favorite activities in the ALG for the students to apply their knowledge to a real world problem. It is one of my favorites because it make them search for additional information, connect ideas from different sciences, and just become more educated citizens. Do not skip!
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 - taken by Gorazd Planinsic when we were observing the eclipse).
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

Level 3 contributor
· ·

Hi all Exploring and Applying Physics people! Our numbers are growing - we have over 2700 people in the group. While this is amazing and makes me feel great, I worry sometimes if the new members have the time and information to know who we are and what resources we have. The question posted by Bill Goodwin yesterday made me think about it. So, today I summarize (very briefly) what we are and what we have. New members, please ask questions!!
The philosophy behind everything that we do is ISLE - the Investigative Science Learning Environment approach to learning and teaching physics. It is an intentional approach to curriculum design that has two major goals: the students learn physics by engaging in the same processes that physicists use to construct new ideas and apply then AND students' well being is improved in the process (they develop confidence, growth mind set and feel that they belong in physics). These goals are achieved EVERY DAY though the use of specific tools that we have developed. The main goal behind those two goals is to raise people who CAN THINK CRITICALLY, which means to distinguish between evidence and inference, understand the nature of assumptions and uncertainties, use hypothetico-deductive reasoning to test their claims, and so forth. The kind of reasoning that our society needs to survive. To summarize: our goal is not to teach PHYSICS but to teach PEOPLE.
To help students learn this way and teachers implement this approach we have created TONS of resources. Most of them are completely free except the textbook (which is free to

teachers but not for the students). The resources are at the website
https://www.islephysics.net/
The textbook information is at https://www.islephysics.net/?page_id=159 in addition to the textbook, Mastering Physics platoform gives you access to the free Active Learning Guide, (ALG) Online Active Learning Guide (OALG), the Instructor Guide and lots of other stuff. Both OALG files and the Instructor Guide are posted here in the FILES. Check them out!
MORE free resources are at https://www.islephysics.net/?page_id=51
To get access to some of the free resources you need to have Mastering Physics account (Pearson). If you are a US instructor, just contact your Pearson rep. If you are not in US, please send me an email at eugenia.etkina@gse.rutgers.edu.
This group represents an example of a communal continuous professional development for those who wish to implement ISLE.
While we share individual activities, those are not the goal of ISLE - the logical progression and the specific implementation are. To learn those you need to attend our workshops and to read two books written about ISLE. If you do not have them in your school library, please email me and I will send you the pdfs. My email is in this post. We have daily posts about specific aspects of ISLE implementation and monthly online workshops (free), 2 hours on Saturday, see your EVENTS for the next workshop (on Magnetic fields).
Below are the books about ISLE.
I am also asking those who have been implementing ISLE for a while (or forever :)) to share their thought about it for the new members. PLEASE!
Etkina, E., Brookes D.T., & Planinsic, G. (2019) Investigative Science Learning Environment: When learning physics mirrors doing physics, Institute of Physics, Concise Publishing; Morgan and Claypool Publishers, DOI 10.1088/2053-2571/ab3ebd.
https://iopscience.iop.org/book/mono/978-1-64327-780-6
Etkina, E. & Planinsic, G. (2024) Investigative Science Learning Environment: A guide for teacher preparation and professional development, IOP Publishing Ltd 2024.
https://iopscience.iop.org/book/mono/978-0-7503-5568-1
Please ask questions! And thank you for reading.
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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi Exploring and Applying Physics people! I continue with the invention of kinematic quantities. I posted about the general approach - students do an experiment, collect the data, plot the data, then make sense out fo the data and give the new quantity the name. In case of velocity it was very simple - position-vs-time data for a constant motion car gives you the slope which we call velocity. For acceleration is is more complicated as the students need to graph velocity-vs-time to get the slope which they will call acceleration. Here is an ALG activity that takes students step by step through doing this. The most important is to choose the clock reading for which to calculate the average velocity for a time interval. The

screen shot of the table that scaffolds students' work helps them do it. Also, clear instructions are in the textbook: page 31 in the textbook (make sure you are using the right edition, the cover is the cover of this group). Here is the activity:
2.7.1 Observe and analyze
PIVOTAL Lab or class: Equipment per group:whiteboard and markers, motion detector (if available), a small object that can be dropped and will not bounce, meter stick or any other length-measuring device, video camera.[https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]
a. Use the available equipment to design an experiment to record position-versus-time data for a ball falling from the height of about 2 meters. It helps to position the motion detector above the falling ball, not below.
b. Perform the experiment and collect data. If you are using a motion detector, the data will be represented as a graph right away. If you are analyzing a video, you will need to figure out how to collect position and time data from it. Repeat the experiment a few times. What can you say about the motion of the ball based on the data you collected?
c. Draw a motion diagram for the ball.
d. Draw a position-versus-time graph for the ball. Discuss whether the graph resembles a position-versus-time graph for an object moving at constant velocity.
e. Determine the scalar component of the average velocity for the ball for each time interval by completing the following table.
f. Plot this average velocity v^x on a velocity-versus-time graph. The time coordinate for each average velocity coordinate should be in the middle of the corresponding time interval (the average time for that time interval). Draw a best-fit line for your graph.
g. Discuss with your group the shape of the graph: How does the speed change as time elapses? Suggest a name for the slope of the graph.
Please try it with your students and share your experiences here! And 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

Level 3 contributor

Hi @everyone! I continue with kinematics. If you are new to the group, scroll down and see the posts in chronological order.
The activities in this post show how to help students derive the expression for the position of an object moving at constant acceleration. Derivations are now a big thing in AP, much bigger than before. Note the "pivotal" notation in the activities, this means that people who

have implemented ISLE consider them super important. The summary table is crucial for reflecting on what students have learned.
Also, please note how activities are worded. Research shows that it is important to articulate in the activity text that students need to work together and share.
2.8.1 Derive
PIVOTAL Class: Equipment per group: whiteboard and markers.
Discuss with your group members how you can construct a function x(t) for a cart that moves at constant acceleration. Choose the simple case first: when the cart starts at the origin of the coordinate system and has zero initial speed. There are many ways of doing this. Think of average velocity or a velocity-versus-time graph. Once you agree on the method, follow through and derive the expression. Evaluate the expression using limiting case analysis – for example, does your equation work for constant-velocity motion? Share the expression with the class – are you in agreement concerning the function x(t) ?
2.8.2 Design an experiment
Lab: Equipment per group: Low-friction track and a cart, motion detector or a stopwatch, meter stick.
Design an experiment to investigate the motion of a cart moving up and down an inclined plane. You push it forcefully at the bottom of the plane so that it moves up the slope, and then it stops and moves back down. You can use a motion detector, a stopwatch, a meter stick, and other equipment available in the lab.
a. Describe your experiment in words and draw the setup.
b. What data will you collect?
c. How will you organize and report your data so that others can understand it?
d. After you have made all the decisions, conduct the experiment and write down your findings. What can you say about the motion of the cart?
2.8.3 Summarize
PIVOTAL Class: Equipment per group: whiteboard and markers.
This is a really helpful activity to do with your group: Use different representations of the two types of motion we have studied to fill in the empty cells in the table. Some cells are completed to give you an idea of the motions and the direction of the coordinate axis for each case. Your responses should relate to the motion already described. Completing the table will help you summarize everything you have learned about the description of motion. Resolve any confusion you may have by talking with your group members.
If you read the post to the end, you know what to do next. Thank you!

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Eugenia Etkina
Admin

Level 3 contributor

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Hi all Exploring and Applying Physics people! A few things today. First, our Magnetism workshop (https://www.facebook.com/events/1019334956441111/?acontext=%7B%22event_action_history%22%3A[%7B%22mechanism%22%3A%22your_upcoming_events_unit%22%2C%22surface%22%3A%22bookmark%22%7D]%2C%22ref_notif_type%22%3Anull%7D) is approaching. To prepare for the workshop you need to study Chapter 18 in the textbook - Electric field. Our approach to fields is different form traditional and as Magnetism chapter comes after Electric field, we assume that the vernacular and the concepts are already familiar to the students. If you do not have a copy of our textbook and you teach in the US, please contact your Pearson rep ASAP (if you do not know how to find them, please send me an email at eugenia.etkina@gse.rutgers.edu and I ill help). If you are not in US and do not have access to the textbook and signed up for the workshop, please send me an email and I will try to help.

Second, I have been posting a lot about teaching kinematics through the ISLE approach. All of the activities that I shared require group work. We talked about group work a lot, but I would like to repeat three things that you could do to make students' group work more effective and also to teach your students the skill of team work that they will benefit from for the rest of their lives. So, three things:

Hedging: model hedging yourself and encourage students to use it when they talk to their peers in the groups. This is what hedging means:

Hedging in the context of communication refers to the use of language that softens or lessens the impact of a statement. It involves using cautious or non-committal language to avoid making definitive claims or to express uncertainty. Hedging is often employed to make statements less direct, to be polite, or to avoid offending someone.

Common Examples of Hedging:

Using qualifiers: "I think," "I believe," "It seems that," "In my opinion."

Softening statements: "It's possible that," "Maybe," "Perhaps."

Indicating uncertainty: "I'm not sure, but," "As far as I know."

Example in a sentence:

Direct statement: "This project will fail."

Hedged statement: "I think this project might face some challenges."

In the hedged statement, the speaker is less direct, making the claim less absolute, which can be useful in discussions where the speaker wants to remain diplomatic or leave room for other opinions.

2. Equal participation. This means that students in a group are aware that everyone needs to have a chance to speak and they encourage shy members to participate. Nobody dominates the conversation.

3. Social awareness. This means that group members value everyone's contributions. Everyone brings an important point of vide ot the discussion. Those who say: Wait a minute, I do not understand... or Why are we doing it this way? are challenging the consensus and thus improving the outcome. Different life experiences enrich everyone.

The same way we teach our students to evaluate uncertainties, develop hypotheses, etc., we need t teach them to work in a team productively. But for them to learn how to do it, we need to model the skill. Think how you can model hedging, equal particpation and social awareness as a teacher.

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9IDOIbPpii-_zQ-igGdjr5Yz6143X_s3clMILRBLXXbbmyzLRA0XH1TQLN-OD5fo0cqupx0S&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin

Level 3 contributor
· ·
Hi all, two things today.
First, we had a huge group of teachers who joined our community today! Welcome! I tagged the new members to make sure that they see the post. Many of the new people wrote that they are seeking help with AP. This is not the group that was created to specifically support AP teachers. BUT! Everything that we do here will help your students be successful with AP, as the ISLE approach is the methodology that is consistent with the AP goals, although it was created a long time before new AP came into the world. To learn about our approach, please visit islephysics.net and read the material under every tab. Today I continue my posts about kinematics (Chapter 2 in the textbook College Physics: Explore and Apply, see the cover image of this group to learn what it is).
We talked a lot about the progression fo the development of kinematics concepts with the students. Today I want ot focus your attention on the back of the chapter problems that are non-traditional. It is those problems that are common on AP exams, but also these are the problem that develop real student understanding of physics and its methods of cognition. We list those problems in the Instructor Guide. Here is the list for Chapter 2. I strongly recommend that you solve those before asigning them to your students. The solutions are all on Mastering Physics if you need to check yourselves. Good luck!
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
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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi @everyone! I finished posting about teaching kinemaitcs through the ISLE approach. As kinematics is a descriptive part of studying motion, there are no causal or mechanistic explanations for why the objects move the way they do. Such explanations (mostly causal) come in dynamics. But before we move into dynamics, I would like to remind you the logical progression of thought that is used for EVERY concept in the physics course if you are using the ISLE approach.
We start by motivating students with the NEED TO KNOW. The NEED TO KNOW is a fascinating experiment or a story that does not require ANY predictions or explanations. It is a cliff hanger that you use to motivate your students to move forward and they only answer or explain it at the very end of concept construction.
Students observe carefully selected experiments (all shown in the ALG or the textbook - for your use only, students are supposed to perform them or watch them). The DO NOT make any predictions before watching those. We do not do predict-observe-explain approach (it is a huge difference between our approach and many other reformed approaches in physics). The students observe those experiments (they are called observational experiments and not demos, we do not have demos in our vernacular) and look for qualitative patterns.
They work in groups to come up with the explanations for those patterns and design experiments (called testing experiments) to test them. This process involves hypothetico-deductive reasoning as they need to make predictions of the outcomes of those experiments using the explanations under test and NOT their intuition. They do the experiments and compare the outcomes to the predictions sometimes ruling out some of their explanations.
The same process repeats quantitatively - collecting data, analyzing them coming up with patterns/explanations and testing them experimentally.
Only AFTER the students go through these processes, they read the textbook. We teach them how to do it using the Elaborative Interrogation technique.
We developed all experiments/activities are for this process for every concept. They are in the ALG/OALG and the textbook. As a teacher, it is great to study all of those materials + the Instructor Guide to plan your lessons.
All materials are on Mastering Physics website, OALG files are posted here in the FILES.
Please post your questions after you finish reading this post. I have been repeating this process many time here but as we have had about 50 people joined recently and because it never hurts to repeat, I am doing it again. The ISLE progression is crucial for its success. But it is not the only thing that we do to help students feel and be successful. Other things will follow tomorrow.
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Noah Segal

Level 1 contributor

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Eugenia Etkina
Admin

Level 3 contributor
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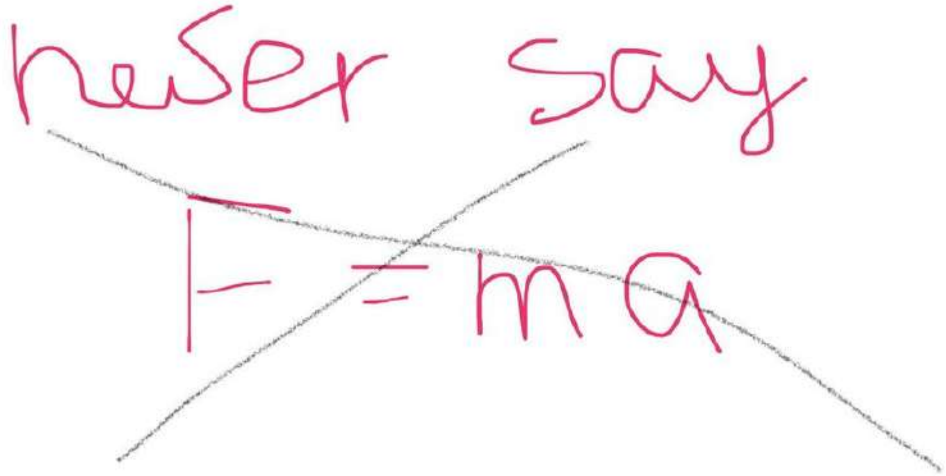
Hi all Exploring and Applying Physics people! I finished posting about teaching kinematics through the ISLE approach and am starting linear dynamics (Chapter 3 in the textbook). Before I talk about the progression of student learning in ISLE, I would like to say what is different or better say, special, in our approach to Dynamics content-wise compared to traditional approaches. I want to emphasize that all these things are based on research findings in the field of Physics Education Research (or PER) published in numerous papers and most importantly, on the work of the members of the Rutgers PER group done in the last 20 years (published in papers and PhD dissertations).
We start by defining a system. A system in physics is anything you want it to be, the rest is the environment. The environment is as important as the system but needs to be distinguished from it.
We define force as a physical quantity characterizing an interaction of an object in the environment with an object in the system. While there can be interactions between objects inside the system, we do not use forces to describe them. In a way our definition of force is similar to the definition of EXTERNAL force by Newton.
Force is not an interaction. Force is just one of the physical quantities characterizing interactions. Another one is potential energy, for example.
Force is not an entity and therefor we do not talk about it as such. What does this mean? The is no "force of" in our language, but "force exerted on by Y on X". Here X is the system and Y is an object in the environment. For the same reason there is no "weight" or "tension in the rope" as the word "weight" implies that it belongs to the object and the tension in the rope belongs to the rope.
All forces are labeled with two subscripts, for example the force exerted by Earth on the system is labeled as F_sub E on S. The force exerted by the rope on the system is labeled as F_sub R on S. If you cannot find those two objects to write the subscripts, then probably what you are thinking about is not a force. Students sometimes want to put "force of motion" or "force of acceleration" on force diagrams, needing two subscripts helps them avoid this mistake.
We do not use the term free body diagram, but instead use the term force diagram. This wording comes from our students who could not understand why an object that interacts with other objects is called a free body. It is not free. The forces on the diagram need to be drawn to scale to make sure that the motion diagram is consistent with the motion (acceleration) of the system if it is known that he system accelerates.
Students learn to draw force diagrams using a specific set of steps. I will comment on those steps in a different post, but you can see them in the textbook in Chapter 3. They also use motion diagrams to check whether the lengths of the forces are drawn to scale.
The formulation of Newton's first law is different form traditional. It basically defines the observer for whom the second and third laws are valid. Do not skip this section in the textbook!
While we write Newton's second law in a vector form as

a (vector)=sum of F (vector)/m, we use it to solve problems in a scalar component form. Check Chapter 3 to see how we move from vectors to their scalar components. The use of scalar components means that we have coordinate axes on the force diagram to help decide what sign to put in front of the component.

10. We never, never ever, truly NEVER EVER EVER use the wording "F equal ma". No single F is equal to ma, only the sum of Fs is. Therefore we systematically use the vernacular of the "sum of the forces" not even using the term "net force". Anything with a name attached to it makes the students think that it is is an additional force.

I think it is enough for today. Hopefully it was not too overwhelming. You can find all these ideas in Chapter 3 of our textbook but only if you read it as if you never studied physics. I know it is hard, but it will help a lot! If you finished reading this post, please either "like" it or comment on it. Thank you!



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Eugenia Etkina
Admin

Level 3 contributor

Hi all Exploring and Applying Physics people! As you probably heard, our textbook is being translated into Italian thanks to the continuous efforts of Valentina Bologna Longo, Eugenio Tufino and many others. Recently, Martín Monteiro asked if we could start working on the Spanish translation. I talked to the publisher and they said that they are looking for a group of people to undertake the translation. If you are interested in working on this project, please email me at eugenia.etkina@gse.rutgers.edu

It would be amazing to make our materials available to more people. Please email! Luis Largo, are you in?

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Eugenia Etkina
Admin

Level 3 contributor
· ·

Hi @everyone! I am starting with describing sequences of student activities for linear dynamics (Chapter 3). Over the last 25 years we have developed a robust progression that helps students really understand what the word 'force' stands for. It is also very ISLEish - as it involves a testing experiment for an idea that all students have (or most students), that our atmospheric air pushes down on objects. As this is the first time the students are testing an idea, it is important to focus on the hypothetico-deductive reasoning steps:
IF my idea (the hypothesis under test) is correct AND I do such and such THEN such and such should happen (this is the prediction) BECAUSE of - the connection to the idea - BUT if did not happen THEREFORE my idea can be rejected (pending the additional assumptions are validated) or AND it did happen THEREFORE I cannot reject my idea.
The key here is that the prediction is based on the hypothesis under test not on the intuition. The prediction is wrong when it is not based on the hypothesis not when it did not match the outcome of the experiment. When it does not match, it means that the hypothesis might be incorrect, not the prediction.
Here is the sequence in the ALG. It needs to be implemented in this order and all of the activities.
3.1 Describing and representing interactions
3.1.1 Observe and represent
PIVOTAL Lab or class: Equipment per group: whiteboard and markers, 1 medicine ball (alternative: bowling ball), 1 basketball (alternative: volley ball, or a kid's inflatable rubber ball with similar size to a bowling/medicine ball).
Each member of the group while standing: hold medicine ball in one hand and a basketball ball in the other hand (make sure you hold the medicine ball first and then follow up with the basketball). Focus on what you need to do to hold each ball still. The goal of this activity is to learn to draw a new representation called a "force diagram." Do this on a piece of paper or on a small whiteboard with your group. Share your ideas with each other.
a. Centered at the top of your page/whiteboard, draw a sketch of a person standing on the ground, holding the balls, one in each hand. To draw a force diagram, you first need to identify systems/objects of interest. In this case, each ball is a system or an object of interest. Draw a circle around each ball to signify this. Divide the rest of your page/whiteboard into a left column for one ball and a right column for the other.
b. The next question you need to ask yourselves is what other objects are interacting with each system/object of interest? So in this case, what other objects are interacting with each ball? If you are stuck, discuss the following: What do you think would happen to the ball if your hand were the only object interacting with it? List the objects interacting with each ball at the top of that ball's column.
c. Drawing the force diagram: Below your lists of interacting objects, leaving enough space, draw a dot that represents each ball as a point-like object. On each dot draw an arrow to

show how your hand pushes on the ball. Let the tail of the arrow start at the dot. This arrow represents the force that your hand exerts on the ball. How could you label this force arrow to show that it is the force your hand exerts on the ball? Add this label to your representation for each ball.
d. Repeat this for the other interactions you identified. Represent these interactions on the force diagrams. Try to make the lengths of the force arrows in the two diagrams representative of the relative magnitudes of the forces. The arrows on the force diagram represent force vectors, physical quantities that have both magnitude and direction.
e. Discuss with your group: The word “force” is used in physics for a physical quantity that characterizes the interaction between two objects. A single object does not have a force because a force is defined as the interaction of two objects. Using the definition of a force in physics, give three examples from everyday life when the use of the term force does not match the meaning of this word in physics.
3.1.2 Test your idea
Class or lab: Single demo setup: Bell jar and vacuum pump large enough to accommodate a 2L soda bottle, empty 2L soda bottle. Light spring (k = 3N/m or 6N/m), ruler taped to outside of bell jar. [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]
a. In the previous activity, did your group decide that air interacts with the ball?
b. If yes, do you think that the total force that the air exerts on the ball points up or down?
c. Discuss with your group members what experiment(s) can you perform to test your idea about whether the air pushes up or down on the ball. Describe the experiment(s) and state the predictions of what should happen if the air pushes up/down on the ball.
d. If the equipment that you need for the experiment is available, conduct the experiment and record the outcome. Did it match the prediction? If not, revise your thinking about how air interacts with stationary objects. If the equipment is not available, read the description of the outcome of a possible experiment on page 53 in the textbook.
3.1.3 Read and analyze
Work through Conceptual Exercise 3.1 on page 54 in the textbook, do the Try it yourselfexample, and compare your solution to the solutions of your group members. Revise your work if necessary.
3.1.4 Reason
PIVOTAL Class: Equipment per group: whiteboard and markers
You stack three identical books on a table. Book A is on the top, book B in the middle, and book C on the bottom.
a. Sketch the situation. Next, work with your group members to answer the following questions.
b. Choose book B as the system/object of interest for a force diagram. Carefully draw a closed dashed line around book B to indicate that it is the system—your whole focus of attention. The top of the line should go between the top of book B and the bottom of book A. The bottom of the line should go between the bottom of book B and the top of book C. This is very important as it allows you to visualize what external forces to include in a force diagram for the system (book B in this case).
c. Below the sketch, construct a force diagram for book B. Remember in the force diagram to model the system as a point-like object, to include force vectors representing how each object outside the system (external objects) interacts with the system, and to label each vector on the force diagram with a force symbol that includes two subscripts (the first for the object that exerts the force on the system and the second for the object/system on which that force is exerted). For example, the force that book A exerts on book B can be written as Try to make the lengths of the force arrows representative of the relative magnitudes of the forces.

