Exploring and Applying Physics

Facebook group

Posts by Eugenia Etkina from 2021

Eugenia Etkina
6. January 2021.

Here is chapter 1 for the OALG where we introduce ISLE approach to the students and teach them how to read the textbook (interrogation method). Do not miss! If you are new to the group, please go to FILES on tope of the home page of the group and download OALG files and Lab experiments files. If you have any questions, please post them here!

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Eugenia Etkina
15. February 2021.

Hi all, yesterday we had a great conversation about experimental uncertainties. Our approach to the uncertainties is very different from traditional. It is focused on the conceptual understanding of the experimental uncertainties, not on complex mathematical manipulations to calculate them. We do not call them errors to avoid student thinking that those are bad and not to trigger "the human error" reply that we all dread. If you are interested in our approach that is called the weakest link rule, download the document at https://drive.google.com/.../0By53x8SYAF1lLWhORU5OTn.../view and you will see a beautiful and simple way to help your students understand how to estimate the largest percent uncertainty in their calculations. Thank you Łukasz Michalak for starting this conversation!

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Eugenia Etkina
18. February 2021.

Hi all, a few months ago I did an interview with a website that interviews professors and now it is published at https://faculti.net/investigative-science-learning.../
Check it out if you wish to learn about ISLE.

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Eugenia Etkina
7. April 2021.

Hi all, tomorrow at 7 pm EST I will be giving a colloquium at the University of British Columbia (UBC) about scientific abilities. The organizer of the colloquium told me that I can share information about it with anyone I like and that they can attend the colloquium. The information and the zoom link are on the website pasted below. Join, if you are interested. You will learn the history and the present of our work on scientific abilities.

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Eugenia Etkina
16. April 2021.

We all wish our students develop grit and persevere. How do we achieve this? I was listening to a Freakonomics podcast with Angela Duckworth - a psychologist who wrote a book on grit and they were taking how studies show that parents help their children develop grit by example. When the children observe their parents persevere and dedicate themselves to a goal, this grit and perseverance rubs off.
I have two grown up sons who, by some miracle (or this is what I always thought), turned out to be extremely gritty and continue to surprise me with their work ethic, dedication to the goals they set, and all other things we want our children to have. I always thought that I was just lucky to have these great kids. But today I realized that it was not just luck (thought I still believe some of it was), but the example they saw with both of their parents.
Why am I telling you this? Because I think that we can use these ideas in our teaching. How often do our students see us persevere and struggle, and overcome? Probably very rarely. What if we could show them how we personally struggle and persevere to achieve our goals? What goals do we have?
I am not sure we often set an example for our students in grit and perseverance. Let's think together how we could do it.

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Eugenia Etkina
19. May2021.

Hi all, I have not posted for a while - the end of the semester, spring and COVID fatigue - all of the above contributed to my lack of communication. I think I am back now and will try to post tips and ideas as often as I can. As I said many times before, this group is for those who are interested in implementing the ISLE approach in their courses, using the resources that we created or/and using our textbook. In this post I will talk about one aspect of our approach - multiple representations.
The idea that graphical representations help students learn by unloading their working memory and creating heuristics to analyze phenomena and solve problems is not new. In PER it actively brought in by A. Van Heuvelen in the 90s. He thought of graphical representations as the bridges between abstract language and abstract algebra/calculus.
In early 2000s Alan and I joined our approaches (the epistemology of physics + mult reps) to create the logical progression of the ISLE process. Since then, multiple representations became tools for reasoning that students use analyzing new phenomena (observational experiments), finding patterns, devising explanations (hypotheses), predicting results of the testing experiments, and solving problems.
We started thinking of them literally as tools (hammers and saws) of those who build the building of physics. In my tomorrow's post I will introduce the first graphical representation and then over the next days I will slowly go through all of them to show how they serve the purpose of tools and how students use them to increase their success in learning physics.

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Eugenia Etkina
20. May2021.

As I promised yesterday, I will post every day about one representation, in order of their appearance and usefulness in a regular physics course. Today's post is about motions diagrams (or motion maps as they are called in the Modeling Instruction curriculum materials). See Chapter 2 in our textbook. Motion diagrams consist of 3 elements: dots, that represent positions of a moving object at equal time intervals, velocity arrows attached to each dot that represent how fast the object is moving at this particular clock reading, and velocity change arrows that show how velocity changed from instant to instant (see the photo at the bottom of this post). They look pretty straight forward and yet we found that 1) velocity change arrows are very difficult for the students; 2) once the students figure out how to draw velocity change arrows, their understanding of Newton's second law is much better.
In order to understand how these diagrams relate to real motion, look at the top photograph (make sure you click on it to see all three experiments). Here you have a cart with a blinking

LED attached to it. A long exposure photo shows the LED traces over time. Looking at the traces, what can you say about the motion of the car?
You probably figured out that the top car was moving at constant speed to the left, the middle car was speeding up to the left and the bottom car was slowing down. You figured it out by comparing the length of the light traces. These are exactly what the velocity arrows show, only they also have direction.
What is the purpose of velocity change arrows? Don't velocity arrows show what is going on? The velocity change arrows will be used in dynamics when the students will need to figure out the direction of the sum of the forces exerted on the system. In fact, the whole idea of a motion diagram is much more useful in dynamics that in kinematics. When the students have to figure out the direction of the sum of the forces exerted on an object, it is the motion diagram that is the easiest and most concrete representation that allows them to imagine what is going on and where the sum should be pointed. Read tomorrow about force diagrams.
To help students construct a motion diagram you can use the experiment in the textbook (see the video attached).
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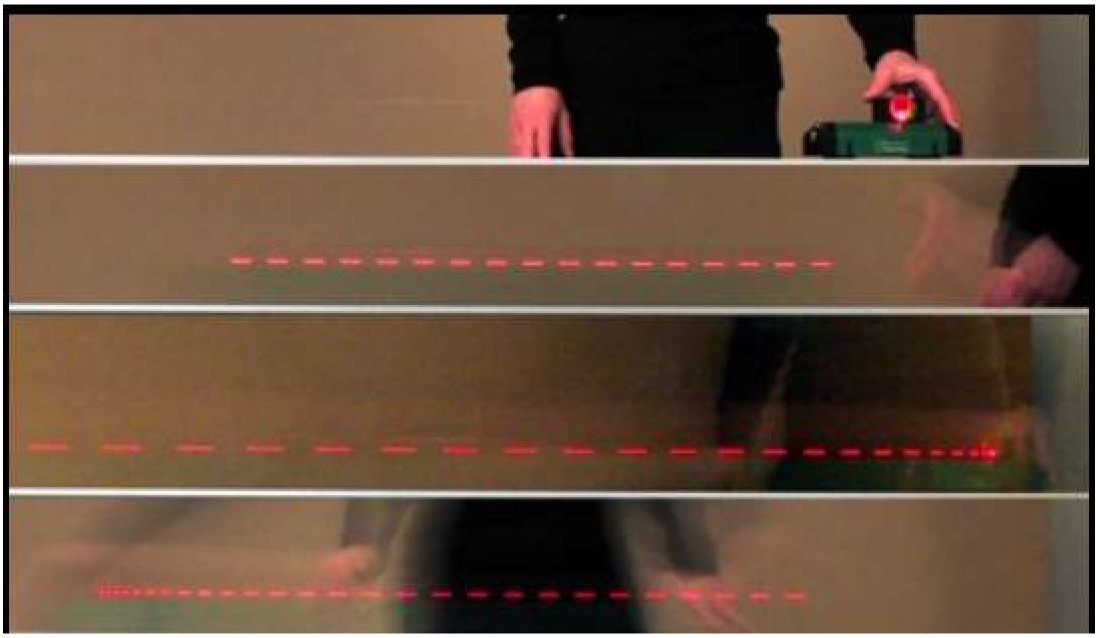