d. Discuss: If you added all the vectors on your force diagram together, what should be the combined result? Adjust the lengths of the different vectors on your force diagram if needed.
If you finished reading to the end, you know what to do. Thank you!
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Eugenia Etkina
Admin

Level 3 contributor
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Hi all Exploring and Applying Physics people! Three things today. First, for those who plan to attend our Magnetism workshop tomorrow, the zoom link is
https://rutgers.zoom.us/my/etkina...
The workshop starts at 9 am Pacific Time (PST), noon East coast time (EDT) and 6 pm Central European Time (CET). Please join 5-10 min early in case zoom will ask you update. We start exactly at the times above.
Second: three days ago I posted about future Spanish translation of our textbook looking for those who are interested in working on this (it is not a volunteer job) and only one person responded. Please email me if you are interested in participating
eugenia.etkina@gse.rutgers.edu
Third: two days ago I posted a sequence of student activities to invent the concept of force and force diagram. I must add that in the first activity EVERY student needs to compare how they feel holding a heavy and a light object. I recommend giving every person a heavy textbook and a sheet of printing paper and ask them to hold those for afew seconds on the palms of their hands with the arms stretched. They will feel the difference right away. If you have medicine of bowling balls it is even better, but it is hard to get so many. Heavy books work perfectly. The point is that EVERY student needs to experience it. Check my post from two days ago to see what activity I am talking about.
If you read to the end, you know what to do. Thank you!
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Eugenia Etkina
Admin

Level 3 contributor
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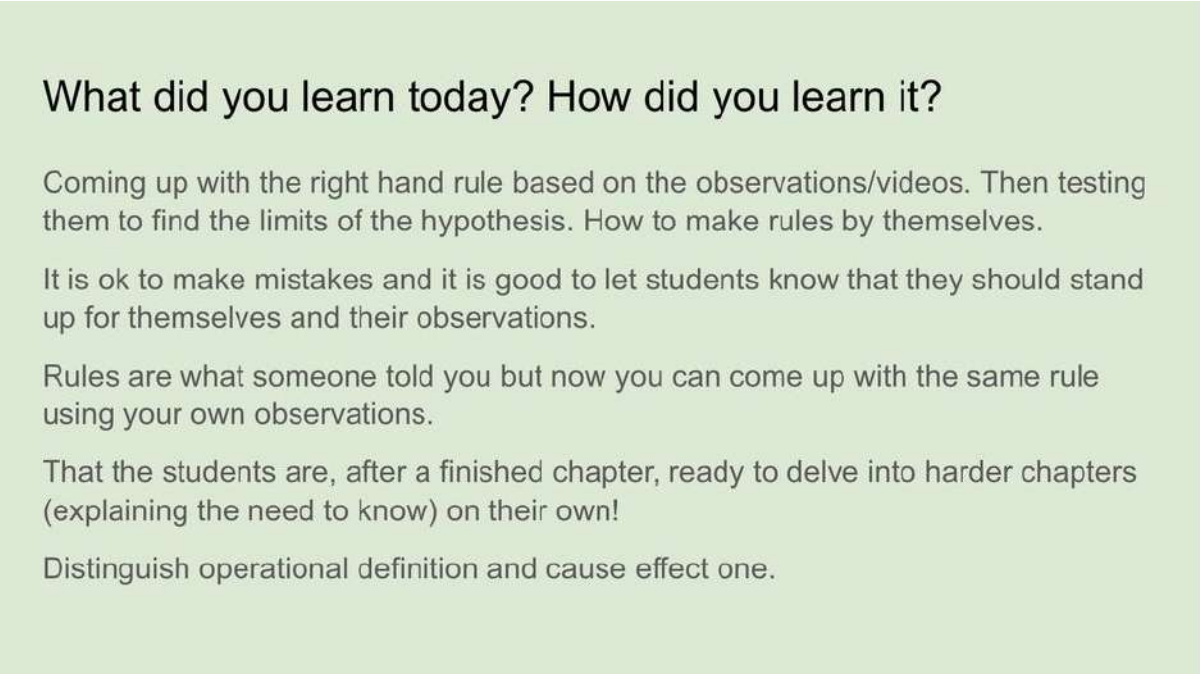
Hi all Exploring and Applying Physics people! we had a wonderful workshop yesterday. Thank you all for attending and working non-stop for 2 hours! I am posting the link to the recording and to the slides.

https://rutgers.zoom.us/.../fhutvtkY1N... Password: $L42&o9H
Slides: https://docs.google.com/.../1NhkyuPRgBh_4-v8n.../edit...
Here is the summary reflection slide.
Our next workshop is on the Electromagnetic induction. Here are possible dates: September 21 and 28. I will post a poll tomorrow to choose, but please comment here on your favorite day. Thank you all again.



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Eugenia Etkina
Admin

Level 3 contributor

Hi @everyone. The field of PER lost 2 of its founders this month. I am not sure that you know (you do if you are my friend on Facebook) that Alan Van Heuvelen died 2 weeks ago. This past Saturday Joe Redish died. Alan had a heart attack and Joe had cancer. They were both in their eighties. It is hard to overestimate what those two people did for the physics teaching.
Alan brought the idea of a system, the bar charts and the practical active learning techniques. He was what we call an experimentalist in the PER.
Joe was a theorist. He explained why students think the way they do. Both affected my personal thinking in different but infinitely important ways. The founders of PER (Physics education research field) are gone. Those were Arnold Aarons, Lillian McDermott, Priscilla Laws, Joe Redish, and Alan Van Heuvelen. All of them are gone. It is our turn to move the field forward.

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Eugenia Etkina
Admin

Level 3 contributor
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Hi @everyone! I did not post for a few days to see if my post after a break will get more views. So, I will continue today with dynamics. Once the students established the concept of force, the next step in the ISLE approach is to find the relationship between force and motion (actually, the sum of the forces and the change in motion). This is one of the most fundamental ideas in Newtonian dynamics and one of the most difficult for the students as in everyday life it is difficult to see the forces and the students often focus on the start of motion when motion is indeed in the direction of the sum of the forces. We have a great sequence of activities for it and I am pasting it here. See ALG/OALG for more. Please like or comment on the post to make it more visible. And if you have implemented this sequence, please share your experiences. Thank you!
Here you go!
3.3.1 Observe and find a pattern
PIVOTAL Lab or class: Equipment per group: 1 bowling ball, multiple sugar packets, stopwatch (alternate: cellphone app.), meter stick.
Perform the experiments in the left column and analyze the observations using motion and force diagrams. All experiments need to be performed on a smooth, hard floor.
Observational experiment
Analysis
Motion diagram
Force diagram
Experiment 1. One group member needs to use both hands to push once but hard on a bowling ball on smooth floor so it rolls in a straight line. The second member needs to count seconds (or use a metronome). The third group member drops sugar packets on the floor next to the bowling ball on every count after it has started rolling. Then the group records the locations of the sugar packets.
Experiment 2. Repeat experiment 1 only now the fourth group member needs to push the moving bowling ball very lightly in the direction opposite to the direction of the ball’s motion trying to exert a constant push (it is easier to do if you use a ruler and keep the same bend). Other group members repeat the same procedure. The sugar packets need to be put on the floor after the ruler touches the ball.
Experiment 3. Repeat experiment 1 only now the first group member needs to continuously push the bowling ball trying to exert a constant push (it is easier to do if you use a ruler and keep the same bend). Other group members repeat the same procedure. The sugar packets need to be put on the floor after the ruler touches the ball.
Patterns

Discuss with your group members the patterns in the direction of the velocity change arrow on the motion diagram and the vector sum of the forces exerted on the ball. Make sure that all your forces are labeled with two subscripts.

3.3.2 Observe and find a pattern

Class or lab: Equipment per group: 1 small ball. [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]

You need a golf ball or any small ball for this activity. With your group members perform each experiment described below. Then construct a motion diagram and a force diagram for the ball's motion during each experiment. Based on our investigation in Activity 3.1.2, you can ignore any force or forces that the air might exert on the ball.

a. Throw a golf ball upward. Observe its motion afterit leaves your hand until it reaches the top of its flight. For details, see the video (use the above link).

b. Hold a golf ball using your straight arm raised up and drop it. Observe its motion after it leaves your hand until just before it hits the floor.

c. Examine the results of both experiments. Is there the same pattern in the directions of the sum of the forces that other objects exert on the ball and in the directions of thevelocity change arrows on the motion diagram as in the previous activity? If so, describe the patterns.

d. Use the patterns that you found in Activity 3.3.1 and in this activity to formulate a statement relating the direction of the sum of the forces exerted on an object by other objects and on one or more of the kinematics quantities that describe its motion.

3.3.3 Test an idea

PIVOTAL Lab: Equipment per group: 1 bowling ball, multiple sugar packets, stopwatch (alternative: cellphone app.), 1 meter stick, 1 mallet

Shawn says that an object always moves in the direction of the sum of the forces exerted on it by other objects. Jade says that an object's velocity change arrow on the motion diagram is always in the direction of the sum of the forces exerted on it by other objects. How can you decide who is right? You need to test both ideas. To test them:

a. Work with your group members to design an experiment whose outcome you can predict using both ideas. The predictions about the outcome of the same experiment based on two ideas need to be different in order to help you make the decision. Think of what additional assumptions you used in the predictions (an assumption is something that you accept as true.)

b. Draw sketches of the experiments and show clearly how the predictions are based on the ideas under test.

c. Perform the experiment and record the outcome. What can you say about the ideas? What can you say about your assumptions?

3.3.4 Reading exercise

Now that you have done the activities, read Section 3.3 in the textbook and answer the following question: Alan says that a prediction is an educated guess, Eugenia says that a prediction is the same as a hypothesis, it explains some observed phenomenon, and David says that a prediction is a description of an outcome of a specific experiment. Use Testing Experiment Table 3.2 to resolve the argument and give examples of the predictions from this table that refute Alan's and Eugenia's ideas.

3.3.4 Test an idea

PIVOTAL Class or lab: Equipment per group: whiteboard and markers,10 N spring scale, 500 g object.

An elevator starts at rest at the first floor of a building and stops at the top floor. The elevator then returns to the first floor. You decide to test the following idea: an object's velocity change arrow on its motion diagram is always in the direction of the sum of the forces

exerted on it by other objects. You do this by hanging a 500 g object from a spring scale while riding the elevator up and back down again. Complete the table that follows to determine the relative magnitude of the force that the spring scale exerts on the object, FS on O, compared to the force that Earth exerts on the object, FE on O. The motion diagram and the force diagram should be consistent with each other and with the rule you're testing relating motion and forces. Predict, for each of the following seven phases of the motion, whether the spring scale will read more than FE on O, the same as FE on O, or less than FE on O.
a. The elevator and object hang at rest at the first floor.
b. The elevator and object start moving upward, going faster and faster.
c. The elevator and object move upward with a constant speed.
d. The elevator and object slow down as they approach the top floor.
e. The elevator and object start moving downward, going faster and faster.
f. The elevator and object move downward with a constant speed.
g. The elevator and object slow down as they approach the first floor and come to a stop.
Motion diagram
Force diagram
Now, with your group members, take a 500 g object and a spring scale and perform the experiment. If it helps, use your phone to video the spring scale reading as the elevator is moving
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Eugenia Etkina
Admin

Level 3 contributor
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Hi all Exploring and Applying Physics people! Despite my break in posts, my yesterday's post still got many fewer views than before, although many more likes. Not sure what is going on, but I will continue. In my post yesterday I described how students can construct the idea that it is the velocity change arrow that is in the same direction as the sum of the forces, not the velocity arrow itself. This means that is the sum of the forces exerted on an object is zero, its velocity does not change. They constructed this idea using observational experiments and tested it in the new experiments that they designed themselves. Now it is time to learn that this rule works for only very specific observers. And it does not work for the majority of observers, including themselves when they are in an accelerating car, train, airplane, etc. Basically, that this rule works ONLY for inertial reference frame observers. This is a very important idea as it contradicts Newton's first law as it is commonly stated in most textbooks. Most textbooks say that if the sum of the forces exerted on an object is zero, the object continues moving in a straight line with constant velocity. But this is not true at all for many situations (nothing to do with friction by the way) and this incorrect formulation of Newton's first law leads to many students thinking that physics only works in the physics classroom or in a textbook. What do we do about it? We change the statement of Newton's first law to incorporate the idea of the observer. That is why studying RELATIVE MOTION at

the beginning of kinematics is so important! Here is the screen shot of the textbook text and one of my most favorite videos showing that for some observers objects can accelerate when the sum of the forces exerted on them is ZERO. Watch it and enjoy! If you read ot the end, you know what to do next
https://mediaplayer.pearsoncmg.com/.../secs-egv2e-strange...

3.4 Inertial reference frames and Newton's first law

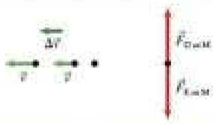
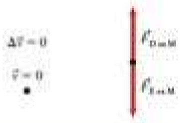
Our description of the motion of an object depends on the observer's reference frame. However, in this chapter we have tacitly assumed that all observers were standing on Earth's surface. Are there any observers who will see a chosen object moving with changing velocity even though the sum of the forces exerted on the object appears to be zero?

Inertial reference frames

In Table 3.3, we consider two different observers analyzing the same situation.

OBSERVATIONAL EXPERIMENT TABLE 3.3 Two observers watch the same coffee mug

VIDEO OET 3.3

Observational experiment	Analysis done by each observer	
Experiment 1. Observer 1 is slouched down in the passenger seat of a car and cannot see outside the car. Suddenly, he observes a coffee mug (M) sliding toward him from the dashboard (D).	Observer 1 creates a motion diagram and a force diagram for the mug as he observes it. On the motion diagram, increasingly longer $\vec{v}$ arrows indicate that the mug's speed changes from zero to nonzero as seen by observer 1 even though no external object is exerting a force on it in that direction.	
Experiment 2. Observer 2 stands on the ground beside the car. She observes that the car starts moving forward at increasing speed and that the mug remains stationary with respect to her.	Observer 2 creates a motion diagram and force diagram for the mug as she observes it. There are no $\vec{v}$ or $\Delta\vec{v}$ arrows on the diagram, and the mug is at rest relative to her.	

Pattern

Observer 1: The forces exerted on the mug by Earth and by the dashboard surface add to zero. But the velocity of the mug increases as it slides off the dashboard. This is inconsistent with the rule relating the sum of the forces and the change in velocity.
Observer 2: The forces exerted on the mug by Earth and by the dashboard surface add to zero. Thus the velocity of the mug should not change, and it does not. This is consistent with the rule relating the sum of the forces and the change in velocity.

VIDEO 3.1

Observer 2 in Table 3.3 can account for what is happening using the rule relating the sum of the forces and changing velocity, but observer 1 cannot. For observer 1, the mug's velocity changes for no apparent reason.

Similarly, in the video in the margin, you see the balls fly inside the box for no reason. For the observer inside the box, Newton's laws cannot explain their behavior. Can you think of some other observers who would be able to explain the balls' motion?

It appears that the applicability of the relationship between the force and motion diagram depends on the reference frame of the observer. Observers who can explain the behavior of the mug (observer 2) and the balls by using the relationship between the sum of the forces and changing velocity are said to be observers in **inertial reference frames**. Those who cannot explain the behavior of the mug (observer 1) and the balls using this relationship are said to be observers in **noninertial reference frames**. Any observer who accelerates with respect to Earth is a noninertial reference frame observer.

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Eugenia Etkina
Admin

Level 3 contributor
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Hi @everyone, no new post today Three reasons - my yesterday's post has fewer than 100 views, which means that Facebook is not notifying people. So, if you wish to benefit from participation in this group, you need to check the posts daily. Facebook will not tell you that they are there.
Second - I will be traveling in the next 2 days.
Third - I hope the absence of the new post will give people time to read two previous posts that are important for helping our students become Newtonian thinkers.

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Eugenia Etkina
Admin
Top contributor
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September 7
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Hi all, Frank Noschese asked for the document describing the Expertise Activity. We do this activity in ISLE introductory workshops and recommend that you do it with the students when they start feeling frustrated that you are not "teaching" them. (In their eyes teaching means the teacher explaining the concepts not them figuring those out). However, our students are very familiar with learning out something by figuring it out themselves. To remind them and focus on the important steps in such learning, Yuhfen Lin and David Brookes devised an amazing activity. I am attaching the handout for teachers for this activity but it is best when you learn it by playing during our intro workshop. Many people participated in those, but if you have not, we will have 2 next summer - one at the AAPT and one online.
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Eugenia Etkina
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September 8

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I posted a few times about Cecilia Payne, but this is too good not to share. I have an astrophysics minor but in my years of education I never heard her name. Let it be known to all our students. This is the woman who was the FIRST not only to hypothesize but to have experimental evidence that our Sun and other stars are made of mostly hydrogen and a little bit of helium. Only for a member of her PhD committee to take credit for this discovery 4 years later. And lots of other stuff. Read and enjoy.

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September 9
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Hi all, I am glad that you enjoyed reading about Cecilia Payne! today I continue with Newton's laws. I will not describe how the students come up with the Second law through the ISLE approach as I posted the link to the slides of the workshop where we did it last year. Scroll down to find the link. Today I am posting an ALG activity that will take your students 3 minutes in class but will be a great source of discussion. A quick formative assessment of their understanding of Newton's second law. Great for a quiz too. Here it is.

3.5.4 Represent and reason

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

Two cars are moving along a horizontal road as described in the table below:

Time interval	**Car A**	**Car B**
$0 \le t < 12s$	Is moving at constant speed 12m/s	Is moving at constant speed 24 m/s
$12s \le t < 20s$	Is slowing down at constant rate	Is slowing down at constant rate
$t > 20$s	Is not moving	Is not moving

In both cases the combined mass of the car and the driver was equal to 1200 kg. Draw a single graph that shows the time dependence of the magnitude of the sum of the forces exerted on each car during the first 25 s of motion. Make sure your graph is quantitative.

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September 11
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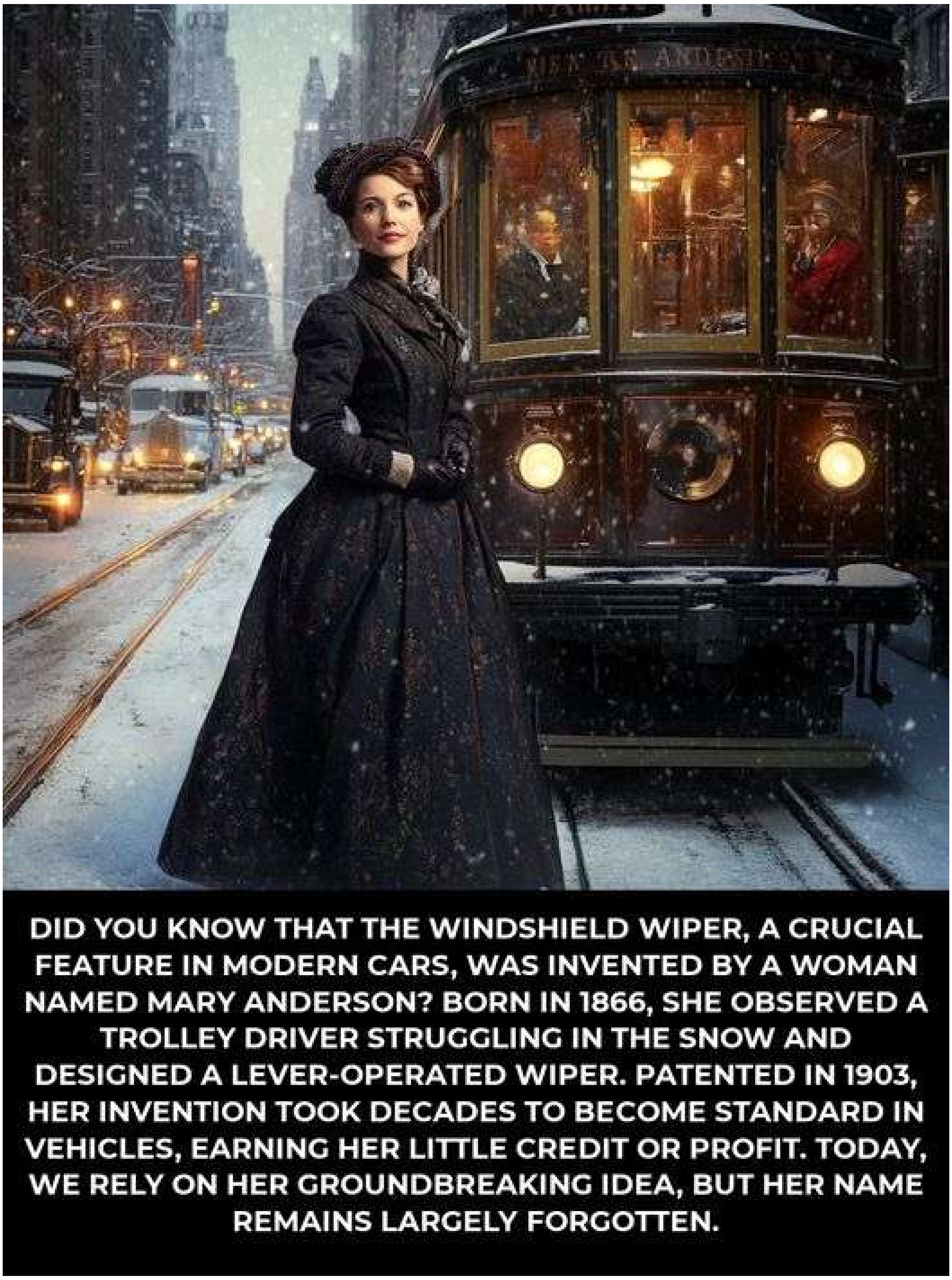
This is an interesting post. How much physics goes into a windshield wiper? How do modern wipers turn on an off automatically? What a great topic for a discussion in class that involves so many physics concepts. When we look for projects for students to do, this could be a winner!