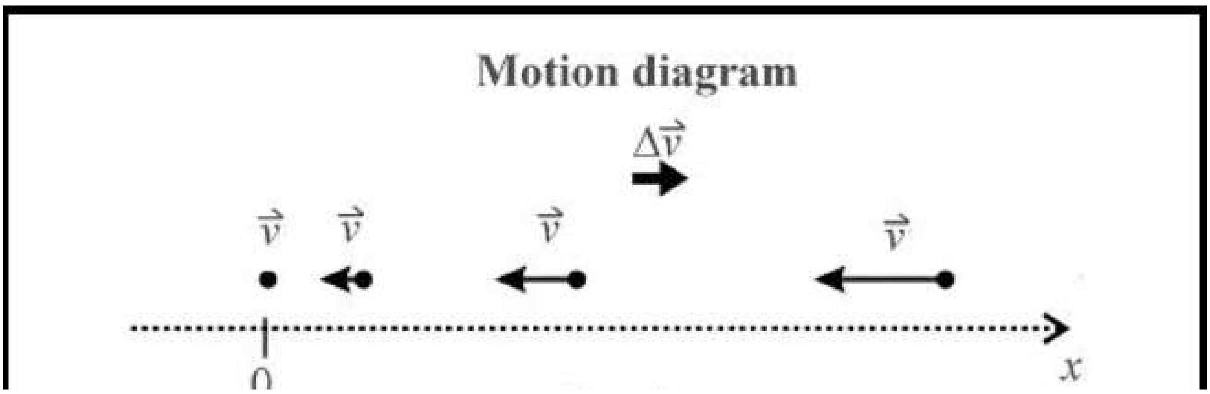

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Eugenia Etkina
21. May 2021.

I thought I would move on to force diagrams today but I think a little more about motion diagrams would be useful. As I said yesterday, students sometimes have trouble with velocity change arrows. To help them, I came up with an idea of cutting arrows from a cardboard (thick paper will work). Photos of these arrows are in the Files here as I posted them a long time ago. Cut 4 arrows, two of the same length and the other two - longer. These will be velocity arrows. Make them one color. Then cut the 5th arrow whose length is exactly equal to the difference in lengths of two different velocity arrows and make it slightly thicker. Color it differently. This will be the velocity change arrow. This is a set. Make as many sets as you need for class so that every student has one arrow. Now you can tell them different scenarios and they need to work together represent them with 2 velocity arrows and one velocity change arrow (if needed).
Here are possible scenarios (to make the exercise more effective, assign positive/negative directions to right/left). Ask students to pay attention to the relative directions of the velocity and velocity change arrows when the object is speeding up or slowing down.

1. An object is moving at constant speed to the left.
2. An object is moving at a higher constant speed to the right.
3. An object is moving to the left slowing down.
4. An object is moving to the left speeding up.
5. An object is moving to the right slowing down.
6. An object is moving to the right speeding up.

After they use the arrows to represent the processes, repeat but this time ask about the sign of the relevant quantities. This is a very useful exercise that helps students see that the sign of velocity change component along the chosen axis does not tell them whether the object is speeding up or slowing down. Only the relative directions of the velocity and velocity change arrows can tell this. When the students learn the physical quantity of acceleration, repeat again but this time help them reason that the direction fo the delta v arrow is the same as the direction fo acceleration. This set of exercises will help your students learn that negative acceleration does not mean slowing down.
Finally, connecting the motion diagram to a position-versus-time graph as it is done in our textbook Figure 2.14 (page 23) is very helpful too.

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Eugenia Etkina
24. May 2021.

Good morning everyone! I took a break for the weekend. Today we will be talking about force diagrams. There a few things that we do differently and they help students a lot.
First, we do not call them free-body diagrams, but force diagrams. This change came from the students who questioned, how an object that is interacting with other objects be free? We also use the definition of a force as a physical quantity characterizing interactions of two objects. If one cannot find two objects interacting with each other, there is no force. This approach eliminates "force of motion" or "force of acceleration" or any other non-existent force in an inertial reference frame.
Second, to start drawing a force diagram, we first identify a system of interest and circle is on a sketch. It is very important do to avoid students putting forces exerted on some other objects on the diagram for the object of interest. Everything else on the sketch (and in the world!) is the environment. We put a dot representing the system not the whole object as for now we are not concerned with the size of the system (we are not considering rotations yet).
Third, we identify objects in the environment that interact with the system (either by touching or at a distance as Earth, or magnets, for example). We will remember that the number of forces on our diagram should be equal to the number of objects.
Forth, we draw arrows representing these interactions. Here two things are important as we represent forces with arrows that start at the dot representing the system: Each force is labeled with two subscripts (see part 1). There is no "weight force" for example, but the force exerted by Earth on the system, so we label it F subE on S, where E stands Earth and S for system. There is no "tension in the rope" but F sub R on S. Such systematic labeling prevents non-existent forces and helps students remember that forces do not belong to objects but are measures of interactions. Another important step is the length of the force arrows. The lengths are such that the sum of the forces is in the same direction as the delta v arrow on the motion diagram. Therefore, if a system is in motion, it is necessary first to draw the motion diagram and only then consider the lengths of the force arrows. How do we know that the sum of the forces is in the same direction as the delta v arrow? To answer this question, make sure that you read Section 3.3 in the textbook. I am pasting the link to the video (OET 3.1 in the textbook) that shows the experiment from which the students infer this relationship.
https://mediaplayer.pearsoncmg.com/.../secs-experiment...