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September 12

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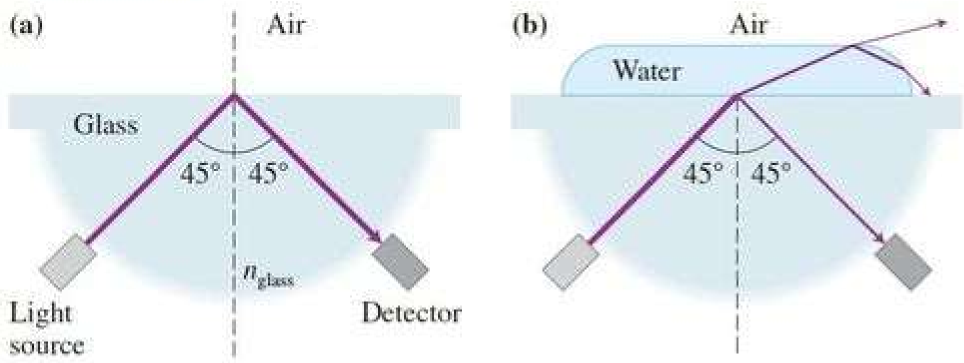
Hi all, yesterday I posted about Mary Anderson who invented windshield wipers. There, I had a question about the modern wipers that turn on and turn off automatically. We have a problem in Chapter 22 (Geometrical optics) that addresses this mechanism. If you enjoyed reading my yesterday's post, save this problem together with it, and when your students are studying refraction, let them figure it out! Here is the problem.
One more thing - thank you all those who signed up for the electromagnetic Induction workshop! We have now 25 people who plan to attend. Please, check the equipment list and also, study chapters 18 and 20 in the textbook as they come before 21 (Electromagnetic induction). Thank you!

45. ** **Rain sensor** Many cars today are equipped with a rain sensor that automatically switches on the windshield wipers when rain starts to fall. The most common modern rain sensors are based on the principle of total internal reflection. Light from an LED is beamed at a 45° angle onto the windshield glass using a semicircular piece of glass that is glued on the windshield from inside the car. When there is no rain, the light beam undergoes total internal reflection and illuminates the detector (see Figure P22.45a). If the glass is wet, the condition for total internal reflection is no longer fulfilled, and some light escapes to the outside (see Figure P22.45b). This results in a decrease in the light intensity at the detector, which is used as a signal to the car electronics to switch on the wipers. Determine the range of values of the index of refraction of the windshield glass (i.e., the minimum and the maximum values) that will allow the described operation of the sensor shown in the figure.

FIGURE P22.45



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September 14

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Hi all Exploring and Applying Physics people! I continue with Newtonian dynamics. We have established the first the second law with the students. What is next? The next step is to figure out what force Earth exerts on the objects. Here are two activities that will help your students figure it out. Please share if your students do it.

3.6.1 Reason

Class: Equipment per group: whiteboard and markers

From Chapter 2 you know that all objects fall with the same acceleration of 9.8 m/s^2 independently of their mass. How is this possible if the acceleration of an object is inversely proportional to its mass? Construct a mathematical relationship for the magnitude of the force that Earth exerts on an object of mass m. Discuss different possibilities with your group members.

3.6.2 Test your idea

Lab: Equipment per group: Spring scale or platform scale calibrated in newtons, set of objects with calibrated masses.

Your goal is to test the hypothesis that Earth exerts a force on every object which is directly proportional to its mass. Work with your group members to design an experiment, make a prediction using this hypothesis, carry out the experiment, and record the outcome. Did you disprove the hypothesis?

If you do not have scales calibrated in newtons, it is easy to make them - just replace the readings in grams to the readings in newtons.Since those activities, we do not use g=9.8 m/s^2 but instead use 9.8 N/kg in all dynamics problems as not g is not an acceleration of free fall but a coefficient in front of the mass that allows you to calculate the force the Earth exerts on objects close to its surface.

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September 15

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After Newton's second law comes the third. I am posting the sequence of activities that we have been using for a long time that reflect the ISLE process in student construction of this law. The observational and testing experiments can be swapped. The question in the textbook that I put as a screen shot will let you formatively assess whether the students grasped the essence of the law. Notice the structure of the question - typical for AP questions. What do you think the right answer is?

3.8.1 Observe and explain

PIVOTAL Lab:Equipment per group: 2 dynamics carts, 2 force probes, 1 dynamics track, computer with data-logging software, hoop-spring bumpers, slotted weight set, string.

The goal of these experiments is to find a relationship between the force that an object A exerts on an object B and the force that object B exerts on object A when they are interacting with each other. Design and perform three experiments that investigate the forces that two interacting objects exert on each other. Look for a pattern that relates the two forces to each other. For example: Place one probe at rest on the table and tap it with the second probe. Or attach the force probes to the carts and vary the amount of mass on one of the carts while rolling it so it collides with the other cart. Remember that the probes are very delicate and if you use them to tap one another, you need to do it lightly. Hint: Keep your experiments simple. Vary only one independent variable for each experiment.

For each of your three experiments, be sure to address the following points in your report:

a. Describe the design and set-up of your experiment, including what physical quantities you're varying and what variable(s) you're going to measure. Evaluate your designs.

b. Describe your findings, sketch the graphs that you see on the computer if necessary.

c. Find a pattern in the pairs of graphs representing the force-versus-time functions recorded by each probe during the time interval the interaction is taking place.

When you have completed all three experiments:

d. Devise and state a general hypothesis about the relationship between the force that object A exerts on object B to the force that object B exerts on object A.

3.8.2 Test an idea

Class or lab: Equipment per group: 2 spring scales.

You and your friend each hold a spring scale and you hook the scales to each other. Use the rule relating the directions and magnitudes of the forces that two interacting objects exert on each other (formulated in Activity 3.8.1, part d.) to predict what your friend's spring scale reads if you pull yours with a force of 3 units. What if she pulls with a force of 5 units?

a. Describe what prediction you're making for each case and the hypothesis on which that prediction is based.

b. Conduct the experiment and record the outcomes. Do the results agree with the predictions?

c. Can you arrange it so that one of you pulls with 3 units and the other pulls with 5 units? Explain.

3.8.3 Represent and reason

Class: Equipment per group: whiteboard and markers.

You push horizontally on two crates of different mass. The surface on which the crates move is smooth. Draw separate force diagrams for crates 1 and 2 for the two scenarios a.and b. below. When drawing force diagrams, use the rule relating the forces that two interacting objects exert on each other (devised in Activity 3.8.1, part d.). Crate 1 has a larger mass that crate 2.

a. You first push crate 1, which pushes against the smaller crate 2.

b. You now reverse the positions of the crates and push crate 2, which pushes against the larger crate 1.

c. Based on your diagrams in parts a. and b., should it be easier to push the crates in one situation or the other? Explain.

d. Is your answer to part c. consistent with the idea that you are pushing the same amount of matter, independent of the order of the crates?

e. If it is equally difficult to push the crates independent of their order, then how should the sum of the forces exerted by crate 1 on crate 2 and by crate 2 on crate 1 for part a. compare to the sum of these forces for part b.? What does this imply about the magnitude of the force that one crate exerts on the other and vice versa? (Note: the sum of the forces used here is the sum of the forces exerted on different objects, thus it does not determine the acceleration of any object.)

3.8.4 Represent and reason

PIVOTAL Class:Equipment per group: whiteboard and markers.

A book rests on a table.

a. Draw a sketch of the situation and identify objects that interact with the book.
b. Draw forces representing these interactions (a force diagram for the book).
c. If the book is stationary, these forces are equal in magnitude and opposite in direction. Can we say that they represent a Newton’s third law pair of forces? If not, why not?
d. Draw the Newton’s third law force pair (using the same color pen for each pair) for each force shown in the force diagram in part b. and identify the cause of each of these forces and the objects on which each of these forces is exerted.

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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
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September 16
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Hi all, I keep posting about Dynamics, but many of you are teaching other topics and are either ahead or behind my posts. For most of the topics we had online workshops for which the slides and supporting documents are on google drive. Please save this link for when you need a particular topic. In the workshops we work on the most essential activities that allow you to see the ISLE logical progression of the material and focus on the issues that are most difficult for the students.
The activities chosen for the workshop are the bare minimum that the students need to do, ALG, OALG, and End of Chapter problems offer much more.
Also, it is important to know that in the workshops we mostly use OALG activities as they have videos of the experiments, but if you are teaching in person, then try parallel ALG activities as they are written differently. The language in the ALG activities focuses on group work and in the OALG - for individual work as it was made for teaching online when students

work on their own. Knowing these differences will help you substitute activities from those two documents. Also, in most folders you will find the Instructor Guide with all chapters. Here is the link. Good luck browsing! Please ask me questions.

https://drive.google.com/.../1kiYbLqbLP7xMBhmZJBrFQgjdQwL…

And the next workshop is on Saturday. September 28, if you did not sign up yet (lots of people did already!), go to your EVENTS and sign up! All workshops are online and free.
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Eugenia Etkina
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September 17
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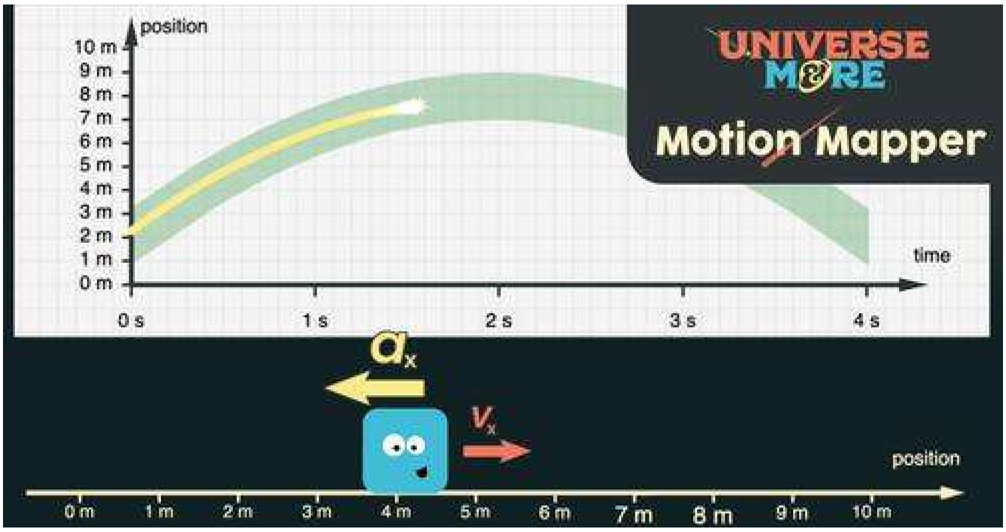
Hi all, if your students are struggling with kinematics graphs, there is an amazing game designed by Matt Blackman (an award winning physics teacher and my former student in the Rutgers Physics Teacher Preparation Program). Millions of people played this game all over the world. Your students will enjoy it. Try, and you will not be able to stop.



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September 19
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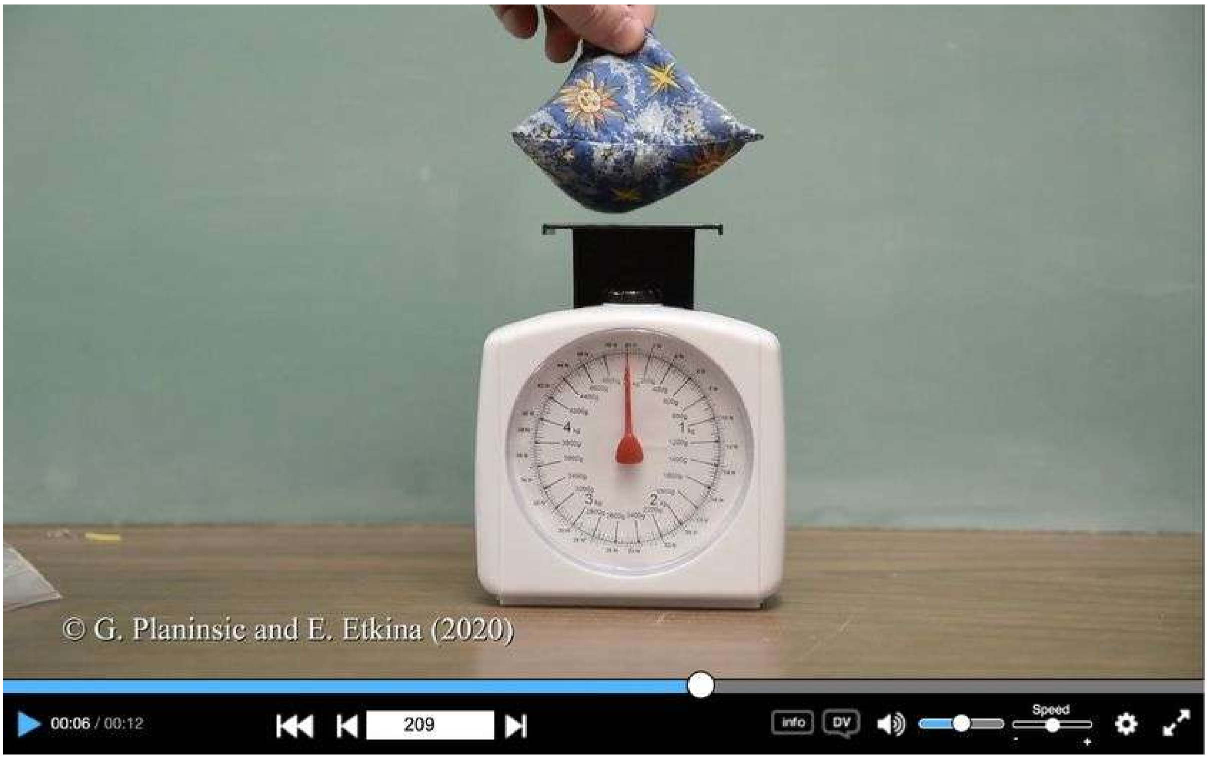
Hi all, two days ago I posted a MC question (choose right answer with the right explanation) and nobody offered a correct choice yet, please check it out and post your choices with arguments!
I continue with an excellent activity for the students to practice both Newton's second and third laws. If you have not done it with your students - try! And if you did, please share how they did.
Here is the activity:
OALG 3.3.4 Test an idea
a. Watch the video https://mediaplayer.pearsoncmg.com/.../sci-OALG-3-3-4a
to note the reading of the scale when the person puts a bean bag on it.
b. Use the pattern formulated in activity 3.3.1 to make a prediction about the reading of the scale when you drop the bean bag on it. Will it be more, less or the same compared to the reading you recorded? Use motion and force diagrams to make the prediction.
c. Watch the video https://mediaplayer.pearsoncmg.com/.../sci-OALG-3-3-4b
and compare your prediction to the outcome of the experiment. What can you say about the pattern formulated in Activity 3.3.1? Does it hold for this experiment too?



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September 21
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Hi all, we talked a lot about strategies that help our students learn to read scientific text. The best strategy is "elaborative interrogation" which encourages students to pose the question" "Why is this true"" when reading the textbook. Below is an example of an activity that helps them develop this skill. It is based on the statement that I heard from many students over the years. The second activity builds on the first by engaging the students in drawing force diagrams for real life phenomena. Do not skip!
OALG 3.6.3 Read and interrogate
Read and interrogate Section 3.6 in the textbook and consider the following question: Is the following statement true? “Because g is the same for all objects, Earth must exert the same force on all objects”. How would you convince a person studying physics of your opinion on this matter?
OALG 3.6.4 Observe and explain
Observe and explain the two experiments in the video https://mediaplayer.pearsoncmg.com/.../_fr.../sci-OALG-3-6-4. What could be the reasons for why the two objects did not fall at the same rate in both experiments? Use force diagrams to support your explanations.

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September 22
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Hi all, happy Sunday! One of the important skills that we wish our students to develop is linearizing data to solve problems. We help students learn this skill right in chapter 3 with the worked example. With worked examples, we suggest that you give them to the students without solutions in class to work through in groups, then have a sharing session about the approaches of different groups and only then let them compare their solutions to the solution in the textbook. Such process follows the "innovation first, efficiency next" approach that was shown by John Bransford and colleagues to be much more beneficial to learning that the traditional efficiency first, innovation after approach. What I mean that if we fist show the students how to solve a specific type of problems and them let them do it themselves with a different example, it is the efficiency first, innovation after approach. When we show them how to solve a problem that they have never seen before, they do not have "the need to know" which is the crucial component of learning. Thus letting them struggle first, collectively work on the problem and then see the model solution is a much better approach (and backed up by research). Here is the example!

EXAMPLE 3.8 Learning to linearize data

Alex is investigating the motion of a battery-powered fan attached to a low-friction cart (a fan cart) that is moving on a horizontal track. As the fan blades rotate, they exert a force on the air, and the air exerts an equal and opposite force on the blades, making the cart move (an analogy for the fan cart is a hairdryer on wheels). Using a motion detector, Alex finds that the cart moves with constant acceleration. He also measures how the acceleration of the cart a_x depends on the mass of the objects that he adds to the cart (m_{added}). His measurements are shown in the table below.

m_{added} (kg)	a_x (m/s^2)
0.10	0.25
0.20	0.21
0.30	0.19
0.40	0.17
0.50	0.15

(a) Draw a force diagram for the cart and use it to explain why the cart moves at constant acceleration for fixed added mass. (b) Two physical quantities that are not listed in the table affect the motion of the cart. Determine these two quantities using the data above. (Hint: Rearrange the mathematical expression for the acceleration of the cart to obtain linear dependence on added mass and then plot the graph using the data in the table.)

Sketch and translate The cart is moving to the left on a horizontal surface. The acceleration of the cart is also to the left due to the fan pushing air to the right (the fan works in a similar way to the hairdryer that we investigated in the previous example). We know the masses of the additional objects on the cart and the respective accelerations. We also know that the acceleration of any system is affected by the sum of the forces exerted on it and the system's mass. Because the mass of the cart (together with the fan) contributes to the system's mass, we hypothesize that the quantities that we need to determine are the sum of the forces and the mass of the cart.

Simplify and diagram We assume that the fan cart can be modeled as a point-like object and that the track is smooth, so we do not need to worry about friction. The only objects interacting with the cart (C) are Earth (E), the track (T), and the air (A). The motion diagram and the force diagram for the cart are shown in the figures below and at right. From the force diagram, we see that the forces exerted on the cart by Earth and the track add to zero, and the only force that is causing the acceleration of the cart to the left is the force exerted by the air.

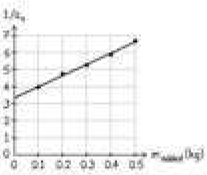
Represent mathematically We write Newton's second law in component form along the axis of motion:

$$a_x = \frac{F_{A\ on\ C}}{m_{added} + m_C}$$

Since m_{added} is changed in each experiment (it's an independent variable), it is useful to rearrange the equation so that it is a linear function with linear dependence on m_{added}:

$$\frac{1}{a_x} = \frac{m_{added} + m_C}{F_{A\ on\ C}} = \frac{m_{added}}{F_{A\ on\ C}} + \frac{m_C}{F_{A\ on\ C}}$$

and to plot $1/a_x$ against m_{added} (see graph at right). The function for $1/a_x$ is a linear function of the form $mx + b$, thus $m = 1/F_{A\ on\ C}$ is the slope of the graph and the intercept is $b = m_C/F_{A\ on\ C}$. (Do not confuse m for the slope with the symbol m for mass.)



Solve and evaluate The intercept of the graph with the vertical axis is 1 divided by the acceleration the cart would have had if the added mass was zero. Thus $m_C/F_{A\ on\ C} = 3.35$ kg/N.

We can find the slope of the graph as Δy divided by Δx. For example, when $\Delta y = 6 - 3.35$ and $\Delta x = 0.4 - 0$, this ratio is $2.65/0.4 = 6.63$. The slope of the graph is thus

$$\frac{1}{F_{A\ on\ C}} = \frac{\Delta y}{\Delta x} = 6.63\ \frac{1}{N}$$

Therefore, $F_{A\ on\ C} = 0.15$ N and $m_C = 0.51$ kg.

Try it yourself How would the graph change (consider intercept and slope) if you placed a second fan on the same cart and repeat the experiment?

Answer The slope of the graph is inversely proportional to the force exerted by the air on the cart; therefore the slope will be cut in half. The intercept is inversely proportional to the force that the air exerts on the cart and directly proportional to the mass of the cart and fan; therefore there is not enough data to determine it. But if we assume that the mass of the fan is much smaller than the mass of the cart, then the intercept will be between the original one and half of its value.

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Eugenia Etkina
Admin
Top contributor
·
September 23
·

Facebook sent me a memory from 10 years ago. It is a picture that I took in Pisa. When we climbed the tower I thought: "There is no way Galileo would drop anything from the top, it is so high! It is terrifying to even come close to the edge." But the tower is beautiful as is the legend. I am sharing this photo as it is my own and you can use it in your slides or anything without worrying about copyright.