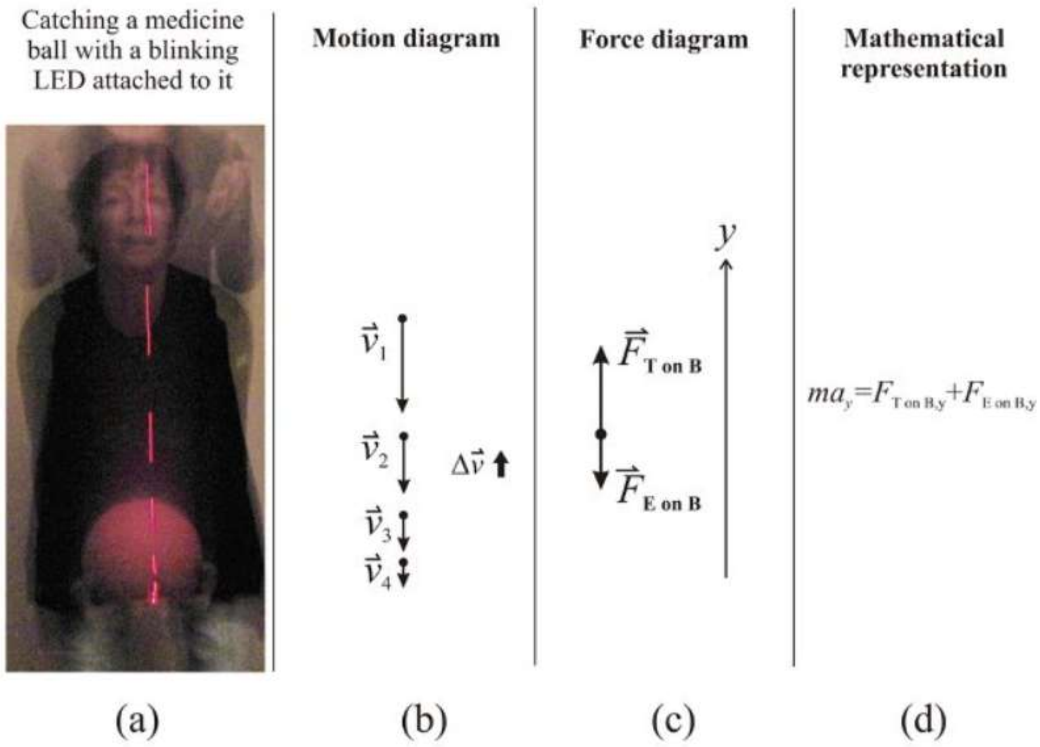

Figure II.1. (a) a photo of the teacher catching the medicine ball; b) motion diagram for the ball; c) force diagram; d) mathematical representation.

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Eugenia Etkina
25. May 2021.

Good morning everyone! I started with force diagrams yesterday. The question today - what are they good for? In our approach we use graphical representations while problem solving for 3 main purposes: to analyze the situation, to construct an algebraic representation, and to evaluate the result. Yesterday we talked about the first step - how represent a situation with a force diagram (and a consistent motion diagram!) Today I will discuss how to use a force diagram to write the statement of Newton's second law in component form.
First, we use two terms for components in our approach: vector components of a vector and scalar components of a vector. The vector components are two (or three) perpendicular to each other vectors the sum of which would give you the original vector. Usually those perpendicular directions are x and y (and z). The scalar components are numbers that indicate the lengths of the vector components and the direction relative to the chosen positive direction (x, y or z). if the vector component points in the positive direction, the

scalar is equal to its length with a positive sign, if in the opposite - the sign is negative (see Section 2.4 for the introduction).
Second, we add coordinate axes to the force diagram so that it is easy to determine the sign of the force components. In Chapter 3 - the beginning of dynamics, we only deal with the forces in one dimension - vertical, thus the components of the force vectors are equal in magnitude to the vectors themselves and the sign is determined what direction (up or down) you chose as positive. We recommend pointing the vertical direction both up and down depending on the problem so that the students learn that in physics directions are chosen for convenience.
Finally, we use the force diagram to write Newton's second law in component form for the situation. We never use F=ma expression, we only use ma=Sum of F or a=Sum of F/m. In this case, the sum is a vector sum, therefore we need components. It is important that in the law it is the SUM, so we always ADD all components (some are positive, some are negative). It is crucial not to skip the step and not to use the minus sign prematurely. Here the plus indicates summation of the forces and the minus in front of a component indicates the direction fo the force. For example, imagine you are lifting a suitcase that is accelerating upward. This is how the mathematical representation of Newton's second law looks like (Y is you, S is the suitcase, E - Earth, y -axis points up). Watch carefully how scalar components of the vectors are used to write the final expression for the acceleration.

$$a_{\mathrm{S}y} = \frac{\Sigma F_{\mathrm{on\,S}\,y}}{m_{\mathrm{S}}} = \frac{F_{\mathrm{Y\,on\,S}\,y} + F_{\mathrm{E\,on\,S}\,y}}{m_{\mathrm{S}}}$$
$$= \frac{(+F_{\mathrm{Y\,on\,S}}) + (-F_{\mathrm{E\,on\,S}})}{m_{\mathrm{S}}} = \frac{F_{\mathrm{Y\,on\,S}} - F_{\mathrm{E\,on\,S}}}{m_{\mathrm{S}}}$$

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Eugenia Etkina
26. May 2021.

Hello everyone! Today I am continuing with the force diagrams. Yesterday, I mentioned that we start by students analyzing situations where forces are exerted in one dimension only (vertical). What if the forces are exerted in different directions? Then, of course, components play even a more important role than before. We have an excellent approach to components when forces are in multiple directions. The two activities from the the OALG Chapter 4 (4.1.1 and 4.1.2) and the text in the textbook Chapter 4 clarify. Once you look at the first activity (I posted the screenshot) you will see the grid. The grid is the key to helping students see the x-and y-components of the forces. The ring experiment when done in person is infinitely

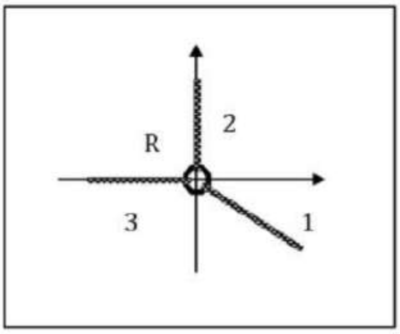
precious (we made a video for teaching online). When you go back to teaching in person, do not skip it!
https://mediaplayer.pearsoncmg.com/.../_fr.../sci-OALG-4-1-2

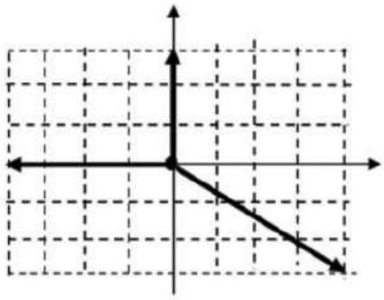
OALG 4.1.1 Components of force vectors

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.

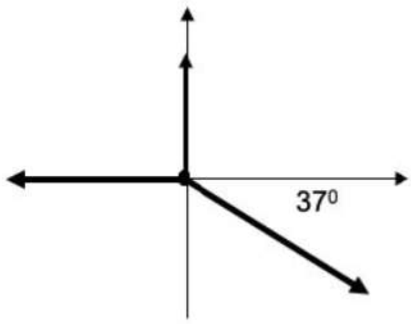
b. Repeat the same for the *y*-direction.





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.

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Eugenia Etkina
31. May 2021.

Hi all, the next few posts will be about a new representation - a bar chart. A bar chart allows us to represent conserved quantities. Before I move to the description of a bar chart and say what the bar charts are good for, I will remind you our approach to conservation, which is VERY DIFFERENT from the approach in all other (or most of) textbooks.
First, analyzing any situation, we start with identifying a system (this is what we already discussed for force diagrams). We can put anything we wish inside the system, the rest becomes the environment. For example, you have an apple and Earth interacting with each other. It is your choice whether to choose apple by itself for the analysis or include Earth in the system. If Earth is not in your chosen system, then it is a part of the environment. It does not, it absolutely DOES NOT mean that Earth does not matter, what it means, is that analyzing the effects of Earth we need to remember that it is not part of our system.
Second, we differentiate between two notions: conserved and constant. A constant quantity means that this quantity does not change with time. Velocity of a system can be constant, acceleration of the system can be constant, the mass of the system can be constant, momentum of the system can be constant, kinetic energy can be constant and so forth.
Constancy of a quantity DOES NOT mean that this quantity is a conserved quantity. Take for example velocity of a system. It can be constant when the sum of the forces exerted on it is zero (for observers in inertial reference frames). Imagine now that an object's velocity decreased from 5 m/s to 0 m/s. While it is possible to find another object whose velocity at the same time increased by 5 m/s, so that the total velocity of the two-object system remains constant, it would be a very rare case (perfectly elastic collision of two equal mass objects), in general the change of velocity of other objects depends on lots of factors. However, if you take money for example (assuming the printing press is off and there is no mechanical loss due to tearing and stuff). When one person loses $5, these $5 appear somewhere else. We can always redefine our system to keep the amount of money constant. Amount of money is a conserved quantity.
A conserved quantity is not necessarily constant in a particular system (you, as a system, did indeed lose those 5 dollars, right?). It is only constant in an isolated system, but in any other system is can change without stopping being conserved. Think of such conserved quantities in physics: linear and angular momentum, mass in classical systems, total energy, electric charge. As we know from Noether theorem, every conserved quantity is the result of some symmetry in our world - temporal, spatial, or some more complicated symmetry as it is in case of charge.
Why am I writing all this? Because the bar chart as a representation, works for ANY conserved quantity. It is one of the most powerful representations in introductory physics. First brought to physics instruction by A. Van Heuvelen, it was adopted by several textbook authors. Unfortunately many of them did not understand that this approach only works for conserved quantities and when you carefully define your system and the environment, without those two parts the bar charts are more confusing than helpful.
Wow, it is a long post and I still did not get to the bar charts themselves. But I think ti was absolutely necessary to explain these two ideas: the role of a system and the difference between constancy and conservation before we move on. Bar charts - tomorrow.

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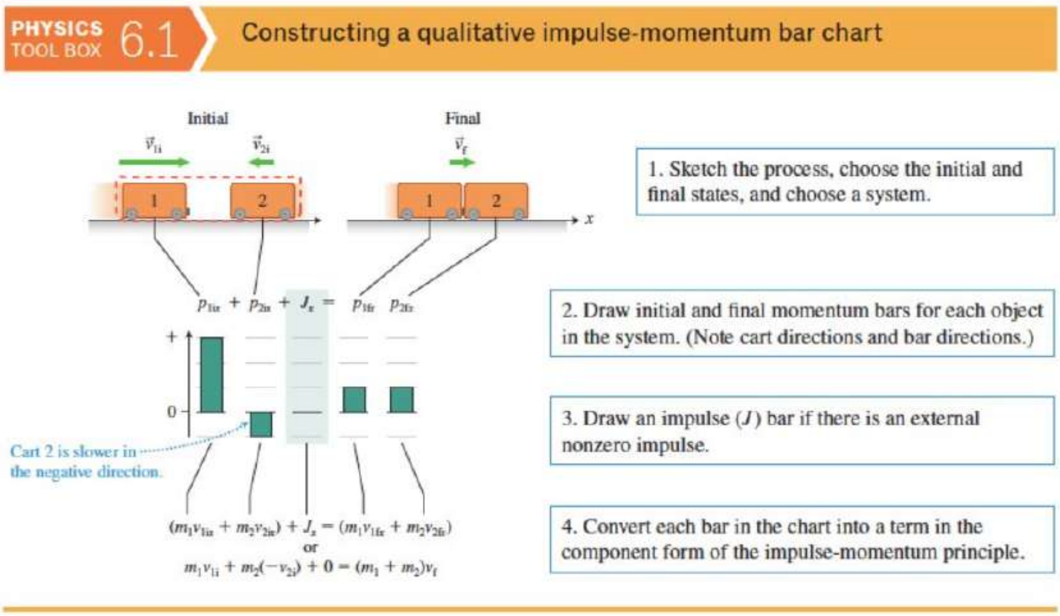
Eugenia Etkina
1. June 2021.