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Eugenia Etkina
Admin
Top contributor
·
September 24 at 12:20 PM

·
Hi all, two things today.
First, did anyone do the Expertise activity yet? It would be great to hear your stories about it.
Second, as my post two days ago about linearizing caused interest, I am posting another problem for linearizing - do not miss, it is one of the end of chapter problems in Chapter 3.
Note that one of the heroes of the problem is named Matt. The name was in honor of Matt Blackman, the author of physics video games at the universeandmore website.
This will conclude my series of posts for chapter 3.
Here it is!

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.)

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Eugenia Etkina
Admin

All-star contributor
· October 1 ·
Hi all Exploring and Applying Physics people! I saw the votes for the Optics workshop and it looks like it is better to run it in November - slightly better. But I also noticed that we have a few posts about difficulties implementing the ISLE approach - noise in the classrooms, complaints of parents and students, pacing issues, etc. These are all normal, but I think we should run a workshop that just focuses on the important aspects of implemeting ISLE with your students and how to overcome obstacles. Therefore, I am thinking of running a workshop that ofcuses on your questions in two weeks on October 12 and then the Optics

workshop on November 16. I do not want to break our 4 year tradition of holding online workshops once a month. So, if you are implementing the ISLE approach and have questions - October 12 is for you. What do you think?

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Eugenia Etkina
Admin

All-star contributor
· October 3 ·
Hi all, this is a post to welcome our new members. Their names are below, and one of them is infinitely dear to me. It is the name of Елена Африна (pronounced as Elena Afrina) who was my mentor when I was doing my student teaching practices in the Fall of 1980 and spring of 1981 in Moscow, Russia training to become a physics teacher. It is during the fall of 1980 that I learned something that would change my life as a teacher. And I learned it from Елена Африна. Here is the story.
At that time Елена Африна was already a famous physics teacher in Moscow. Teachers who achieved her status were asked to run "open lessons" for other teachers who were doing their professional development.
This meant that a group of teachers (up to 20!) would come to a regular lesson, sit in the back, observe and then discuss it. The purpose was to learn from the best.
I was a student teacher and she was my mentor. Thus, I was also present at that "open lesson". Although it was over 40 years ago, I still remember that lesson. It was on on electric circuits. I expected the teacher to stand in the front and provide beautiful exciting explanations of Ohm's law, derive the total resistance in different circuits, and so on. None of this happened. I could not even see the teacher in that lesson (it did not help that Elena is a petit woman with very soft voice). I only saw the students. They were working all 45 minutes on their circuits, writing something in their notebooks, talking to each other, even getting up and moving to talk to other students, and there was no lecture. Elena was quietly moving among their desks saying something to each couple (students were working in couples) and did not spend almost any time in front of the classroom - teaching. Literally - none. I was sitting in the back thinking: "Oh, my goodness, what a disaster!". When the lesson ended I waited with fear of what 20 some teachers who sat in the back with me would say. I loved my cooperating teacher and was worried that they would bury her in their criticism. And guess what??? The experienced teachers who observed the lesson WERE IN AWE. They said that they had never seen students working so hard and so productively, that this was one of the best lessons they have ever seen. I was confused. She did not TEACH. But they learned! How could this be??? I thought long and hard what happened in that lesson for weeks. What she did was not teaching, it was masterfully organized LEARNING. That lesson was just the beginning of my journey to the development of the ISLE approach - a method when all students learn physics by engaging in the processes and activities that physicists engage in while doing real physics. They (students) succeed and fail, just like physicists do,

but if we guide them right, they come out learning to think like physicists. Critically. And feeling that they are capable of learning anything. What more do we need now?
New members, please visit islephysics.net to learn about the ISLE approach to learning and teaching physics. And enormous thanks to my teacher, Елена Африна.
https://www.facebook.com/groups/320431092109343/posts/1717304962421942/?__cft__[0]=AZUOAnfvFF8YahkRTL7JBpkvroZ6gTrIbATJpVX9mP1ELXP6UO-h4xRsXuP6AyDmfB3TSU5RySLdEcj4H0VLBkU-be8rOgCGS3g1njP2AOKPLYNcNzUXot-TRDyeqp7Rr72G4XNTflcQ_on6fa2zSn7P2FWP4biOHjx2E5euUUnpdFWHEinEMHWLM2gGcuJcgDQ&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin

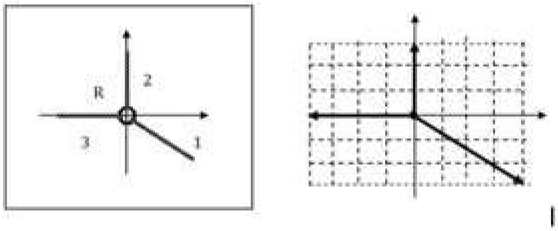
All-star contributor
 · October 4 ·
Hi all, this psot is for those who are teaching forces. As you probably noticed, in chapter 3 we do not have any horizontal forces, everything is in one dimension - vertical (as much as possible) and we only have positive and negative force scalar y- components. Forces at an angle, when you need both x- and y- components, come in chapter 4. Alan Van Heuvelen came up with a brilliant way to help students understand the nature of vector and scalar components. This brilliant idea is the GRID. Using his idea and the ISLE process we have two activities that help your students construct the concept of components by themselves. I am pasting the OALG version with the videos of the experiments but in my experience when students actually DO these experiments, the benefit in huge! All you need are force scales and a ring. Here is the text of the second activity in the ALG (there it is two activities):
4.1.2 Components of force vectors
PIVOTAL Class: Equipment per group: whiteboard and markers.
The sketch on the right (this is the figure in the attached document for the same activity) shows the same three strings pulling on the ring as in the previous activity. However, an angle is now shown for the pulling direction of string 1 relative to the x-axis.
a. How could you calculate the effect of string 1 pulling in the x-direction?
b. How could you calculate string 1's effect pulling in the y-direction? That is, how could you calculate the x- and y-components of if you know only the magnitude of the force (5 N) and the direction of the force relative to the x-axis (below the positive x-axis)? What are the magnitudes of the other two forces?
4.1.3 Test your ideas
Lab: Equipment per group: whiteboard and markers, metal ring, 3 spring scales [Alternate: Use a force table with ring, strings, pulleys, hangers and slotted objects]
Work with your group members to recreate the situation in Activity 4.1.2 and check whether the forces that you found keep the ring in the equilibrium.

OALG 4.1.1 Components of force vectors

The sketch below shows three strings pulling in different directions in a horizontal plane on a small ring (R) at the center. The corresponding force diagram for the ring is also shown on a grid.

a. Based on what you see in the force diagram, explain why the ring does not accelerate in the positive or negative *x*-direction. Be explicit.

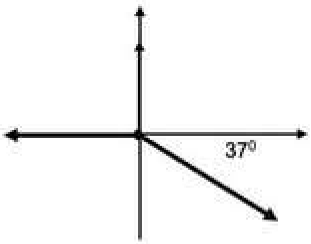
b. Repeat the same for the *y*-direction.



Comment Notice that string 1 exerts a 4-N force on the ring toward the right, which balances the 4-N force exerted by string 3 toward the left. Similarly, string 2 exerts a 3-N force on the ring upward, which is balanced by the 3-N downward pull exerted by string 1. If you don't see this, go back to the force diagram and try to visualize it. You should be able to realize that string 1 pulls in both the horizontal *x*-direction and the vertical *y*-direction. We say that $\vec{F}_{1 \text{ on } R}$ has an *x*-component of $F_{1 \text{ on } R\, x} = +4$ N, and a *y*-component of $F_{1 \text{ on } R\, y} = -3$ N. Normally, we don't have force diagrams on grids that allow us to visualize the components so explicitly in this way. In the next activity, we will do the same analysis using trigonometry.

OALG 4.1.2 Test your ideas

The sketch on the right shows the same three strings pulling on the ring as in the previous activity. However, an angle is now shown for the pulling direction of string 1 relative to the *x*-axis.



a. How could you calculate the effect of string 1 pulling in the *x*-direction?

b. How could you calculate string 1's effect pulling in the *y*-direction? That is, how could you calculate the *x*- and *y*-components of $\vec{F}_{1 \text{ on } R}$ if you know only the magnitude of the force (5 N) and the direction of the force relative to the *x*-axis (37° below the positive *x*-axis)? What are the magnitudes of the other two forces?

c. Watch the video of this experiment https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-4-1-2 and check whether the forces that you found keep the ring in the equilibrium.

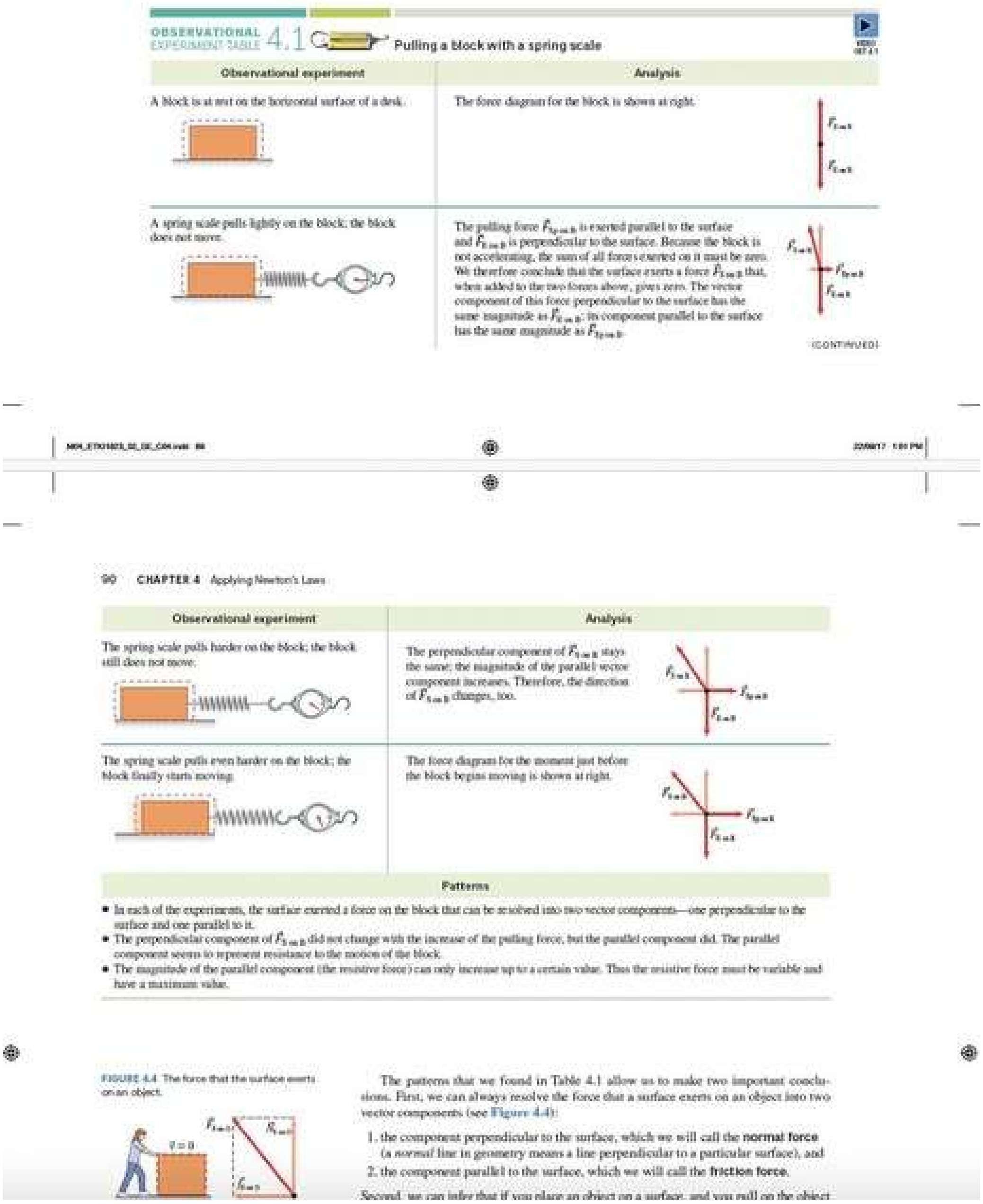
https://www.facebook.com/groups/320431092109343/posts/1718166632335775/?__cft__[0]=AZXs23jmgxJnwR0INzjfLucTAuytWtmJ50pz_MIK1yOb7N8--tM1A1p-mDx6iSQMdrfCFNKb32VePpUSIjl4qs_uXgKxQD_ibrTwzKaVurh68ZeQwMhHua3pIjUPhwVmXpPip-0-wmIhd4KHIWGaIDGoDdpbsY6hB0V3ivYejO1A9XM16HN8TGYmK4PyeboYq8wEqtL25MfZx63Jd4ep9_K4&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin

All-star contributor
· October 5 ·

Hi all Exploring and Applying Physics people! Thank you all who have been sharing their experience, posting questions and resources, THANK YOU!

Today, I will continue with components stuff. One thing that we rarely discuss with our students is that there is no separate normal force or friction force. These two are vector components of the same force - the force that the surface exerts on an objects sitting on it or sliding across it. To help students construct this idea we engage them in a very - ISLE-based observational experiment and the follow up analysis. I am pasting the screen shot of the textbook page, but similar activities are in the ALG and OALG (I am reminding that all OALG files are posted here in the FILES). If you do not have access to the ALG files, please send me an email at eugenia.etkina@gse.rutgers.edu


OBSERVATIONAL EXPERIMENT TABLE 4.1 Pulling a block with a spring scale

Observational experiment	Analysis
A block is at rest on the horizontal surface of a desk.	The force diagram for the block is shown at right.
A spring scale pulls lightly on the block; the block does not move.	The pulling force $\vec{F}_{Sp\ on\ B}$ is exerted parallel to the surface and $\vec{F}_{E\ on\ B}$ is perpendicular to the surface. Because the block is not accelerating, the sum of all forces exerted on it must be zero. We therefore conclude that the surface exerts a force $\vec{F}_{S\ on\ B}$ that, when added to the two forces above, gives zero. The vector component of this force perpendicular to the surface has the same magnitude as $\vec{F}_{E\ on\ B}$; its component parallel to the surface has the same magnitude as $\vec{F}_{Sp\ on\ B}$.

(CONTINUED)

90 CHAPTER 4 Applying Newton's Laws

Observational experiment	Analysis
The spring scale pulls harder on the block; the block still does not move.	The perpendicular component of $\vec{F}_{S\ on\ B}$ stays the same; the magnitude of the parallel vector component increases. Therefore, the direction of $\vec{F}_{S\ on\ B}$ changes, too.
The spring scale pulls even harder on the block; the block finally starts moving.	The force diagram for the moment just before the block begins moving is shown at right.

Patterns

- In each of the experiments, the surface exerted a force on the block that can be resolved into two vector components—one perpendicular to the surface and one parallel to it.
- The perpendicular component of $\vec{F}_{S\ on\ B}$ did not change with the increase of the pulling force, but the parallel component did. The parallel component seems to represent resistance to the motion of the block.
- The magnitude of the parallel component (the resistive force) can only increase up to a certain value. Thus the resistive force must be variable and have a maximum value.

FIGURE 4.4 The force that the surface exerts on an object.

The patterns that we found in Table 4.1 allow us to make two important conclusions. First, we can always resolve the force that a surface exerts on an object into two vector components (see Figure 4.4):

1. the component perpendicular to the surface, which we will call the **normal force** (a *normal* line in geometry means a line perpendicular to a particular surface), and
2. the component parallel to the surface, which we will call the **friction force**.

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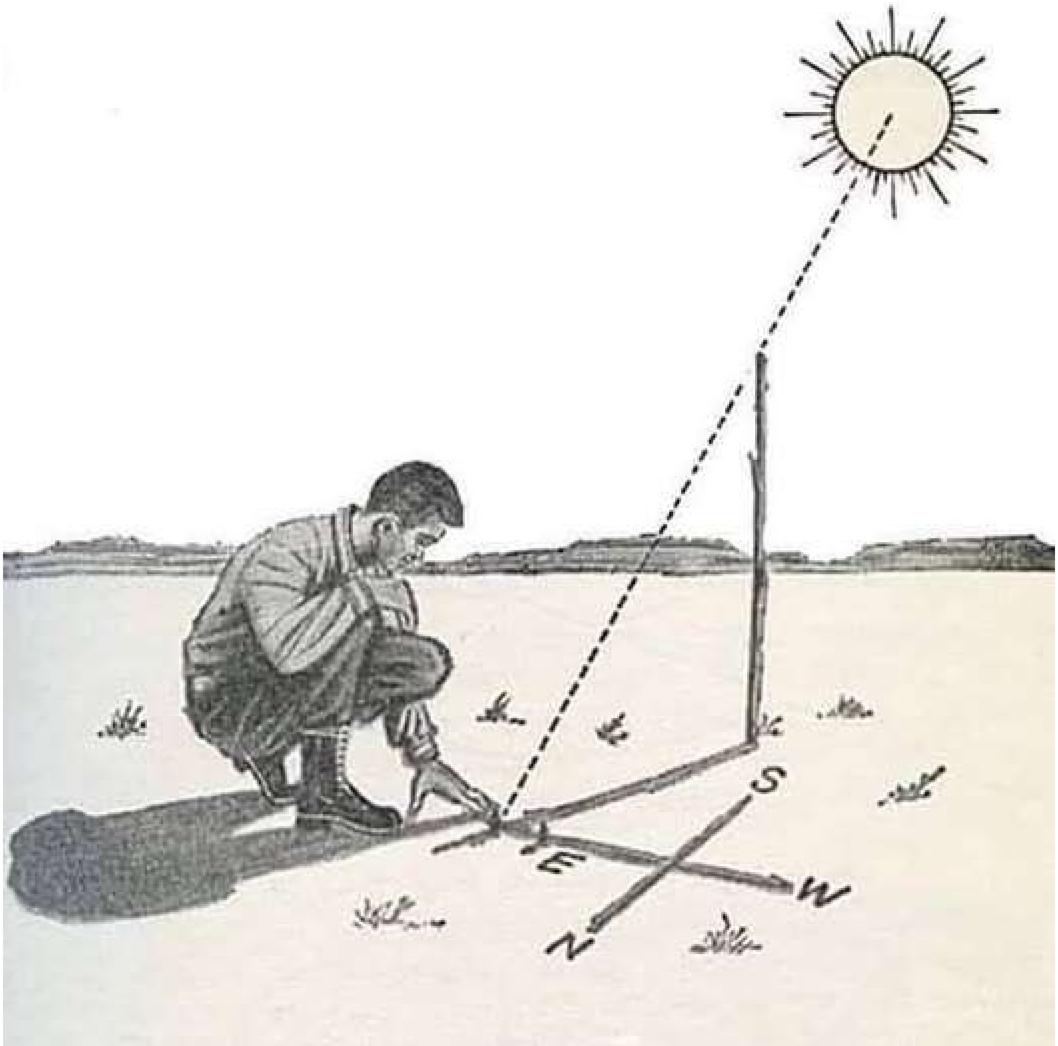
Eugenia Etkina
Admin

All-star contributor
· October 8 ·
Hi all, if you are teaching Magnetic fields, Geometrical optics, or an astronomy course, and it is a sunny day outside, this is a great short lab to do with the students. It is an application experiment, if add a compass so that the students can compare the directions that they foind using this approach with the directions showed by the compass, they can even do the relative uncertainty estimations!



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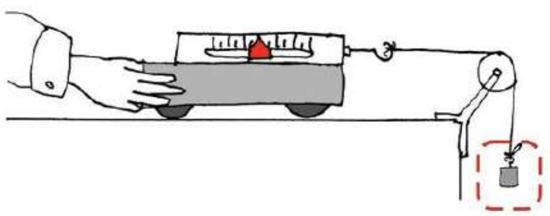
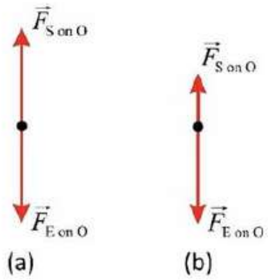
Eugenia Etkina
Admin

All-star contributor
· October 9 ·
Hi all Exploring and Applying Physics people! I continue my posts abut dynamics and today I want to focus on two ideas: the idea of a system and why even when we ask for predictions, we do not follow the POE structure (predict, observe, explain). In the ISLE approach students do not make predictions of the outcomes of testing experiments based on their intuition. They do not start learning a new concept by confronting their previous ideas. On the contrary, they start learning by observing new phenomena without being asked to make any predictions, then they devise explanations of the observed phenomena and only then they use these explanations to make predictions of the outcomes of the new experiments (designed by them or offered by the teachers). These predictions are NEVER guesses. They need to follow from their explanations and not from their intuition. This way of approaching predictions is very different from POE sequence.
In the example that I describe today the students are asked to make predictions. BUT it is not the beginning of their learning of Newton's laws, this is close to the end. They need to know how to choose a system for analysis, analyze its interactions with external objects, draw force diagrams and only then make a prediction about the outcome of the experiment. It is a great activity and teaches the students the importance of choosing a productive system. Here is goes (the text is from our second ISLE book: Investigative Science Learning Environment: A guide for teacher preparation and professional development):
"To apply Newton’s second law to solve problems, we first need to choose our system. We then look at the external objects that interact with our system. They can either touch it or interact at a distance (such as Earth, magnets, or electrically charged objects). We represent the forces that those external objects exert on the system with arrows on force diagrams. We then use the force diagrams to write Newton’s second law. The choice of the system determines the analysis. The following exercise shows the difference.
A dynamics cart is held at rest on a level track. A spring scale is attached to the cart and a string is attached to the spring scale. The string passes over a pulley at the end of the track and a hanging object is attached (see the attached figure). Predict what will happen to the reading on the spring scale when the cart is released.
Here the choice of the system is crucial for making the prediction. A productive choice is choosing the hanging object as the system and not the cart (our system is indicated by the red dashed line on the attached sketch). When the cart is held by the person, the sum of the forces exerted on the hanging object is zero (see the attached force diagram). The scale reads the force exerted by the string on the cart and on the hanging object. When the car is released, the object starts pulling it to the right and accelerating down itself. As it accelerates down, the sum of the forces exerted on it should point down, this means that the force exerted on the object by the string decreases, and so does the reading of the scale. This is our prediction. As you can see, it is not a guess, it is the result of complicated reasoning using the models that the students have learned before.
See the video at (https://youtu.be/pznrUVWFNgU). While the problem is relatively easy to solve when we choose the hanging object as a system, it becomes impossible if we choose the cart as the system.





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Eugenia Etkina
Admin

All-star contributor
· October 11 ·
I got it in my Facebook feed. An excellent application experiment for static fluids! If you are teaching AP1 - this is a great exam question and also a great mini-lab or a great homework assignment with the requirement of their own video and an explanation of how every step worked.

https://www.facebook.com/groups/320431092109343/posts/1723123275173444/?__cft__[0]=AZW-hBcx2fFI_xiAaPhrxFBL7xrIOPcm9LfhCJW_q5PvEUL8HjetnYVb70ECJC1o5vEVCYuRKsQ0tcR6ONNIeONN8Il6B7Jj6DMilz3TpUyYgf7ARLW1rcZKu1JNWPW6zQT2COumkxYspLhzrt9InqzzkD5BXHpOjEI9vZv9BDHQTx0dzWCdJIsBKN_VD3AEVsbwIJWqwOGXR_FQktIxZpeg6p0EnUCqXweQ1oU8XhHZJg&__tn__=%2CO%2CP-R

Eugenia Etkina
Admin

All-star contributor
· October 14 ·
Hi all, at our meeting for "Successes and Challenges in implementing the ISLE approach" last Saturday there were a few challenges that we did not have time to discuss in detail and a few that are very important to be discussed many times. Here is one of the latter:
Lack of support from admins, students report faculty for complains.
This is a common challenge and I am asking those who had it and resolved the issues to comment. This is what I recommend:
Before switching to ISLE completely or even before starting to implement it step-by-step, talk to your administration what you plant to do and why. If needed, use my paper in Physics

Today - the magazine read by almost every physicist in the US that explains why ISLE approach is good for student learning and well being. I am attaching it to this post. The goal of these conversations is to make sure that your administration is on board, that they understand why you are teaching this way and ready to explain it to anyone who complains. Have regular conversations with your students about how people learn in general, how they themselves have learned things that do well - play music, sports, computer games, etc. Use Expertise activity (posted here in the FILES and in the folder for the meeting for which I put the link on Sunday). I emphasize having multiple conversations with your students that include how our brain learns (use the book by J. Zull The art of changing the brain) and the findings from physics education research (I will attach the papers to my next message) that students do not learn from listening to lectures.
If you are a high school teacher, do the same work with the parents. During back to school nights have them engage in one of our introductory activities and then explain how this style of learning helps EVERYONE learn. Also, you can play a short version of Expertise activity with the parents.
Finally, try to get your colleagues on board by inviting them to observe your lessons and explaining why you do things the way you do. But do it with a lot of hedging. This part is the trickiest.
Hope this helps, but again, I invite those who have solved this problem to share their experiences. Thank you!
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Eugenia Etkina
Admin

All-star contributor
 · October 15 ·
Hi all, yesterday I started responding to the challenges identified in our Saturday meeting and I hoped that experienced ISLErs will comment about their experiences. Please, check my yesterday's post and contribute! Today, I am posting my thoughts about another challenge expressed in the meeting. I have experienced this one too. Many times.
I am the only physics teacher at school, students vary from year-to-year, some year students couldn’t do the same activities as well as they should (especially in the assessment)
I think it is a common thing for groups of students to vary. The most important thing here is to spend time learning about your students - what their interests are, what their situation at home is, who their friends are, what school subjects they like most. Then talk to other teachers who teach those students (it does not matter that they are not physics teachers) and ask them about their strategies to motivate the kids.
Finally, there are always leaders in every social setting who affect the whole group, it is very useful to find these leaders, talk to them and figure out how they can help you lead the class to learning.
In terms of assessment - sometimes it is useful to ask the students how they want to be assessed - through writing reflections, through solving problems, though independent

projects, through talking to you? Varying your forms of assessment might help you find an initial connection with them.
As for being the only teacher - that is why we have this community - to share, to support, to help and to cheer!
Yesterday I promised to post two papers that showed that students learn better when they are actively engaged. This paper was written over 25 years ago and has a study of 6000 students. Another paper that I will post tomorrow was written 20 years after this one and had 50000 students. The findings are very similar.
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Eugenia Etkina
Admin

All-star contributor
· October 16 ·
Here is the second paper published 20 years after the one I posted yesterday about how interactive engagement helps students learn and traditional instruction not so much (or sometimes at all).
Save it for your files to work with administration and parents.

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Eugenia Etkina
Admin

All-star contributor
· October 17 ·
Hi all, I continue with the challenges identified in our meeting past Saturday that did not have time to be discussed in the meeting. Here is the next one:
There are so many activities. How do we know which ones to choose? What is enough? What is too much? Timing?
I completely agree with too many activities. That is why we marked the most important ones as "pivotal" in the ALG. We also discussed important activities in the Instructor Guide (it is posted here in the FILES). I suggest reading the IG before planning your classes. Also, it is important to know your students. Do they need more time and practice? Less time? Watch the groups carefully to make decisions to move forward.
Also, remember that we come back to the same idea many times, so if they did not grasp it on the first try, they might do it later. The resubmission policy should encourage them to fix

their mistakes too. It is great to pair stronger students with struggling ones and encourage collaboration.
The timing is important. Give your students a fixed time for an activity so that do not waste time at the beginning. Watch the bast groups - how much time did they need? Why were the others behind? Ask the students from the group that finishes first to help other groups. Watch carefully that there is no time when they finished and are just waiting. The "sense of urgency" is important in the lesson. There is no general recommendation on how long an activity should take - it depends on your students. The faster pace you establish for the lessons, the faster they will work.
Finally, it takes time for you get the feeling for what activities are most helpful for your students. So, if during the first year of implementation you feel overwhelmed, it is normal. That is why we have this group - post your questions, challenges and successes and the community will come together to help. Hope this helps. I am asking here experienced ISLErs to share their thoughts on this subject. Please do! Thank you!
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Eugenia Etkina
Admin

All-star contributor
· October 18 ·
Hi all, here is another challenge identified in our meeting last Saturday on successes and challenges implementing the ISLE approach:
For resubmissions in hs, no office hours to talk to students.
I am not sure what this means - does the school not allow you to come a little earlier or stay after school to work with students? I don't know who posted this challenge as it was group work in the meeting, thus I would like this person to say more.
But, let's say there is zero outside class to meet with students for them to explain how they redid stuff for resubmissions. Here is one possibility that I learned from one of high school teachers. He designated one period a week for not teaching any physics but playing educational and community building games with the students. This loss of instructional time did not affect his students performance at all (it was magnificent) as they were more motivated to work during other class times.
So, my suggestion is to designate some time every week for "self-improvement". During this time those who submitted Revision forms prior to this lesson (this is a form that asks the students to explain what they did wrong, how they learned what to do correctly and what the correct response to the question is) have an opportunity to work on extra similar problems and answer your questions orally. Those who did not feel the need to improve their prior work, just get some extra activities to work on or help those who need help. I know how we are all pressed for time to make sure that we address all needed content with our students. But if they are not ready to learn because they have not mastered previous stuff, us moving forward is not successful.
Maybe giving your students an opportunity to improve (only if they worked on this before!) will not only boost their knowledge and skills but also motivation so that you next lessons will go faster.

What do you think?
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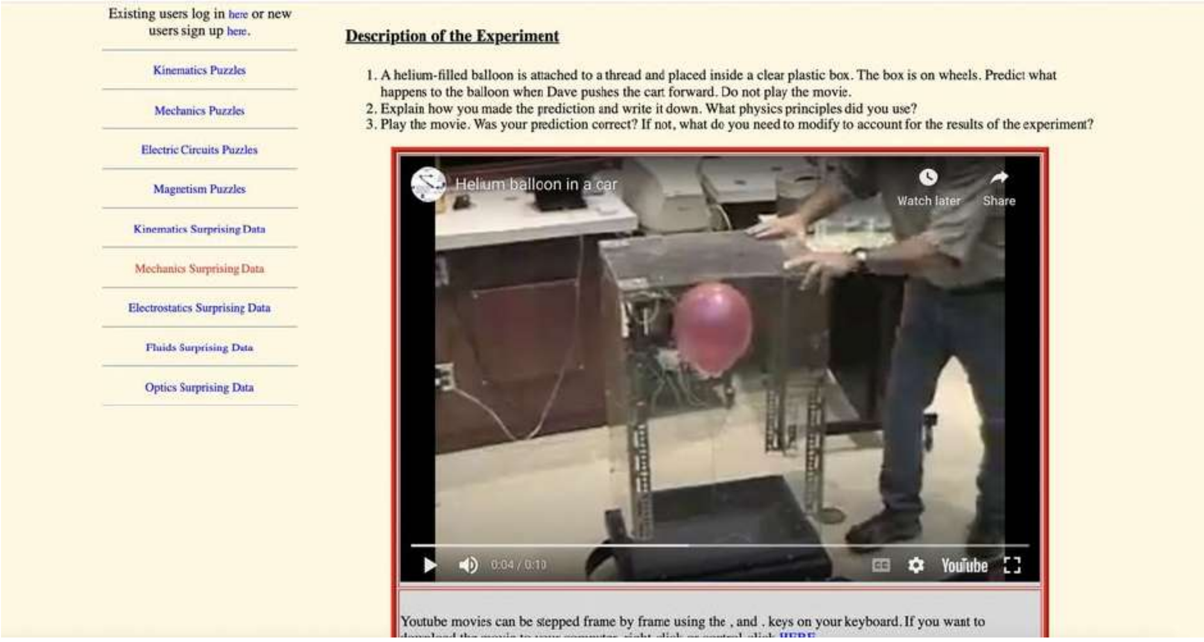
Eugenia Etkina
Admin

All-star contributor
· October 20 ·
Hi all Exploring and Applying Physics people! I addressed all challenges that came up in our meeting a week ago and were not discussed during the meeting and now I am going to back to Newton's laws and a type of experiments that we have not discussed yet.
As you know, in ISLE, we classify all experiments in physics into three categories: observational, testing and application. The testing experiments intend to test hypotheses invented by the students to explain the outcomes of the observational experiments. Th students use these hypotheses to make predictions of the outcomes of the testing experiments before running them. But often there is more than just a hypothesis that goes into making a prediction. This "more" is hidden assumptions, something that we take for granted whic might not be true. To alert students to the assumptions, a long time ago David Brookes and I came up with a new type of testing experiments that makes students question their assumptions. They are called surprising data experiments. A lot of those are on our old video website islevideos.net.
Here is my favorite example:
http://islevideos.net/experiment.php?topicid=13&exptid=121
Description of the Experiment
A helium-filled balloon is attached to a thread and placed inside a clear plastic box. The box is on wheels. Predict what happens to the balloon when Dave pushes the cart forward. Do not play the movie.
Explain how you made the prediction and write it down. What physics principles did you use?
Play the movie. Did your prediction match the outcome of the experiment? If not, what do you need to modify to account for the results of the experiment?
After watching the experiment:
Questions
What physics models did you use to make the original prediction?
What limitations of the models did you need to take into account to explain the result of the experiment?
What information about the box could have been helpful at the beginning?



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Eugenia Etkina
Admin

All-star contributor
· October 22 ·

Felix Baumgartner... Lots of the "needs to know" and application experiments for all kinds of physics. You can use it for kinematics, dynamics, rotational motion, pressure, and optics. You can use this video multiple times during the year to help your students see how much physics goes into it. All areas work together to describe and explain what is going on.

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Eugenia Etkina
Admin

All-star contributor
· October 27 ·
Hi all Exploring and Applying Physics people! I stopped posting for a while as my posts were not getting many views. But it looks like the situation did not improve. Even the posts from you that normally receive 800-1000 views are not very visible. I am not sure what to think about it but as some of you are already starting circular motion, I decided to resume my posts and share the most important ideas for the students to construct when they are in the first lesson learning circular motion at constant speed.
Here kinestetic activities are crucial. We have a set of observational experiments for the stuents to construct the idea that the sum of the forces exerted on an object moving in a circle at constant speed points towards the center. While we have the videos, the key for them to do the experiment trying to get a bowling ball to move in a circle at constant speed.
(ALG&OALG 5.1.1) https://mediaplayer.pearsoncmg.com/.../_fr.../sci-OALG-5-1-1
After the students construct the ides that the sum of the forces is towards the center, they need to test it!
https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...
3. After they test this idea they need to explain why they feel pushed OUT not IN when they are in a car making a turn. Here the ideas of the observer and a non-inertial reference frame are key!
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Eugenia Etkina
Admin

All-star contributor
· October 29 ·
Hi all Exploring and Applying Physics people! On Sunday I posted how to start the unit on circular motion (the "need to know" is in the post with the workshop materials). The point of the first lesson is to establish that when an object is moving in a circle at constant speed the sum of the forces exerted on it points towards the center of the circle. But why? Here is the sequence of activities that will help your students figure it out.
To help student see how the velocity vector changes its direction in circular motion, give them meter sticks and let them hold those perpendicular to their bodies and run/walk along a circle. The direciton fo the meter stick is the direction of their instantaneous velocity!

5.2 Analyzing velocity change for circular motion

5.2.1 Represent and reason

Class: *Equipment per group:* whiteboard and markers

In the activities in the previous section you learned that the sum of the forces exerted on an object moving in a circle at constant speed is pointed toward the center of the circle. Why is that? Think of the motion of the object. The speed is constant but is the velocity constant? How can you find the direction of the velocity of such an object at every instant?

a. Work together with your group members to draw on a whiteboard the velocity vectors for such an object at four different points of the circle. What is the direction of the velocity vector? What is its magnitude?

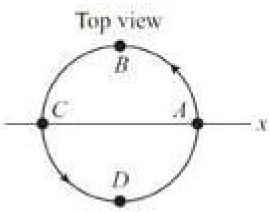
b. What can you say about the motion of the object? Is it motion with constant velocity? If not, how can you determine the acceleration at each point in the motion? Think of the definition of acceleration ($\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$) and how you determined the direction of the acceleration in Chapter 2 for objects moving in a straight line.

c. Read Physics Toolbox 5.1 in Section 5.2 of the textbook to learn the technique for determining the direction of acceleration of an object that is not moving along a straight line.

5.2.2 Represent and reason

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

An object moves at constant speed in a circle.



a. The task of your group is to determine the direction of its acceleration at each of the four positions shown in the illustration. Split the work among group members so that each member is responsible for one point. Work on a shared whiteboard. Use what you learned in Physics Toolbox 5.1. Make sure you take a point right before the point of interest and right after, and use a ruler to make sure the lengths of the velocity vectors remain the same and their directions are tangent to the circle.

b. Examine the findings of other members of the group. Can you agree on a pattern in the directions of the acceleration vectors? If so, what is it? Summarize your pattern on your whiteboard and compare what you found with the findings of another group

5.2.3 Explain

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

Have a discussion with your group: Explain how the pattern you found in Activity 5.2.2 is connected with the pattern you found in Activity 5.1.2. Does your explanation for why the sum of the forces exerted on an object moving in a circle at constant speed points toward the center of the circle match the one you constructed in Activity 5.1.3? If not, which one needs to be revised? Put your revised ideas on a whiteboard and discuss with another group.

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Eugenia Etkina
Admin

All-star contributor
· October 30 ·
Many tools that we use in our lives are made for men. This is an example of engineering of women in the world of men. And it is a great application for circular motion!

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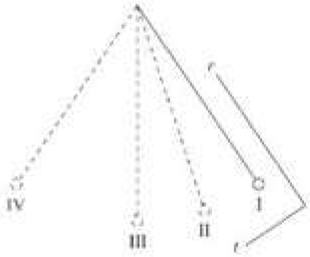
Eugenia Etkina
Admin

All-star contributor
· October 31 ·
Hi all Exploring and Applying Physics people! Today I continue the logical flow of the knowledge construction by the students. In my previous post (the day before yesterday) I showed the activities that help students figure out the direction of velocity in circular motion and explain why the the sum of the forces exerted on an object moving in a circle at constant speed points towards the center. But what if the speed is not constant? Where does the sum of the forces and thus, acceleration point? I am sharing an activity from chapter 10 - Vibrations. Although it is in vibrations, it is excellent for the students to really understand circular motion. Here is the screenshot from the ALG. The students first find the directions of the acceleration at different points using kinematics and then the directions of the forces. When you have the "Time for telling moment", discuss the roles of the radial and tangential components of the sum of the forces. Tomorrow I will post a testing experiment for some of the answers in the table.

10.5.1 Represent and reason

PIVOTAL ***Lab or class:*** *Equipment per group:* whiteboard and markers.

You have a small bob on a long string (a pendulum). The pendulum bob swings back and forth, as shown in the figure below. It is released at position I and swings all the way to position IV before coming back. At each of the marked points in the figure, the coordinate system consists of an axis in the radial direction (*r*-axis) and a perpendicular axis in the tangential direction (*t*-axis). Disregard air resistance.



a. Collaborate with your group members to complete the table that follows for positions shown in the figure.

Use the graphical velocity method to estimate the direction of bob's acceleration.	Position I	Position II	Position III	Position IV
Draw a force diagram for the bob.	Position I	Position II	Position III	Position IV
Draw the sum of the forces and of the acceleration. Do they match?	Position I	Position II	Position III	Position IV
Draw the *t*-component of the sum of the forces and of the acceleration. Do they match?	Position I	Position II	Position III	Position IV
Draw the *t*-component of the sum of the forces and of the acceleration. Do they match?	Position I	Position II	Position III	Position IV

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Eugenia Etkina
Admin

All-star contributor
· November 3 ·

Tom Prewitt said something in his comment responding to my comment yesterday, and it is so good that I want to share it with all of you. This is what he said:
"Sort of like Physics is this beautiful park and I'm going to take them to the spots where they can get the best views."

So true, if you are teaching through the ISLE approach...
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Eugenia Etkina
Admin

All-star contributor
· November 4 ·
Hi all, if you live in the US you know how I am feeling now. Worried and terrified that our country will make the wrong choice. All of us who believe in science and people's rights, please vote! One of the reasons for my work spreading the ISLE approach is that I hope that students who learn physics through ISLE learn to understand the difference between evidence and inference; that they learn to think like scientists, and that they care about other people belonging. This is what ISLE hopes to teach our students and I can only hope that we can still teach it after tomorrow. Please do your part and vote.
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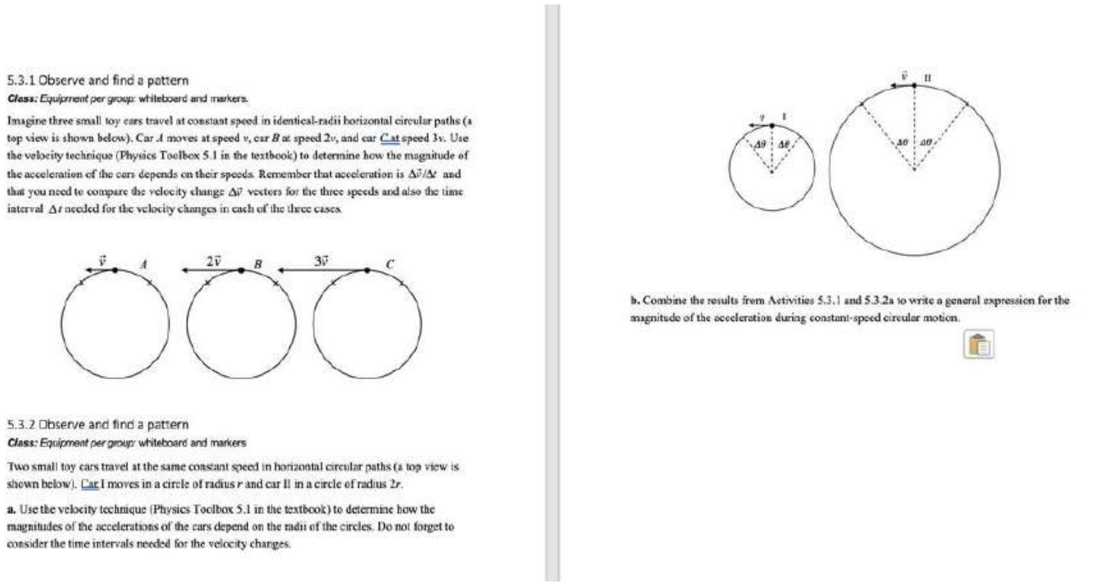
Eugenia Etkina
Admin

All-star contributor
· November 7 ·
Hi all Exploring and Applying Physics people! I continue posting about using the ISLE approach to teaching circular motion. Notice, that we teach this topic AFTER Newton's laws combining kinematics and dynamics. We also use the same tool - a motion diagram to help students make sense of what is going on. How do they invent the mathematical description of acceleration? After using the graphical techniques to find its direction, we proceed to mathematics. The process allows them to focus on the idea that acceleration is NOT delta v. It is delta v over delta t. Below are two activities that allow students to reason conceptually to the important v^1/r mathematical expression. Once they do it, they can evaluate the expression for units. But yet our way does not give them the coefficient - 1, this comes through testing experiments. I will post the next activity tomorrow. Please ask questions!



5.3.1 Observe and find a pattern

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

Imagine three small toy cars travel at constant speed in identical-radii horizontal circular paths (a top view is shown below). Car *A* moves at speed v, car *B* at speed $2v$, and car C at speed $3v$. Use the velocity technique (Physics Toolbox 5.1 in the textbook) to determine how the magnitude of the acceleration of the cars depends on their speeds. Remember that acceleration is $\Delta\vec{v}/\Delta t$ and that you need to compare the velocity change $\Delta\vec{v}$ vectors for the three speeds and also the time interval Δt needed for the velocity changes in each of the three cases.