Hi all, I continue today with the bar charts. The idea behind a bar chart is the following (only works for conserved quantities): choose your system and initial and final states. Represent the initial state with a bar or bars (depending on what the bar chart is about) on the left side of the chart and the final state - with a bar or bars on the right side of the chart. Use another bar in the middle to represent the change in the quantity that the bar chart is for. Check whether the sum of initial bars (bars can be negative if the quantity is directional or has a sign - like work) plus the change bar is equal to the sum of the final bars. Use the bars to write an algebraic representation of the process. Then solve for the unknown quantity.
We can do it for mass for a classical case. You have 2 kg of oranges and you represent it with a bar on the left of 2 units of length. A friend comes to visit and you give them 0.5 kg of oranges (represent it in the middle of the chart with a negative 0.5 unit bar). You are left with 1.5 units in the final state - bar on the right side of the chart. Now we can write: 2 kg +(-0.5 kg) = 1.5 kg. Note, that the mass of the system has changed! Only if nobody takes or brings you oranges (you are an isolated system), the mass of the system is constant in the process. However, it is always CONSERVED as the mass does not disappear - we can always redefine the system to find the missing mass.
We can repeat the same process for momentum once we choose a positive axis or axes if the process is two dimensional (use a separate bar for each object's scalar component of momentum). The initial state will have a few bars, and the final will too. The change bar is for impulse (it is also directional, thus we can draw a positive or a negative component). Then we can use the bar chart to write impulse-momentum equation for the process.
Again, the initial momentum is equal to the final momentum only when the external impulse is zero. In this case, the momentum of the system is constant. However, even if the momentum changes due to the impulse exerted on the system, the momentum of the system is still CONSERVED as we can always redefine the system to find the missing or the extra momentum. Both mass in classical processes and momentum are ALWAYS conserved, but not necessarily constant.
We start bar charts with mass and momentum (Chapter 6 in the textbook), not with energy, as it is more complicated. I will post notes relevant to energy tomorrow. See the Physics tool box on page 157 in the textbook, I am attaching the screen shot here.



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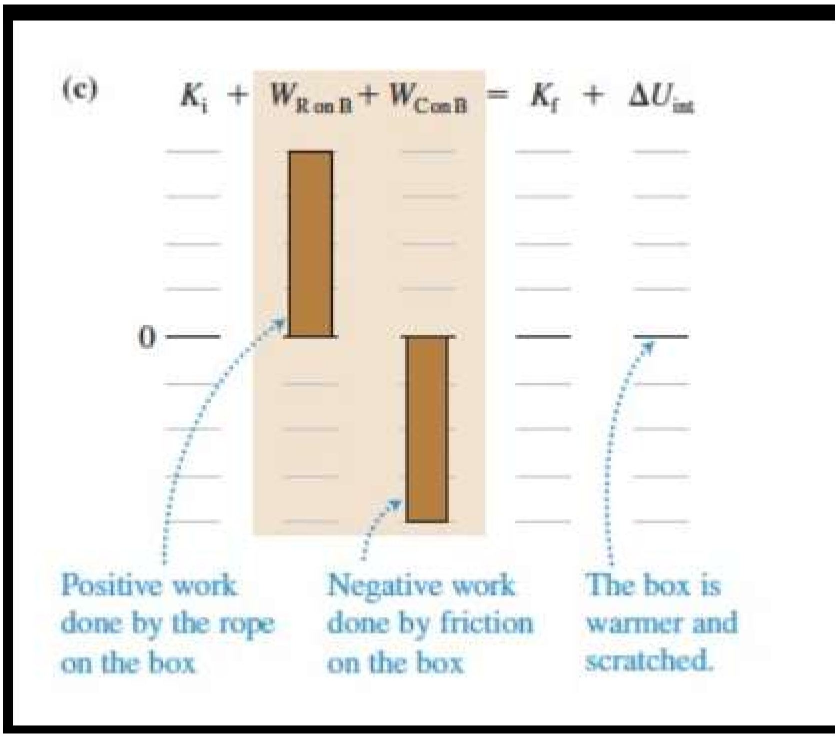
Eugenia Etkina
7. June 2021.

Hi all, I am continuing with the energy bar charts today. But before I start, I am asking you to sign up for the AAPT workshop (post of David Brookes) July 10-11. If we wish to have advanced ISLE workshops, we need to have people who are familiar with ISLE to run them. This is the longest of our introductory workshops (8 hours) and it allows you to experience the ISLE process multiple times, from the first day of class till almost the last chapters. Do not miss!
Now, back to work energy bar charts. Here we add the issue of friction. Imagine you have a heavy box (your system). You and the carpet you are pulling it across are outside the system - they are the environment. You are pulling the box at slow constant speed. Kinetic energy remains constant and there are no other energies involved. You do positive work, friction component of the force exerted on the box by the carpet does negative work and these works are the same in magnitude as the forces are the same in magnitude. Therefore the total work done on the box is zero. Yet, if you take an infrared photo of the bottom of the box you will find it warmer (as well as the carpet). So the internal energy of the box increased (so did of the carpet but as it is outside the system, we should not worry about it - yet). Where did this extra internal energy come from? (see the the figure from the book). If we draw the bar chart for the process it will not be balanced - it means that the energy is not conserved in this process. How can this be? We have been learning that energy is a conserved quantity...
Traditionally, you would find an answer to this question - friction is a non-conservative force, so energy is not conserved in this process. But as friction is present in almost all real

processes and with it, energy is not conserved, what is the point of even studying energy conservation if it happens in only in a few rare cases?
We have a completely different approach here, arguing that energy is ALWAYS conserved. To see where the extra internal energy came from, let's include the carpet in the system. Now it does not do any work on the box, the only work done on the box is by you, and it is positive. This positive work is equal to the increase of the internal energy of the box and the carpet. No need to deal with non-conservative forces. Energy is constant in the process and thus conserved. To see the details of how to calculate this increase in internal energy, please read Chapter 7 section 7.5 in the textbook.
Wait a minute, you would say, how is it possible for the energy to be constant (and conserved) in one system and not being conserved in another system for the same process??? I will leave this question for you to ponder till tomorrow. Maybe we will get some "crazy ideas". Those who attended our workshops know what this term "crazy ideas" means in ISLE. I, again, invite you to join the workshop!



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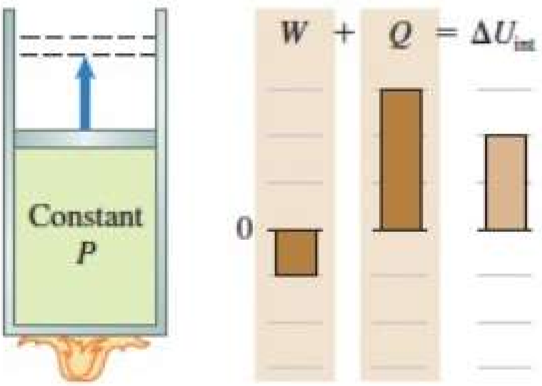
Eugenia Etkina
9. June 2021.