5.3.2 Observe and find a pattern

Class: *Equipment per group:* whiteboard and markers

Two small toy cars travel at the same constant speed in horizontal circular paths (a top view is shown below). Car I moves in a circle of radius r and car II in a circle of radius $2r$.

a. Use the velocity technique (Physics Toolbox 5.1 in the textbook) to determine how the magnitudes of the accelerations of the cars depend on the radii of the circles. Do not forget to consider the time intervals needed for the velocity changes.

b. Combine the results from Activities 5.3.1 and 5.3.2a to write a general expression for the magnitude of the acceleration during constant-speed circular motion.

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Eugenia Etkina
Admin

All-star contributor
· November 8 ·

Hi all, I continue with circular motion. How do we test that the derived expression for the radial acceleration which was a proportionality in my yesterday's post can be turned into an equality with the coefficient of 1. a=v^2/r instead of a is proportional to v^2/r? Here is the testing experiment:

5.3.3 Test the relation

PIVOTAL Lab: Equipment per group: whiteboard and markers, ruler, string, objects, ring stand, arms and rods, clamp, digital scale, stopwatch, protractor.

Learning goal: Use the equipment to construct a conical pendulum and use that set-up to test your derived expression for radial acceleration v^2/r.

a. First brainstorm with your group members. What physical quantities can you measure? What physical quantity could you predict with the equation in order to test it? Describe how you will model the objects, interactions, and processes you will use in your mathematical model. Construct force diagrams as appropriate.

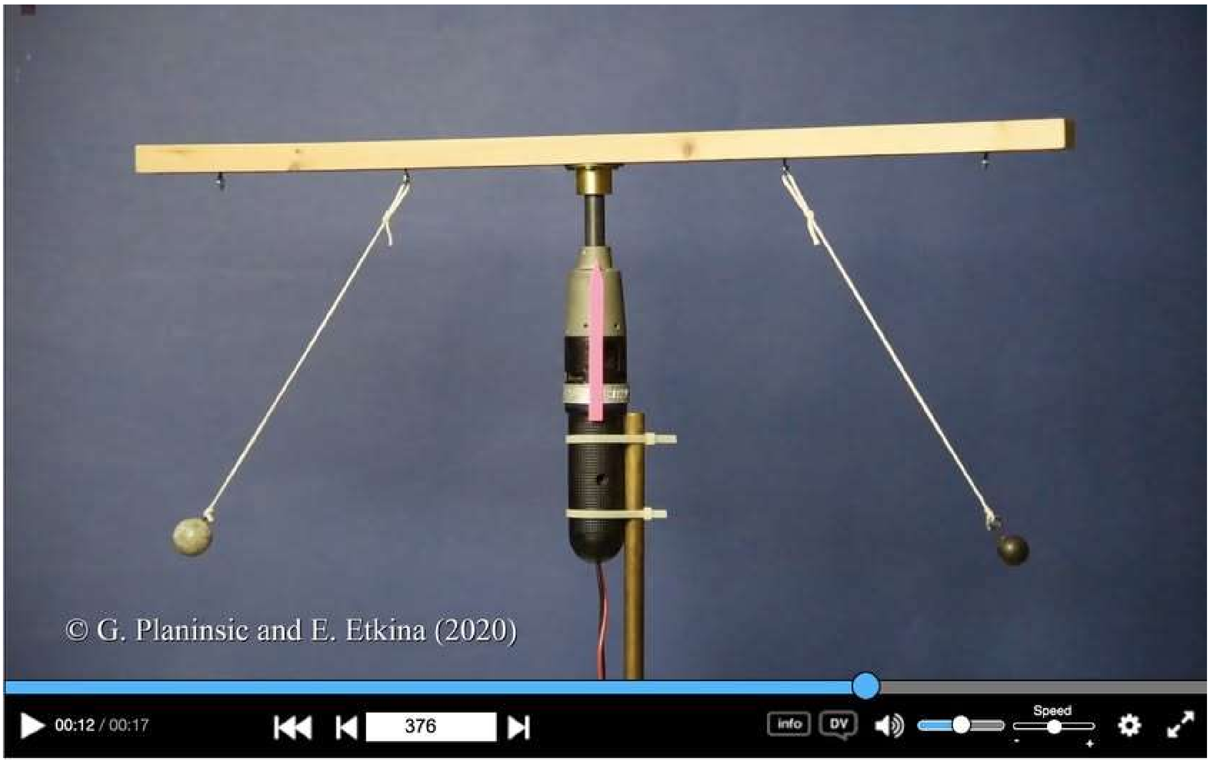
b. Describe your experimental procedure. Include a sketch of your experimental design. Explain what steps you will take to minimize experimental uncertainty.

c. Decide what assumptions about the objects, interactions, and processes you need to make to solve the problem. How might these assumptions affect the result? Be specific.

d. What are the sources of experimental uncertainty? Which measurement is the most uncertain? How did you decide?

e. Make a numerical prediction. Be sure to show your mathematical procedure. Show your work to an instructor.

f. Perform the experiment. Record your results in an appropriate format. What is the outcome of the experiment?
g. Make sure to compare your experimentally measured and predicted values. Taking into account experimental uncertainties and the assumptions you made, decide if these two values are consistent or not. If they are not consistent, explain possible reasons for how this could have happened.
There are multiple ways to do the experiment (better several!). Please share what your students have done.
In the OALG we have a video alternative if your students do not have access to equipment.
OALG 5.3.3 Test the relation
Equipment: a ruler, a protractor.
Use the video https://mediaplayer.pearsoncmg.com/.../_fr.../sci-OALG-5-3-3to test your derived expression for radial acceleration v^2/r.. For this experiment, you will need a ruler and a protractor.
a. Watch two spheres A and B of different masses move in a circle ((and). What do you notice about their motion? Write all your observations below (do not measure anything). Draw force diagrams to explain the tilt of the strings qualitatively.
b. Use the data in the video for sphere A to determine whether the angle is consistent with the equation under test. What other quantities do you need to determine to make this judgment? Describe how you will model the objects, interactions, and processes that you will use in your mathematical model. Construct force diagrams as appropriate.
c. Consider the uncertainties in your data. How do they affect your judgment?
d. How can you explain that the tilt of the string for sphere B is the same as for sphere A although sphere B has about three times larger mass?



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Eugenia Etkina
Admin

All-star contributor
· November 10 at 6:50 PM ·
Hi all Exploring and Applying Physics people! This is my last post for Chapter 5 - Circular motion. If you are teaching AP Physics, it is the post for you.
As you know, in the revised AP there are four types of questions/problems that students will encounter on the exams. One of them is TBR - translation between representations. The person who was the first to advocate that translating between the representation is one of the important aspects of thinking like a physicist was Alan Van Heuvelen - my long time collaborator and a co-author of our textbook.
In our textbook the multiple representation problem solving strategy is the the foundation of problem solving. In the ALG/OALG we have lots of activities for the students to do in the classroom where they do not need to solve for anything, but translate, translate and translate again. I am posting a representative activity form the ALG/OALG in the circular motion chapter. Do not skip!

OALG 5.4.1 Represent a process in multiple ways

Below are three scenarios involving a rollercoaster car running on a smooth nearly-frictionless track.

I	II	III
The roller coaster car glides at constant speed along a frictionless, level track.	The roller coaster car moves along a frictionless circular dip in the track. 	The roller coaster car moves inverted along the top of a frictionless loop-the-loop. 

For each of the scenarios described above, perform the following:

a. Re-draw the diagram of the scenario on your page.

b. Indicate the direction of the radial acceleration $\vec{a}_r$ of the car on your diagram.

c. Draw a force diagram for the car, labeling each force with two subscripts to show what object is exerting a force on the object of interest. Indicate the direction of the radial axis on your diagram.

d. Apply Newton's second law $\vec{a}_r = \frac{\sum \vec{F}}{m}$ to the car, making sure you are consistent with how you chose your radial axis.

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Eugenia Etkina
Admin

All-star contributor
 · November 13 at 4:00 PM ·
Hi all Exploring and Applying Physics people! I am starting a series of posts on conserved quantities. These are mass, linear and rotational momentum, total energy, and electric charge. There are four crucial ideas when students are learning conserved quantities:
The idea of a system and the environment. In physics any group of objects (fields are considered objects here) can be considered a system, all other objects (and fields) are the environment that interacts with the system.
For the analysis of the system you need to choose initial and final states. What happens in between is not important.
There is a difference between the terms conserved and constant (they are not synonyms). A conserved quantity (mass, momentum, total energy, etc.) is constant in an isolated system and changes in a non-isolated system but you can always find a system in which a conserved quantity is constant (the same in the initial and final state) A non-conserved quantity can be constant (constant acceleration, constant velocity) but when it changes, you cannot redefine the system to keep the quantity constant.
conserved quantities can be graphically represented with bar charts. For each quantity the bars are labeled differently, but the principle is the same. Once you learn bar charts for one quantity, it is easy to transfer this knowledge to a different quantity. non-conserved quantities cannot be represented by bar charts.
ISLE students start learning the ideas of conservation in Chapter 6 - Linear momentum, but in that chapter, they first learn about mass as a conserved quantity. We had several workshops dedicated to Chapter 6. I am posting the link - you will find all documents there.
Please pose questions and share your experiences with students!
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Eugenia Etkina
Admin

All-star contributor
 · November 14 at 10:21 AM ·
Hi all, this is a reminder of our workshop for Optics on Saturday. If you plan to attend please sign up going to your EVENTS.
I posted the link to the registration two days ago. The enrollment if very small and it worries me. Please let me know if these workshops are useful. Alternatively we could have office hours on Fridays or Saturday once a week so that you can ask questions. I could have a standing zoom meeting every Friday or Saturday at the time that is convenient for people.

The problem is that we are in different time zones and it is impossible to find the day/time convenient for everyone. Please share your ideas. Thank you.
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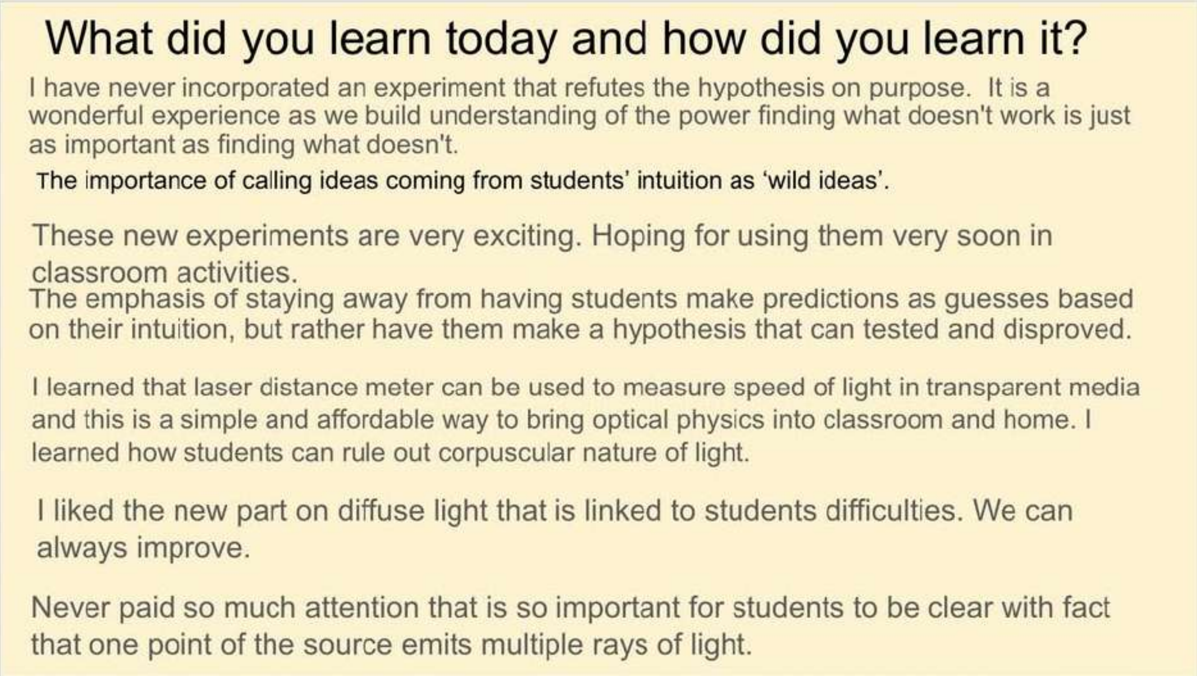
Eugenia Etkina
Admin

All-star contributor
· November 17 at 7:20 AM ·
Hi @everyone! We had a wonderful workshop on optics (part I). Thank you all those who participated and created a unique atmosphere of learning and love for physics. Not only that we went through the logical progression of the material and worked with new and exciting experiments, but we also focused on the nature of the ISLE approach - no predictions before observational experiments, testing hypotheses not intuition and the differences between hypotheses and predictions. The more times we return to these pillars of the ISLE approach, the more ISLE process becomes habitual. I enjoyed the workshop very much and I hope the participants did too. Huge thanks to Gorazd Planinsic for his amazing experiments and help with them during the workshop.
Here is the reflection slide and links to the workshop folder and zoom recording.



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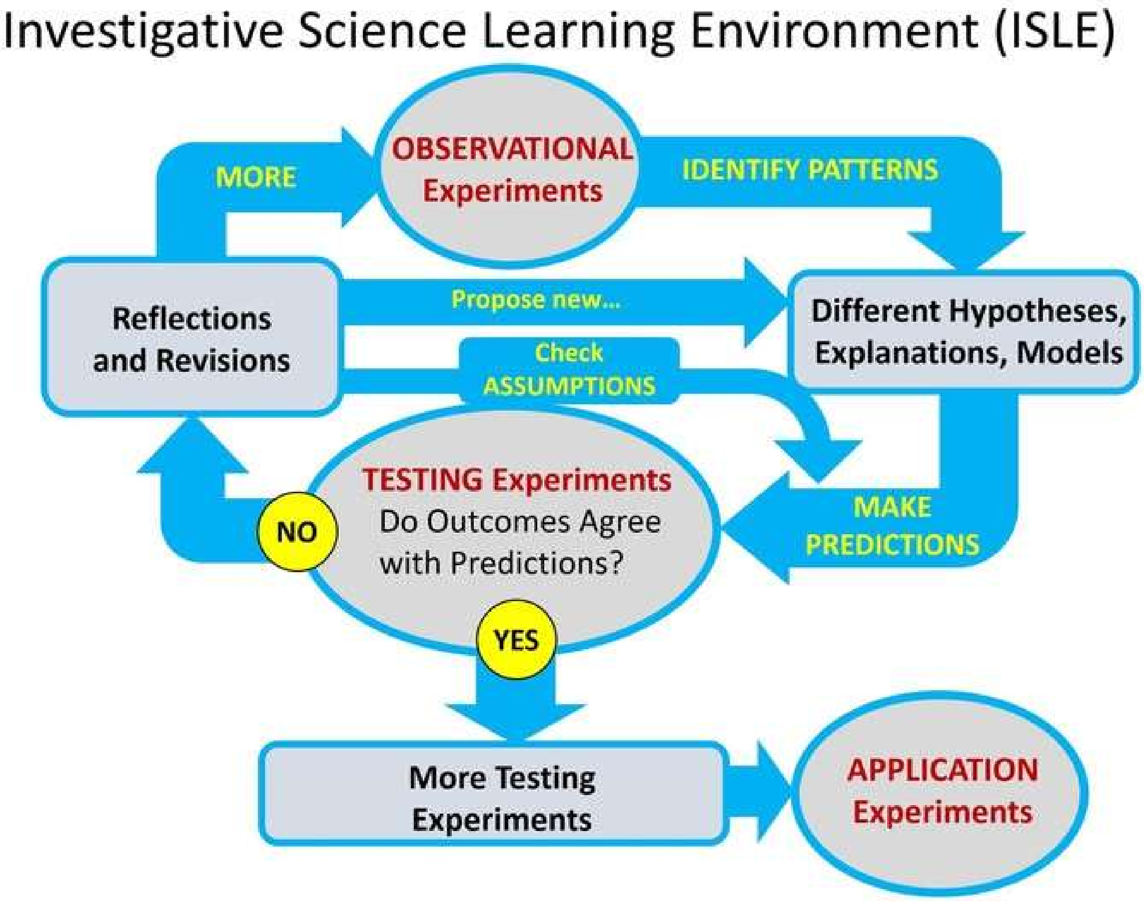
Eugenia Etkina
Admin

All-star contributor
· November 21 at 8:33 AM ·
Hi all Exploring and Applying Physics people! The votes for the Optics II: Wave optics workshop are evenly split. I am thinking of running it on December 14th not on the 21st as when it is closer to Christmas, people have more chores and other things. So, it will be on the 14th. If you teach Wave Optics, please sign up for the workshop when I post the link to the EVENT.
Based on our conversations in Optics I workshop last Saturday, I think it is important to remind the new members the logical progression of the ISLE materials: We start the development of EVERY concept with the students OBSERVING simple experiments without making any predictions; they find patterns and come up with EXPLANATIONS/MODELS/HYPOTHESES. Then they design TESTING experiments to test their explanations (or patterns). They then PREDICT the outcomes of those experiments using the explanations under test, not their intuition. They run the testing experiments and compare the outcomes to the predictions. The predictions are correct when they are based on the explanations under test, not when they match the outcomes of the testing experiments. The explanations are ruled out when the predictions and outcomes do not match but the explanations can never be proven correct, we can only fail to disprove them. After several tries to disprove, we keep the ones that we cannot rule out and use them in APPLICATION experiments. In all those steps students work in groups and then share their ideas with the rest of the class. The following slide shows this logical progression. It is very different form POE (predict-observe-explain) for many reasons that I have elaborated before. But if there is a need to repeat I will be happy to do it. Please comment and ask questions!



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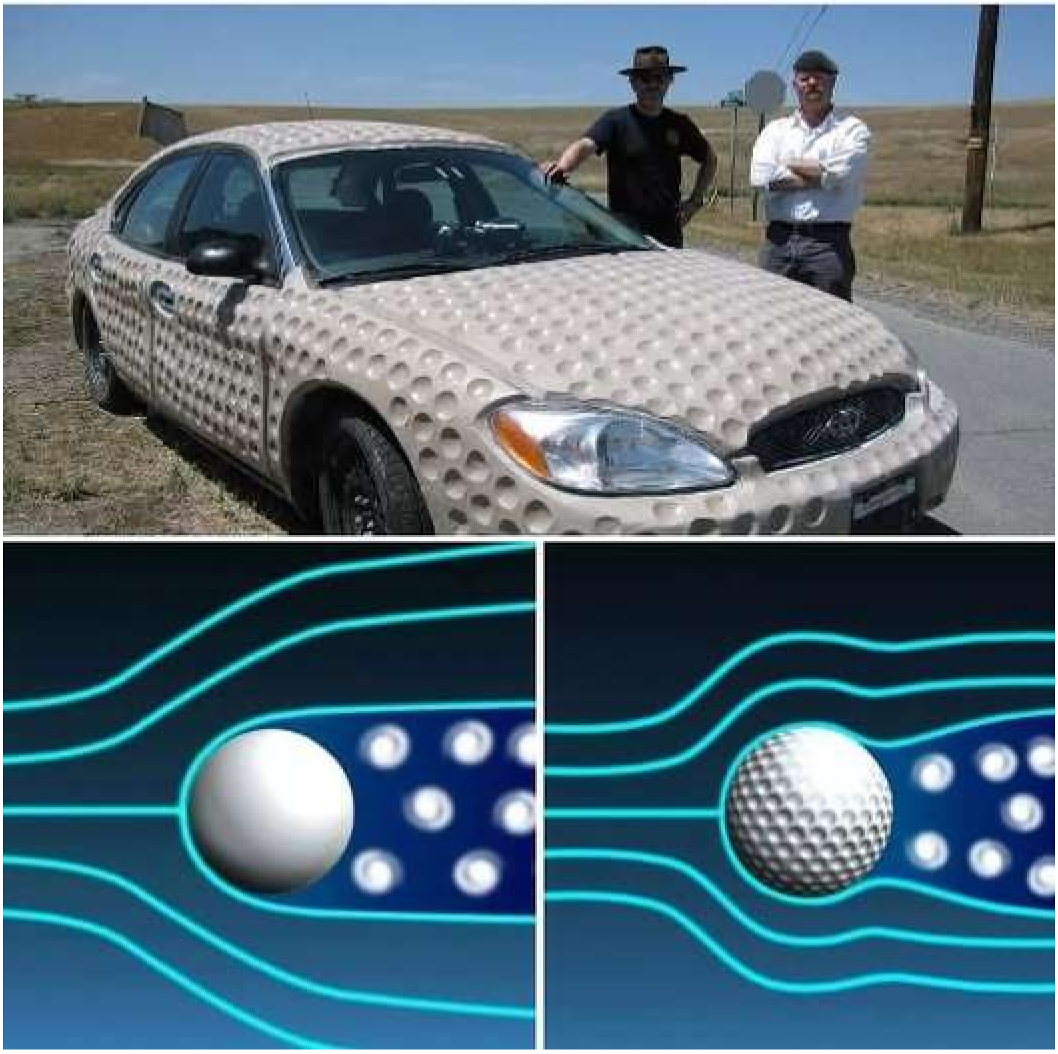
Eugenia Etkina
Admin