Hi people, thank you for all your "crazy" ideas about the analysis of the system consisting of the box only. Please read Bor Gregorčič reply for an answer that I agree with, although many others have great and useful ideas there too. Now, we are moving on. Brent W. Barker

brought in heat yesterday and this is where we are going now. This is chapter 15 in the textbook.
First, in order to move students away from thinking that heat is a thing similar to energy, we use the term "heating" instead of "heat" and define it as a process of the transfer of energy to a system without doing work when the system and the environment are at different temperatures. When the environment is warmer, the heating is positive, when cooler - negative. Positive heating does not necessarily lead to the warming up of the system (think of an isothermal expansion for example)
Now that we are familiar with the internal energy change, all we need to do on the bar chart is to add heating Q to the work W between the energies of the initial and final state. In this approach the system does not do any work, the work is done ON the system only and the energy is transferred to the system through heating. Work and heating depend on the process, the energy is the state function. Heating similar to work does not reside in the system.
When mechanical energies of the system do not change (gas in a piston for example), then the energy conservation statement (1st law of thermodynamics) is as follows: the change in the internal energy of the system is equal to the work done on it plus energy transferred through heating. When the gas is compressed - the environment does positive work on it, when it expands - the work is negative. The figure for the book (Chapter 15) shows the bar chart for an isobaric process. More details are in Chapter 15 (many-many more).

FIGURE 15.4 A work-heating-energy bar chart for Experiment 2 in Table 15.1.



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Eugenia Etkina
17. June 2021.

Hi people, see the announcement below, it is a good opportunity to learn about ISLE if you have not familiar with it. If you are familiar with it, it is still good to watch the video (new sequence on photoelectric effect) and to participate in the event.
PoLS-T Network Monthly Speaker Series
Speaker: Eugenia Etkina, Rutgers University
Title: 'When Learning Physics Mirrors Doing Physics'
Moderator: Eric Mazur, Harvard University
Saturday, June 19, 11am-12pm EDT
More information (this link has everything you need to know to participate), you need to RSVP - see the link again.
https://projects.iq.harvard.edu/.../pols-t-june-monthly...
RSVP/Sign Up Saturday Live Q&A Discussion Hour
Pre-Watch talk before the LIVE event via Perusall now (we will not be showing the talk during the discussion hour!)
If you are not already familiar with Perusall, watching the talk on Perusall allows engagement in asynchronous interaction with others as you watch. Set up a free Perusall account and use course: MAZUR-8JESK.
YOUTUBE
If you do not wish to watch via Perusall or participate live, pre-watch the talk on YouTube and also tune in to watch the Live Q&A discussion on Harvard's PoLS-T Channel via YouTube LIVE on Saturday 11am-12pm EDT.
Here is the link to it: https://www.youtube.com/channel/UCRzn7nZ4f8JksXXUTrouSZg

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Eugenia Etkina
12. July 2021. ·
Hi all, first, I welcome our new members who joined the group after surviving an 8-hour ISLE workshop at the AAPT.
Second, I would like to introduce to you Anindya Roy who is a Data Scientist/Learning Engineer at MIT. Anindya developed a collaborative video-watching platform which lets users in different locations watch videos (say, from Youtube or our videos in the OALG, ALG or the textbook) together in real-time, as they chat via video/text, and take notes on a shared scratchpad. I just had a short session when I could see how the tool works and I think it is very promising and very easy to use. If you are interested trying it with Anindya, send him an email and he will meet with you. He is looking for people to use it with the students and give him feedback. His email is anindya@zipsync.us.

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Eugenia Etkina
19. July 2021.

Hi all, we have a big group of new members who joined our community in the last 2 days. REALLY BIG! This is wonderful, welcome new members! To benefit from the group, please go to FILES, download them and start reading. The philosophical foundation of the all the materials posted here is the Investigative Science Learning Environment approach to learning and teaching physics. We call it ISLE (pronounced as a small island, E is silent). The ISLE approach is an intentional approach to curriculum design. The two intentionalities of the ISLE approach are: (1) students construct physics concepts by engaging in the processes that mirror activities of physicists constructing and applying knowledge: (2) students' well being is enhanced in the process. These two intentionalities permeate everything that ISLE students experience - activities in class, class settings, assessment, etc. The textbook that follows the same approach is "College Physics: Explore and Apply" published by Pearson (high schools get an AP edition) authored by Etkina, Planinsic and Van Heuvelen. All high school and college instructors can get a free examination copy from their Pearson rep. All other materials that come with the book - the Active Learning Guide (ALG), the Active Learning Guide when teaching on-line (OALG), and the instructor guide are free to use. OALG files with youtube links for videos instead of Pearson links are published here, in the FILES. Please feel at home here, ask questions and share your ideas!

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Eugenia Etkina
22. July 2021.

Hi all, I have not posted anything in a while with the AAPT workshop, welcoming new members, etc. I would like to resume to regular posts (more or less regular) to continue sharing how the ISLE approach is different from other teaching/learning approaches and how this knowledge can help you benefit from our textbook and materials more. Today I wanted to start a conversation about the meaning of the words "hypothesis" and "prediction". While in science textbooks and even in the NGSS these words are used interchangeably and without careful definitions (students see both s educated guesses), when physicists use them, they do it precisely and NEVER mix them up. First, let's see what these words mean.
Explanation is a statement of a possible reason for why something happened in the experiment. It answers the questions “why” or “how”. An explanation might contain a hypothetical mechanism of how something happened. In this case it is a mechanistic explanation. For example the mechanistic explanation for drying of alcohol is the random

motion of its particles. However, sometimes an explanation does not have a mechanism in it - it only explains the causal aspect of the phenomenon. In this case it is a causal explanation. For example an object's acceleration is explained by the net force exerted on it and its mass. If you are collecting data, an explanation might be an inference from the data – why the data look they way they do.
Hypothesis is a synonym for an explanation. There are multiple hypotheses that can explain what happened. A hypothesis should be experimentally testable.
Prediction is a statement of the outcome of a particular experiment (before you conduct it) based on the hypothesis being tested. Without knowing what the experiment is, one cannot make a prediction. A prediction is not equivalent to a hypothesis but should be based on the hypothesis being tested.
Why do you think the firm distinction between a hypothesis/explanation and a prediction is important in science? Once we have your ideas, I will post more.

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Eugenia Etkina
24. July 2021.

Good Saturday to everyone! I am continuing with the hypotheses/predictions chain. Thank you all who contributed. There is one more important reason why we want our students to understand the difference. A hypothesis is something that we TEST experimentally. The prediction is something that we COMPARE to the outcome of the testing experiment. Thus a prediction that does not match the outcome of the experiment is not WRONG. It shows a mismatch and makes us think whether we need to revise the hypothesis or to examine additional assumptions that went into the prediction. The prediction is only wrong when it is not based on the hypothesis. The hypothesis is wrong when it makes predictions again and again that do not match the outcomes of the testing experiments. More to come!

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Eugenia Etkina
26. July 2021.

Good morning, everyone! Today I continue with the arguments why our students should understand the difference between a scientific prediction and a prediction based on their intuition.

Many curriculum approaches require students to make predictions using their intuition before any experiment that they watch. There is a whole approach - POE - predict, observe, explain, used in many curricula - Washington tutorials, Peer instruction, and many many others. Why is it not a good idea in my opinion? When we ask students to make a prediction about a new phenomenon using their intuition (for example, "what will happen if you drop two objects - heavy and light, which one will reach the ground first?") they rely on their world experience, in which air is a factor in such motion and in their experience (a correct one!) the heavy objects fall faster. But when we ask this question, we mean the situation when air is not important. We take two small objects of different masse and about the same shape and drop them. Those students who predicted that the heavy one falls first are now "wrong" and have to rethink their prediction. What does this exercise teach our students? First, that physics is different from everyday life (as in everyday life they never experience the fall of objects without air), second, that their intuition is wrong.
When we ask them to make predictions in the areas in which they do not have any experience (DC circuits or even quantum mechanics), then their predictions are just guesses. If we repeat this sequence many times, many of our students (especially females) start losing confidence in their ability to do physics and do not develop the sense of belonging. While cognitive dissonance is a good thing to make people think, the right place of this dissonance is VERY important. It is not only important for the development of confidence but it also very important for communicating the nature of science. No scientist will get a grant to run a testing experiment which outcome is predicted based on intuition.
In the ISLE approach the predictions are always based on the hypotheses under test, not the intuition. And then, the predictions are not right or wrong, the hypotheses are (or additional assumptions). Running testing experiments becomes an exciting game instead of an exercise "who is the smartest here?"
But when do students reconcile their intuition with the outcomes of the experiments? The answer will come tomorrow. Stay tuned.
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Eugenia Etkina
29. July 2021.

Good morning everyone! We have a lot of new members who joined yesterday. welcome, people! Please read my post of July 19th to know what to do to benefit from this group the most. Today I will continue the conversation about the meaning of predictions and how to deal with our students' intuition. WARNING: LONG POST.
As we talked about before, in the ISLE approach students make predictions of the outcomes of the testing experiment using the hypotheses or "crazy ideas" (not their intuition) that they have just developed to explain carefully selected observational experiments. Why don't we ask them to make predictions before observational experiments the way the predict-observe-explain (POE) approach does? I gave a lot fo arguments before why we do not do it but today I will focus on the intuition.

Where does our students' intuition come from? It comes from being an observer in the outside world speaking every-day common language. The observer is usually in a non-inertial reference frame (as accelerating car, an elevator, etc.), surrounded by surfaces (thus lots of friction) and communicating with other "observers" using common language (in which the word electricity, for example, stands for everything - energy, power, current, electric charge, and many more things, as we as force stands for force, energy, momentum, mass, and lots of other stuff). This observer navigates this world using their intuition and does it very successfully.
Now, we take this person, place them in a physics "spherical cow" world and ask them to make a prediction for a situation that either puts them into a reference frame that never thought about (example with the moving ball coming out of a ring that David used, where the student needs to make a prediction being on the ground while all their experiences are being an observer in a rotating or revolving reference frame), or for a situation that they never experienced (objects of different mass dropped in the world without air) or using the language that they do not really understand (most of Newton's third law questions on FCI that make students confuse force with damage).
The students make their predictions using their well developed intuition which is not wrong at all if you consider an observer in a rotating reference frame, a person in the world with air and the person for whom the term force is equated with damage, but in a physics class they are wrong. When they do it repeatedly and they do not feel confident to begin with as physics is new and very scary, what should happen to them? You all observed it, I know.
Now, how do we address intuition in the ISLE approach? We do it AFTER the students developed their "crazy ideas" and tested them and feel good about themselves. Imagine that the students constructed an idea that the force exerted on an object moving in a circle at constant speed is towards the center. But then the question comes- why do we feel thrown out when we are in a car making a turn? Here comes the discussion about the role of the observer - where were you as an observer when we invented the idea of the force towards the center? - on the ground! Where are you when you feel pulled outward in a turning car? - in a non-inertial reference frame! this is the start of the discussion. The same goes for any experiment for which the students make "wrong" predictions when asked "cold". AFTER they have constructed the physics concept and understand WHEN it is applicable, they can discuss how their intuition addresses a different situation compared to one in question, assumes a different observer, or uses the language that they did not use when making their prediction. Once they consider all three of those they (and you too!) will see how their intuition was not wrong, it was just not applicable to the experiment or a situation that you gave them.

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Eugenia Etkina
10. August 2021.

Hi all, I have not posted for a while being in a place with very slow internet and electricity that goes out unexpectedly. I will try to resume my posts as much as technology allows. We have been talking for a while about hypotheses and predictions, their epistemological differences, and what is means to make a "wrong prediction". If you came into this conversation later, please scroll down and read the posts backwards in time. Today I would like to finish this discussion by bringing your attention to the formula of CER - claim -evidence-reasoning that now became very popular in high school science.
While in some cases it is a good formula to use - for example you claim that near Earth not all objects fall with constant acceleration acceleration of 9.8 m/s^2. The evidence is easy to collect - drop a beach ball with the motion detector above and you will see a different in magnitude acceleration. Then you can reason explaining why the acceleration is different (buoyant force is important as well as drag if you drop from a really big height, if it is 1 m or less then there is no drag).
However, epistemologically this approach is not always productive and in many situations leads to unscientific conclusions.
Example: Claim: Days and nights on Earth are due to the Sun moving around Earth.
Evidence: The Sun goes every day from easterly direction to the westerly direction (rises and sets) and so do all the stars.
Reasoning: The stars and the Sun are on a sphere that rotates around Earth, that is why we see the Sun rising in the East and setting in the West (approximately). But when the stars are attached to the sphere, the Sun moves across it during the year to change the locations of rise and set.
Another example:
Claim: Air absorbs moisture.
Evidence: Spilled liquid dries.
Reasoning: Air sucks up moisture like a vacuum cleaner suck dust. The more air you blow on the liquid (a hair dryer) the faster it dries.
I can go on and on with the examples that when you look for supporting evidence for your claim, you can always find it. This is how the intelligent design claim works. There is lots of supporting evidence for it. But what you cannot find is the evidence that disproves it. This is the difference between scientific and non-scientific approach. Scientific claims have potential to be disproved by evidence and non-scientific claims do not. Teaching our students to look for contradicting evidence or for the testing experiments that will rule out the claim is real science.
Another point, where do claim come from? To have ANY claim, we need to observe something first. So, evidence is the start of ANY exploration, not a claim.
I can go on and on about it, I hope you see my point here. The ISLE process is more complicated than CER approach but it resembles scientific processes much more closely. I am attaching a slide with it to clarify.

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Eugenia Etkina
15. August 2021.