All-star contributor
· November 24 at 7:07 AM ·
Hi all, in our new edition of the textbook (is about to be ready for use in September) we spend some time discussing the reason for the golf balls to have dimples. The text is below. But today, I saw this in my Facebook Feed - and because we wrote the paragraphs I pasted below, I could understand the physics and humor in the car's photo. This is a great application experiment! If you are teaching FLUIDS IN MOTION, save this car's photo! Here is our text:
"...Just because laminar flow is more energy efficient does not mean it is always preferred. If you look at a golf ball, you see small dimples on its surface (Figure 14.9a - not shown here, but is in the textbook). They are there to increase the turbulence of the balls in flight. Why is increasing turbulence a good thing? When the ball is flying through the air, behind it is a wake (similar to the wake that we see behind the ships in the water). The wake is a region of relatively low pressure and the resulting pressure difference between the forward and rearward regions results in a pressure drag on the flying ball. The greater the size of the

wake the greater the drag will be. The increase of the speed of the ball increases the size of the wake and thus, the drag exerted on the ball. However, when the ball flies very fast, the air close to the ball surface becomes turbulent. It turns out that such layer of turbulent air sticks longer to the ball, which causes the size of the wake to decrease and so does the drag. Unfortunately, the golf balls do not fly fast enough for this to occur. Therefore, golf ball designers came up with a clever way to create a layer of turbulent air at lower speed – by making dimples on the ball surface! Dimples trigger turbulence, decrease the size of the wake and the drag force exerted on the ball (Figure 14.9b). This makes the golf balls fly farther. Researchers studied the difference in drive distances of the gold balls without dimples and with the dimples. In their study, the drive distance of the golf balls without dimples was only about 125 meters, while the average distance reached by the golf balls with dimples was about 215 meters



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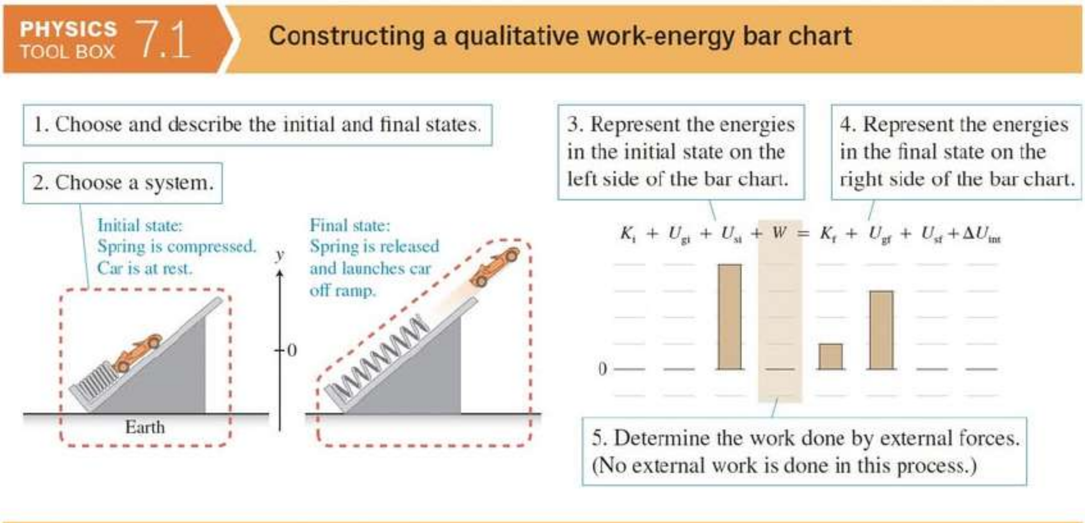
Eugenia Etkina
Admin

All-star contributor
· November 25 at 12:15 PM ·
Hi all, two things today. First, we still have only 7 people who signed up for the Wave Optics workshop. In my experience about half of those who sign up usually attend. This leaves us with 3.5 people, which is not enough for group work. If we do not have over 12 people registered, I can't run the workshop. I already asked if there is interest in these workshops, if not, we will come up with something else to keep the community going. So, please sign up.

Second, today, I continue posting about conserved quantities. If you think about the biggest departure from traditional approach to teaching any topic, our approach to energy is this fundamental departure. We do not teach mechanical energy in mechanics. We teach TOTAL energy as it is the only energy that is a conserved quantity (mechanical energy is not a conserved quantity) and it makes no sense to talk about conservation when dealing only with mechanical energy. I am posting below the start of our Chapter 7 (Work and energy) in the Instructor Guide.
Here it is:
In the last chapter, students learned about two conserved quantities—mass and momentum. Here they encounter the idea of the total energy of a system and the means to change it by doing work on the system. Just as the quantity momentum is either constant for a system of one or more objects if the system is isolated or can change when an external impulse is exerted on the system, the total energy of the system is constant when the system is isolated and it changes when an external force does work on it. This approach allows us to incorporate the changes in the internal energy of the system into the generalized work-energy equation and removes the need to discuss conservative and nonconservative forces. As you read though the chapter, you will learn the details of this approach. Here we summarize briefly:
1. To determine the energy of a system, one must first choose a system. Any choice is allowable, but given the objective, often certain choices of system are better than others.
2. Total energy is a property of a system. Different forms of energy describe the interactions between objects in the system and their motion. The various forms of energy can be converted from one to another within the system.
3. External objects (parts of the environment) can do work on the system (positive or negative) and thus change the system's total energy. Objects within the system cannot do work on the system.
4. The energy conversions within the system and the changes of the total energy due to work done by external forces can be represented on a bar chart.
5 In cases that involve friction, we include both surfaces of interacting objects in the system. Thus when one object slides across the surface of the other object, there is no force of friction doing work on the system (this force is an internal force) but mechanical energy is converted into internal energy of the system.
Many physics education research studies have found that students have difficulties differentiating between work and energy and often double count them. For example, in a system including Earth and another object (and therefore possessing gravitational potential energy) students will still reason that Earth does work on the system. The approach used in the book not only allows us to address this problem but also helps with the first law of thermodynamics and all other areas of physics in which energy is the primary focus—electrostatic interactions, photoelectric effect, atomic spectra, fission, and so on. The approach establishes a link not only between different areas of physics but also between

physics and chemistry. The idea of energy arises first in mechanics and develops throughout the text. The content-based learning objectives in the chapter are as listed below.
Students should be able to:
1. Connect energy to everyday experiences.
2. Recognize the role of a system in energy analysis, be able to analyze the same situation using different systems and explain the benefits and drawback of different choices.
3. Calculate the work done by constant and variable forces (such as an elastic force). Understand that the sign of work does not mean direction but addition and subtraction.
4. Differentiate between energy and related ideas (work, power, momentum, force).
5. Recognize that energy is a conserved quantity but not necessarily constant in a particular system.
6. Represent processes using work-energy bar charts and convert the bar chart into a mathematical statement of a generalized work-energy principle, and use the bar chart to evaluate numerical solutions.
7. Account for conversions of different forms of energy into other forms within the system, including conversions into internal energy.
8. Explain where the mathematical expressions for different form of energy came from, explain how to choose the zero level for gravitational potential energy and why the gravitational potential energy is negative when zero is chosen at infinity.
9. Design experiments to test energy conservation.
10. Analyze collisions using momentum and energy.



TIP In Physics Tool Box 7.1, the system is isolated. No work is done on it. If we do not include Earth in the system, then Earth will do negative work on the cart. However, such a system will not have gravitational potential energy.

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Eugenia Etkina
Admin

All-star contributor

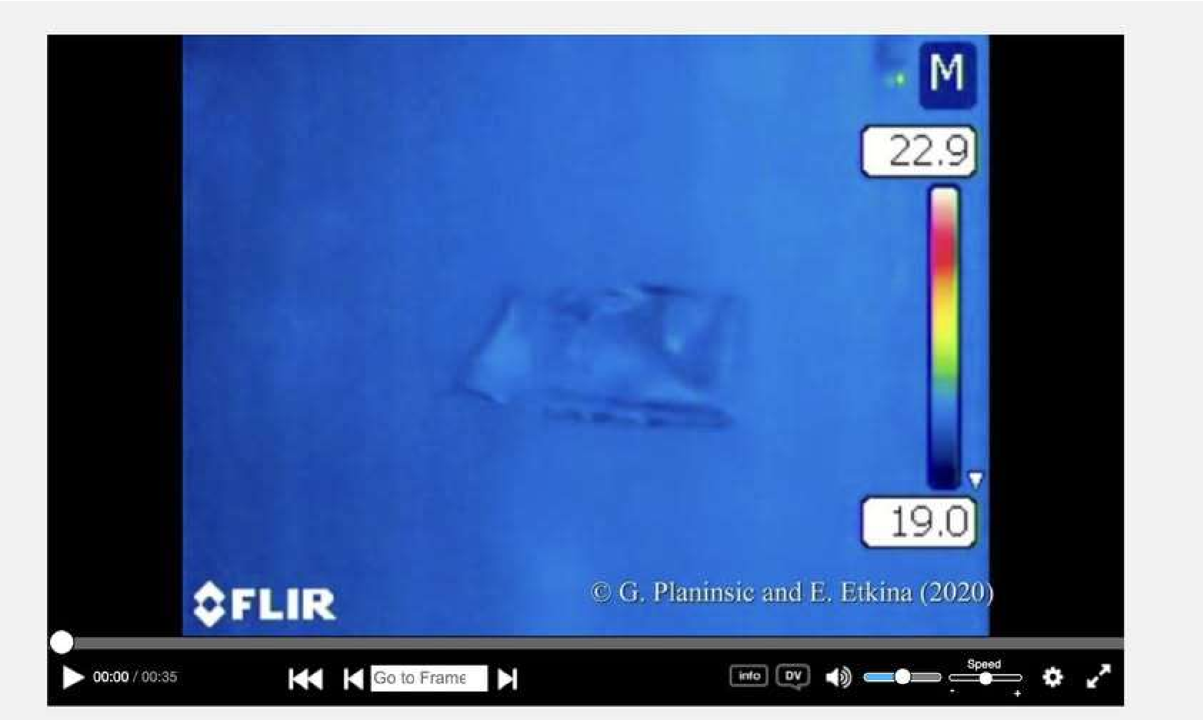
· November 26 at 11:51 AM ·

Hi all, I continue with work/energy today. This is the text in the upcoming edition of our textbook, you will not find it in the current edition.

"In our approach we separate forces into external forces that do work on a system and thus change the total energy of the system and internal forces that do not do work and do not change the total energy of the system. Why internal forces do not do work follows from the law of energy constancy in an isolated system. If internal forces could change the total energy of a system, then total energy would not be a conserved quantity, and we would be able to get energy from nowhere. But does this mean that internal forces are "useless" for work-energy analysis? The answer is "far from it". Imagine that you investigate what happens to the energies when you drop an object, let's say a ball. We choose our system to be Earth and the ball. The initial state is when the ball is lifted above Earth and the final state is when the ball is moving at some speed right before it hits Earth. In the initial state the system possesses gravitational potential energy and in the final state the system possesses kinetic energy. While the force exerted by Earth on the ball does not change the energy of the system as it is an internal force, it does work by converting the gravitational potential energy to kinetic energy. While external forces change the total energy of the system, internal forces help convert one type of energy into another.

Now, think about what happens when the ball lands on the floor and stops. Both the ball and the floor deform a little and warm up. If we include the floor in the system, we can explain this deformation and warming saying that kinetic energy of the system was converted into internal energy. But what forces "did" the conversion? We can think of internal forces that different parts of the ball exert on each other and the forces that the ball and the floor exert on each other. All those forces do work to convert kinetic energy of the ball into internal energy. To help visualize this process, see
https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-7-5-4

In the experiment shown in the video, a steel ball falls on a metal plate. The video is taken with a thermal camera, so you can see the increase in temperature of the ball and the plate."



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Eugenia Etkina
Admin

All-star contributor
· November 27 at 9:21 AM ·
No new post today. Happy Thanksgiving break to everyone in the US and for those who are not on break - there is plenty to read in the latest posts. Please ask questions and share your successes and challenges. Finally, please sign up for the Wave optics workshop in your EVENTS. We still did not get to 14 people, the minimum number of registrants for the workshop to go on. I will be back with new posts on December 2nd.
I am thankful for all participants in our group for their love of physics, dedication to their students and commitment to ISLE. Huuuggggssss!
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I already shared about this incredible woman, but it never hurts to do it again. Because of her we have the term "scientist".

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Hi all, a few days ago Geraldine Cochran posed a question about her students struggling with the physical meaning of negative work bard in the work-energy bar charts. Many people responded to Geraldine and it started a conversation about the use of mathematics in physics. In our second books about the ISLE Approach: "Investigative Science Learning Environment: A guide for teacher preparation and professional development", that many of you have (and if you don't just send me an email), in Chapter 4 we have a long discussion of the use of mathematics in physics. Here I post a part of this section. Hope it is helpful when you help your students struggle with mathematics. Here is goes:
"A long time ago, Galileo said that a field of study becomes science when it starts using the language of mathematics. But while physics uses mathematics as a language through which it communicates its laws, the use of mathematics in physics is very different from its use for pure mathematical purposes. In their paper, “Obstacles to mathematization in introductory physics”, S. Brahmia, A. Boudreaux, and S. Kanim said: “University students taking introductory physics are generally successful executing mathematical procedures in context, but often struggle with the use of mathematical concepts for sense making” (p. 1, Brahmia et

al. 2016). In this section, we will explore some of the physics habits of mind related to using mathematics.

As Brahmia and colleagues put it: “Mathematizing in physics involves translating between the physical world and the symbolic world in an effort to understand how things work. Specific skills include representing concepts symbolically, defining problems quantitatively, and verifying that solutions make sense. Physicists develop and communicate ideas through the shared meanings they have built around these strong connections between mathematics and physics.” (p. 1, Brahmia et al. 2016).

We can argue that mathematics, being the language of physics, has its own vocabulary and grammar. We can see physical quantities and other symbols as a part of physics vocabulary and their arrangement and rules using which we combine them as the grammar of mathematics in physics. It is in the vocabulary and grammar that the important differences and details of using mathematics in physics lie.

Let’s start with the first part of the vocabulary – physical quantities. Similar to mathematics, in introductory physics we have numbers and vectors. An important difference is that in physics, all quantities have units and therefore we cannot have certain operations with the quantities that have different units. Physical quantities that have different units cannot be added or subtracted from each other. They can only be divided or multiplied.

However, multiplication and division of quantities in physics are very different from multiplication and division in mathematics. In mathematics, multiplication means addition. When we multiply the number 5 by the number 3, it means that we will either have the number that is made of 3 fives (5+5+5=15) or of 5 threes (3=3+3+3+3=15). In physics, when we multiply two physical quantities, the new quantity cannot be made by summing anything. For example, momentum of an object is a product of mass and velocity of an object. To obtain it, we multiply the magnitude of velocity (speed in m/s) by the mass of the object (in kg). The new quantity has the units of kg×m/s and we assign the direction of this quantity to be the same as the direction of the velocity vector. Nowhere in this progression do we find any addition.

The same is true for the division procedure or ratio quantities. In mathematics, division means a sequence of subtractions. For example, to divide 15 by 5 we take away 5 from 15, then another 5, and then one final 5. It took a total of 3 times to be left with nothing (15:5=3). We know how many fives is contained in 15 – three fives. However, when we do a similar operation in physics, the result is different. For example, if we divide the distance that a person traveled (15 km) by the time they took (5 hours), we will not find 15 km to be made of three 5-hour intervals. Instead, we will find the average speed of the travel of 15 km in 5 hours: 15 km: 5 h = 3 km/h. The result is a new quantity – average speed – and it has new units, km/h.

Physicists execute these operations habitually while remembering the importance of units. However, we very rarely discuss the differences in these mathematical procedures in physics and mathematics. It is difficult to separate the vocabulary and grammar when we talk about physical quantities. We can think of basic quantities (those that have SI units) as vocabulary and the compound quantities as sentences – combining both vocabulary and grammar.

In addition, we can also think of mathematical signs as the grammar of mathematics. Let’s examine a few meanings of signs in physics. The plus or a positive sign in an equation can mean many different things: adding quantities that have the same units (m_total=m_1+m_2), the positive sign in front of a force or velocity vectors scalar component (often omitted) means that the vector itself points in the direction chosen as positive (when the y-axis points down, the component of the force that Earth exerts on the system of interest is positive and equal to +m_system g), the positive sign in front of work done by a force (also often omitted) means that this work adds to the total energy of a system ($W = +10$ J), and a plus sign in front of an electric charge means that it is a positive charge ($q=+10^{-9}$ C). It is interesting to notice that when physicists use the plus or positive sign, they only use it when it signifies an operation of addition whereas in all other cases mentioned below, the sign is dropped and is assumed to be positive.

The situation with the negative sign or a minus sign is even more obscure. In their paper, “Framework for the natures of negativity in introductory physics” (Brahmia et al. 2020), Brahmia and colleagues discuss the following use of the negative sign in physics (p. 010120-1):

In the equation, $x(t)=-40\text{ m}+(-5\text{ m/s})t+1/2(9.8\text{ m/s}^2)t^2$ the minus sign shows that initial position, velocity, and acceleration of the object all pointed in the negative direction of the chosen positive axis. Thus, the sign signifies direction in relation to the a priori chosen positive direction.

In the equation, $F_{1\text{ on }2}=-F_{2\text{ on }1}$, the negative sign signals that the force exerted by object 2 on object 1 is in the exact opposite direction as the force exerted by 1 on 2.

In the expression, $0 - (-5\ \mu C)$, the first negative sign indicates that a quantity of electric charge is being removed from an electrically neutral object. However, the second negative sign indicates which of the two different types of electric charge is being removed.

In Faraday’s Law, $\varepsilon=-\frac{d\Phi_B}{dt}$, the negative sign reminds the expert that the emf induced by a changing magnetic flux opposes (rather than reinforces) the change that created it.

We add to Brahmia et al. examples that the negative sign in front of work, $W=-5$ J, means that the work done by the force in question decreased the energy of a chosen system. Also, the negative sign in front of gravitational potential energy, $U_g=-5$ J, means that it is the energy of a bound system, and one needs to do positive work to separate two interacting objects. Conducting a deep theoretical analysis of the nature of negativity, Brahmia and colleagues developed a categorization scheme that encompasses all possible uses of the negative sign in physics (p. 010120-6, Brahmia et al. 2020).

From the above discussion, it is clear that while the sign conventions might be “transparent” for physicists, the students need additional discussions every time they meet a positive or a negative sign in front of a quantity or in an equation." (Etkina and Planinsic, 2024)

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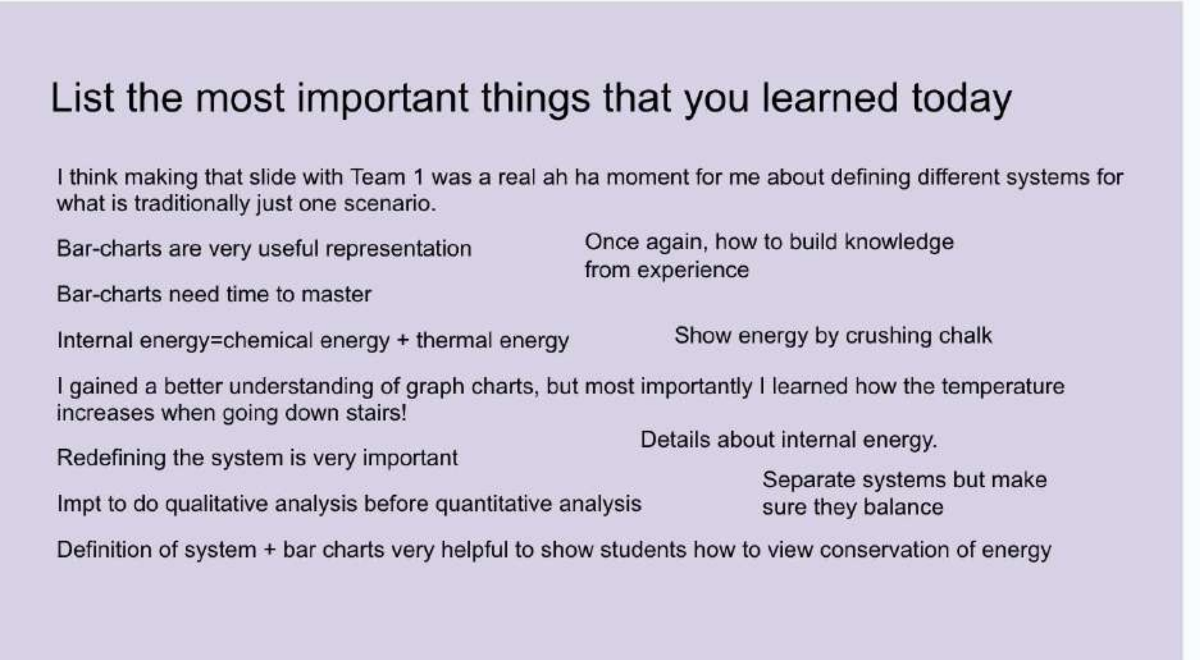
Hi all, in order not to repeat my posts for energy, I am putting the link here to two workshops (2023 and 2024) for the first part of teaching energy and the summary slide from 2023. Hrvoje Miloloža will add a link to the video recording of one of those workshops when he has a minute. I am reminding you that our approach to teaching energy is very different form traditional and consistent with the AP approach. If you wish to become comfortable with the systems approach and the difference between "conserved" and "constant" terms, please visit the link below. Not only it has slides of the workshops but also research papers to explain why we do things the way we do. Here is the link. The Reflection slide shows what workshop participants found important and useful.



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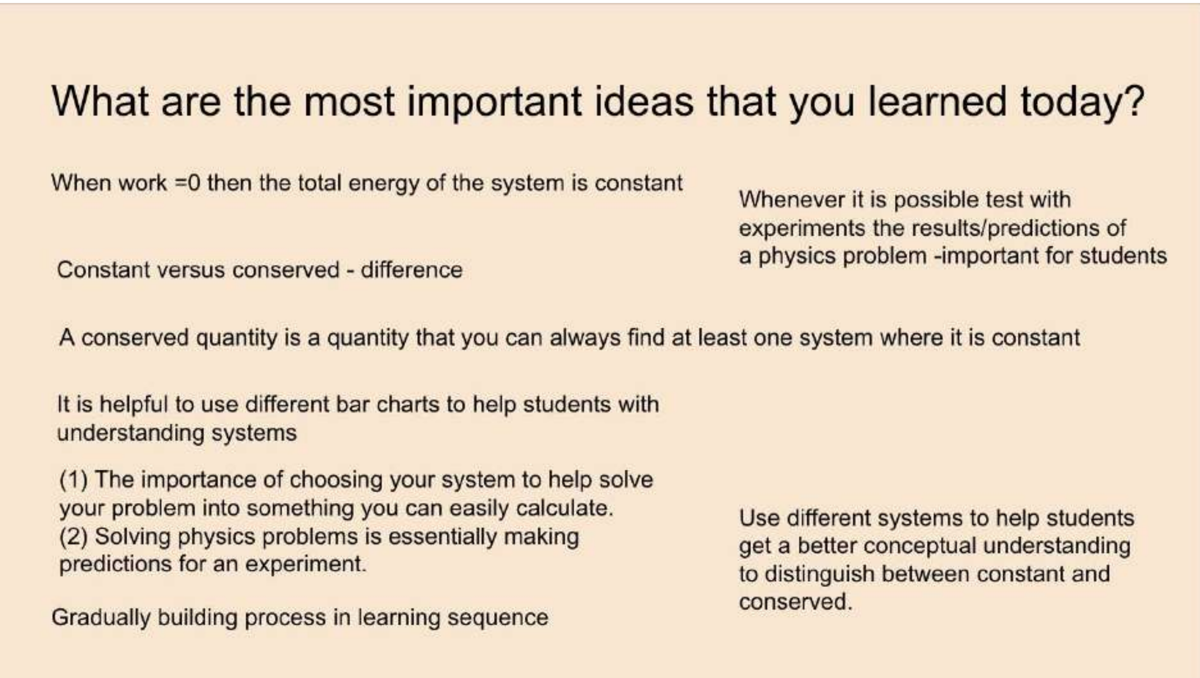
I continue with the information about the workshops on Energy that were held before. We usually have two workshops for energy, and here is the link to the slides of the second one and the summary slide so that you can get an idea of what people learned there.
One of the important ideas is that when we walk (horizontally or up and down the stairs), the ground exerts an impulse on is but does not do any work. How can this be? If the ground does not do work, what makes us accelerate? These are the questions to ponder - please share your thoughts.



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Great representations of a very complex idea. Even if it is not a part of your curriculum, it is still fascinating!

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Yesterday Noah Segal started an interesting conversation about using ISLE in the AP C physics course after students already had some physics. I would say, yes, use as much as you can and as often as you can (every day, actually), especially the activities where students design their own experiments (we have calculus based labs on the scientific abilities website), use graphical representations to solve complex problems, and try to use one star and double stat end of chapter textbook problems as much as you can. But...
If you wish your students to develop physics habits of mind they need to start the construction of a new idea with observing something (or remembering what they observed last year), they need to discuss the patterns, they need to express them mathematically, they need to develop graphical representations, they need to test their explanations of the patterns by designing new experiments or by discussing experiments that they did last year, and so forth - it is the ISLE approach to learning that develops physics habits of mind, and if you wish your students to develop them, they need to experience it every day. Tom Prewitt posted about the benefits of persistence in ISLE on Saturday, check his post!
A long time ago, when we just working together, Alan Van Heuvelen was teaching a calc based physics course for honors engineering students at the Ohio State University in Columbus (1999). He taught the first semester using his materials - all interactive and great, but the students did not develop their ideas as they do it in ISLE. So, at the beginning of the second semester in a large lecture hall he asked a question: "Do you know Newton's second law?" The hands went up - everyone raised their hand, they were very good students! Then he asked: "how do you know it?" There was silence and then one students said: You told us. That response sold Alan to ISLE.
So, it is not necessary to repeat activities that you did last year, if it was you who taught these students before, but if it was not you who taught them and they did not use ISLE, I bet their answer to a question about any concept, would be the same as the answer of Alan's student.
This is what I think. I welcome your ideas!
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Hi Exploring and Applying Physics people! I wanted to share something that is very useful for those who is using ISLE with their students. I have been reading an amazing book by Rutger Bregman "Human kind: A hopeful history". While this book is an eyeopener in itself, there is one page that is very relevant.
The book describes the studies conducted with students that show that when a teacher believes that their students are gifted, the students do much better than when a teacher thinks that they are teaching regular students. Here is the study. Two matched groups of students had two teachers (also some kid matched). One teacher was told that they have a selected gifted group and the other one was not told anything. They taught the same material in exactly the same way to the students and the students in the group of the teacher who believed that they were gifted outperformed significantly the other group. How can this be? The videos of two teachers teaching explained the outcome. The teacher who thought that their students were selected as gifted students treated them differently - with more patience, more care, more tolerance, etc. And that made all the difference.
All my life I thought that the students become what you think of them - if you think that they are lazy and incapable, they become lazy and incapable. If you think that they are motivated, hard working and talented, they become those people. I observed this again and again with my own students but I never had research to back it up. Students always meet our expectations. The higher the expectations - the better they do. But care, understanding and support are necessary with high expectations. So, there, food for thought. We have tremendous power and we need to use it wisely...
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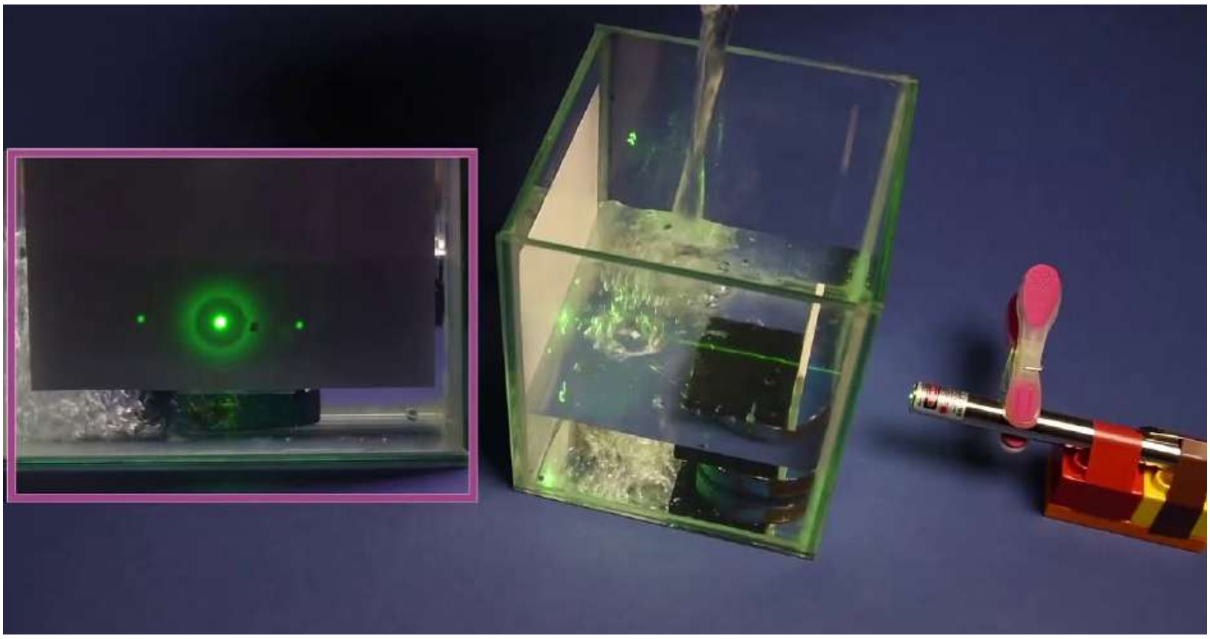
Hi all, a question. In our Optics II workshop on Saturday we had a following activity (a testing experiment for the derived expression of the maxima for the diffraction grating)
$d\sin\theta = n\lambda$ - imagine that your students derived this expression and then you ask:
Imagine you a shining a laser pointer at a diffraction grating and notice where the central and first maxima are. Where will those first maxima be (closer or farther away from the central) if the hole set up is submerged in water? The participants made a prediction (the bright spots will be closer together as the wavelength of light in water is less than in the air) and then watched the experiment. The prediction matched the outcome - see the video below.
However, when the same activity was done with the students, one of them asked: "The wavelength of light should change in water, why do we still see the green light?"
How would you respond here? What will you do?
https://www.youtube.com/watch?v=HGwc2sgWMYc



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That is the whole point of the ISLE approach - everyone in your classroom will have a feeling that they figured out something and it does not matter that someone else figured it out before them, what matters is that THEY did it for THEMSELVES. Every day, in every lesson there is a bit of "engineered" discovery for every students. This is how we wrote our materials and this is what makes them "real science". By the way, I created an event for our Quantum optics workshop and only 8 people signed up there so far, while over 30 said that they are interested and will come. Did you see the event announcement? It was yesterday. Please sign up if you plan to attend.

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Second, I was posting about energy for a while but I thought it would be helpful to share our reasoning for teaching energy differently and the goals of the unit. I pasted the text form the Instructor Guide below. The Instructor Guide is posted here in the FILES.

"In the last chapter, students learned about two conserved quantities—mass and momentum. Here they encounter the idea of the total energy of a system and the means to change it by doing work on the system. Just as the quantity momentum is either constant for a system of one or more objects if the system is isolated or can change when an external impulse is exerted on the system, the total energy of the system is constant if the system is isolated and changes if an external force does work on it. This approach allows us to incorporate the changes in the internal energy of the system into the generalized work-energy equation and removes the need to discuss conservative and nonconservative forces. As you read though the chapter, you will learn the details of this approach. Here we summarize briefly:

1. To determine the energy of a system, one must first choose a system. Any choice is allowable, but given the objective, often certain choices of system are better than others.
2. Total energy is a property of a system. Different forms of energy describe the interactions between objects in the system and their motion. The various forms of energy can be converted from one to another within the system.
3. External objects (parts of the environment) can do work on the system (positive or negative) and thus change the system's total energy. Objects within the system cannot do work on the system.
4. The energy conversions within the system and the changes of the total energy due to work done by external forces can be represented on a bar chart.

5 In cases that involve friction, we include both surfaces of interacting objects in the system. Thus when one object slides across the surface of the other object, there is no force of friction doing work on the system (this force is an internal force) but mechanical energy is converted into internal energy of the system.

Many physics education research studies have found that students have difficulties differentiating between work and energy and often double count them. For example, in a system including Earth and another object (and therefore possessing gravitational potential energy) students will still reason that Earth does work on the system. The approach used in the book not only allows us to address this problem but also helps with the first law of thermodynamics and all other areas of physics in which energy is the primary focus—electrostatic interactions, photoelectric effect, atomic spectra, fission, and so on. The approach establishes a link not only between different areas of physics but also between physics and chemistry. The idea of energy arises first in mechanics and develops throughout the text. The content-based learning objectives in the chapter are as listed below.

Students should be able to:

1. Connect energy to everyday experiences.
2. Recognize the role of a system in energy analysis, be able to analyze the same situation using different systems and explain the benefits and drawback of different choices.
3. Calculate the work done by constant and variable forces (such as an elastic force). Understand that the sign of work does not mean direction but addition and subtraction.
4. Differentiate between energy and related ideas (work, power, momentum, force).

5. Recognize that energy is a conserved quantity but not necessarily constant in a particular system.
6. Represent processes using work-energy bar charts and convert the bar chart into a mathematical statement of a generalized work-energy principle, and use the bar chart to evaluate numerical solutions.
7. Account for conversions of different forms of energy into other forms within the system, including conversions into internal energy.
8. Explain where the mathematical expressions for different form of energy came from, explain how to choose the zero level for gravitational potential energy and why the gravitational potential energy is negative when zero is chosen at infinity.
9. Design experiments to test energy conservation.
10. Analyze collisions using momentum and energy.
Brief summary of student difficulties with work and energy
Students might think that work is a property of a system; this mistake often carries over to thermodynamics. Given work can be positive or negative, students might think that work is a vector quantity and has direction. Students still might have difficulties identifying a system and initial and final states, and identifying the zero level of the gravitational potential energy. As we said above, the failure to identify a system and external objects often leads to double counting. Changes in internal energy of the system are imperceptible: this creates another difficulty – students might think that energy disappears. Often students think that the change in gravitational potential energy of the system is exactly equal to the change in its kinetic energy and vice versa (compensatory reasoning). Students might confuse work with energy, energy with force, and so forth. Thus they might think that both the elastic force and elastic potential energy are directly proportional to the first power of displacement."
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Hi all Exploring and Applying Physics people! Happy holidays, whatever you celebrate! I am going to take a break from posting for a while to let you catch up with the posts, watch the recordings of the workshops, etc.
If you are new to the group, just scroll down and read the posts - they will take you the trove of resources that we have. Check the FILES here too - lots of reading for the winter break!
Experienced participants: I am asking you to share here your questions, wins, and challenges this year. This groups is over 6 years old and many of you have been members and active participants for a long time. How did you classroom change? What is a common habit for you and your students now that were not in your teaching practice before? How are your students doing? Please share!
Thank you for participating and happy holidays again!

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A story about another woman in physics.

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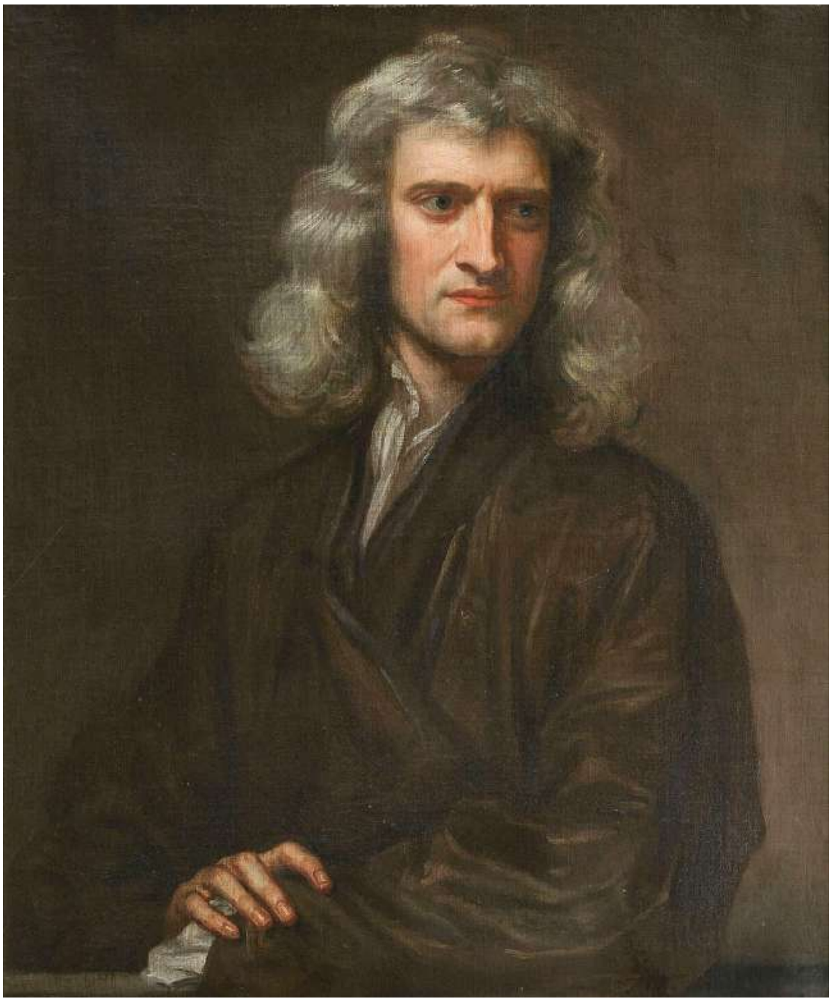
He would be a special needs child in our classroom. I usually post about unrecognized people in physics, and Newton is, of course, very recognized. I am sharing this post so that we all remember that behind a strange or an uncomfortable child in our class a genius is hiding. How do we give them space and the right attention to make sure that this genius is not shut down by our educational system? Thus - the second intentionality of the ISLE approach.



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Hi all Exploring and Applying Physics people! Hope you are having a little break now. Today I wanted to talk about "contrasting cases". Research shows that when physicists solve new problems, they use contrasting cases at every step - when they are discussing original observations, when they are noticing patters, when they are coming up with hypotheses and when they are testing them. Basically, as they are trying to figure out what something is, they immediately focus their attention on what it is not! How often do we use this strategy when helping our students construct new ideas? Here are two examples of contrasting cases to ponder. Tomorrow and the day after tomorrow I will post activities that engage students in thinking about those contrasting cases.

When we walk or run (without slipping), the road exerts a force and an impulse on us but does no work. This is also true when we go up or down the stairs. The stairs exert an impulse on us but do not work.

When a wave travels, it carries energy but does not carry momentum.

Please comment, question, and share!

If you google "contrasting cases" - lots of stuff comes up in different subjects.

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Hi all, yesterday I posted about two important contrasting cases, and Joseph Wachs commented on one of them. But the second case was left "uncommented". How can the waves carry energy but not momentum? Here is an exercise in our new ALG (coming out with the new edition of the textbook) that helps your students explain how it can be.

11.6.9 Apply

Run the PhET simulation at the following link:

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

Set the following parameters:

Excitation mode: PULSE

Amplitude: 1 cm

Pulse width: 0.7 s

Damping: NONE

Rope tension: HIGH

Playback mode: SLOW MOTION

In the following, assume that the rope oscillates in a horizontal plane (e.g. sliding on a flat floor with negligible friction). Since we have set the damping to zero, we can also assume that the rope is ideally flexible. This means that if the rope is stretched slightly, this increases the elastic energy of the rope. We also assume that the elastic energy of the undisturbed rope is zero.

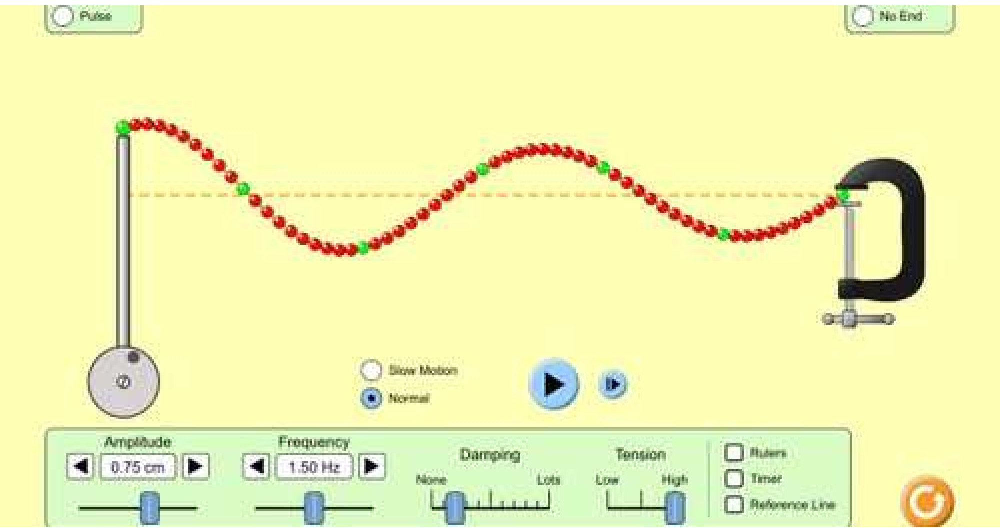
Create a pulse on the rope by clicking on the green button with the triangular symbol. Answer the following questions, specifically for the case when the right end of the rope is rigidly clamped (FIXED END) and for the case when it is free (LOOSE END). In all cases, the system is the rope.

a. What types of energy are present in the rope when a pulse is traveling along the rope? Describe in which parts of the rope each type of energy is residing (add a sketch). What can you say about the total energy of the rope along which the pulse is traveling before, during and after the reflection? Explain. Indicate any assumptions that made.

b. What can you say about the total momentum of the rope along which the pulse is traveling, before it reaches the end? Explain. Indicate any assumptions that made.

c. Which parts of the rope along which the pulse travels have non-zero momentum? Add a sketch.

d. Analyze the reflection of the pulse at the fixed and loose end of the rope in terms of energies and in terms of momenta, by drawing appropriate bar charts. See the table below for details. Note that the observed system is the rope.
Fixed end for both energy and momentum
Initial state
Just before the pulse reaches the end (the pulse is moving to the right)
Final state
The moment when the rope is straight (horizontal)
Then again for
Initial state
The moment when the rope is straight (horizontal)
Final state
Immediately after the pulse moves away from the right end of the rope (the pulse is moving to the left)
Loose end both energy and momentum bar charts
Initial state
Just before the pulse reaches the end (the pulse is moving to the right)
Final state
The moment when the right end of the rope is furthest from the equilibrium position
And again
Initial state
The moment when the right end of the rope is furthest from the equilibrium position
Final state
Immediately after the pulse moves away from the right end of the rope (the pulse is moving to the left)
e. Are your answers to questions a, b, and c consistent with the bar charts that you drew? Explain



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Hi @everyone! Happy New Year! It was a very productive year for our group!

We had 10 2-hour workshops in 2024 and one 8-hour workshop. This year we ran several new workshops that we did not have before - Gases, Fluids (2 workshops), 1st Law of Thermodynamics, Magnetic fields, Electromagnetic induction, and Optics (2 workshops so far, and one one more coming in January). All workshops are recorded and are available on the google drive together with the slide shows used the workshops (I am not posting the links here as if I do, Facebook does not tag everyone).
We had over 500 people join our group in this last year, making the number of members 2853 - almost 3000 people!
There are many of you who attend every workshop that I offer, which is amazing, considering that you are all busy and the workshops are on Saturdays only. I thank all regular attendees for their dedication and the support of our group.
Many of you expressed interest in the Quantum optics workshop but only half of those who said that they wanted to come actually registered. If you did not see the announcement for the workshop here, go to your EVENTS and you will find them.
This year we (Gorazd Planinsic and I) published a new book on ISLE (the first book came out in 2019, same authors + David Brookes). Many of you asked me for a pdf. I sent the pdf to everyone who asked but I did not hear back from those who have read the book. Please share what you have learned from it and if was useful for the understanding of the ISLE approach.
Happy New Year everyone and I hope that our next year will be as productive as 2024!
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