Hi all, I am continuing with "thinking like a physicist" theme. A long time ago (18 years to be precise, long before the NGSS and AP came up with their list of science practices) our research group at Rutgers came up with a list of processes in which physicists engage while doing physics. To carry out these processes people need to develop what we called "scientific abilities) - do not confuse this word with skills, as skill is something that we do automatically (riding a bicycle, for example) while an ability is something that we know how to do but need to think every time we do it.
The list of these abilities and self assessment rubrics to be used by the students and the teachers is free for everyone to use and they are at https://sites.google.com/site/scientificabilities/.
Please read the descriptions of different abilities and go to the rubrics to see the rubrics. There are also tons of labs posted for in-person teaching and for teaching on-line. There are a few really important documents in the References in the ISLE labs tab, I will comment on them tomorrow, but you are free to download and read them before.

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Eugenia Etkina
17. August 2021.

Hi people, if you are teaching AP or using the ISLE approach, please join the event that Yulia posted yesterday. We will talk about the coherence of physics and about problem solving approaches. These two issues have been found to be very important for learning physics.
Coherence: our students often see physics as a collection of unconnected facts to be remembered (when we teach lessons as a string of activities it exacerbates the problem - students move through the motions from activity to activity without seeing a big picture). When there is no coherence, chunking does not occur, and as we know, without chunking, there is not much that is remembered. But there is much more to the coherence issue than chunking - it is seeing the big picture behind all those "formulas" that the students need to learn. How do we help our students see the beautiful coherence and connectedness of physics?
Problem solving: We are all familiar with "I know the theory but I cannot solve problems" statement from our students and we hear "what is the right formula?" question often. How do we help our students develop expert approaches to problem solving and at the same time help them feel that they CAN solve physics problems? "College Physics: Explore and Apply" offers a unique approach to problem solving - it is based on years of research and practice. What is it and how do you implement it?
Join the meeting and you will learn. The invite is in yesterday's post.

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Eugenia Etkina
21. August 2021.

Hi all, thank you those who attended the meeting yesterday. Thank you, Yulia Turchaninova for organizing it! I am not very good at organizing and I am very thankful that Yulia did it.
We do not have the recording but I am posting the slides that I used. Please ask questions is something is not clear. I will post more about problem solving strategy. Andrew Yolleck, please ask your question here, so that I can answer for everyone. The topic for our next meeting came from a question that was asked yesterday: How do we deal with the pacing when our students are engaged in the construction of their own knowledge? What tools do we have to make sure that the students are exposed to the needed breadth of the material?
We actually have many tools that allow us to do it and I will share them in the next meeting which will be on September 10th at 3 pm EST, 5 pm PDT. Yulia Turchaninova will post the notice. I know that this time is not convenient for those in Europe, I am sorry for this. We will try to record the meeting from the beginning next time. Thank you all again for participating!
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Eugenia Etkina
21. August 2021.

Anindya Roy asked a questions about problems and misconceptions, I responded in a comment but could not post a video (see my response in the post with the ppt for the meeting yesterday). It looks like the person who posted the video removed it and it is not available. Therefore I am explaining it here.
What does the term "misconceptions" mean? It means a conception (1) that it wrong (2). It also kind of tells us that if a person has a wrong conception, our goal is to help them get rid of it (3). Below I will explain why all three ideas need to be reexamined very carefully.
(1) Research shows that the students do not hold firm conceptions about the physical world. They have bit and pieces, small ideas that they put together in different combinations when we ask them a question. Depending on the context their answer will change. But these small ideas in their heads can be productive resources when they learn, not obstacles as the old education research taught us.
(2) "Mis" part in the word misconceptions. The "mis" part is tricky. What we see as a "wrong" idea is almost never absolutely wrong. We can always find the context in which it is correct or replace the word that the student is using and the wrong answer becomes correct. I will

give you two examples. You ask a student when you drop two objects - heavy and light - which one will fall first?. The student says - the heavy one. And they are absolutely right - on Earth in the presence of air, the heavier object always falls faster. But you were thinking of a very special case of small objects for which the drag is not important. The student did not know about the context and was not familiar with it. If you ask them about dropping two objects in a vacuum, the answer should be - I have no idea, I never saw it.
The second example is from language. A student explaining why an objects thrown upward stops and comes back says: "The force of your hand runs out and gravity takes over". Clearly a wrong answer, right? But if you replace the word "force of your hand" with "momentum of the ball", the answer is almost perfectly correct.
(3) Can we help students get rid of the wrong ideas? When we think that they are really wrong is all contexts with all language issues. The answer is NO. Any idea is a physical part of our brain. To get rid of it is only possible through brain surgery. What can we do then? We need to help a student realize what context we mean and what language to use and how to apply their ideas productively in a specific situation that we have in mind. This way student ideas become PRODUCTIVE RESOURCES TO BUILD ON instead of the wrong stuff to get rid of. There is a whole theoretical framework called KIP - knowledge in pieces that helps us learn how to use student ideas to build on them. Does it make sense?

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Eugenia Etkina
29. August 2021.

Hi all, as the new school year is right here (and many of you probably started already) and we have new members joining the group every day, and people are asking questions about the resources, I am going to summarize in this post what we have and how to find it. It is a VERY LONG post, so please be patient. All resources that I describe here follows the Investigative Science Learning Environment (ISLE) approach to learning and teaching physics, papers about it are posted in the FILES, if you want to learn more about it, please post your questions here.
1. Textbook College Physics: Explore and Apply (2nd edition). The same textbook marketed for high schools says: College Physics: Explore and Apply AP Edition. The authors are Etkina, Planinsic and Van Heuvelen. On the cover is a woman on a bicycle. If you have College Physics with the first author Etkina, but the middle author Gentile, you have the first edition. It is outdated and other supporting materials do not work with it (unless they were made for this edition). The textbook comes as a hard copy or an e-text. Pearson is very generous with the e-text, so if you want your students to use it, negotiate with your Pearson rep. If you have difficulties with the rep, send me an email directly. The textbook has lots of unique approaches to the content, representations, language, problems, logical flow of the material, etc. If you have it, you need to read it as if you NEVER studied physics. systematically, starting with Chapter 1. If you skim it, thinking that you know algebra-based physics and do not need to read the details, you will lose the benefits of our approach which

is heavily based on research and hundreds of years of practice. I cannot emphasize enough how important is to READ EVERY WORD carefully and think about it. The justification for all our pedagogical moves is in the Instructor Guide which I will mention later in the post. Reading Instructor Guide will let you learn the results fo the last 40 years of physics education research and see how they are applied in practice.

2.The second edition comes with all solutions for all questions and problems and a test bank and a set of ppt slides - all on Mastering Physics platform that your rep will give access to.

3.The second edition comes with the Active Learning Guide (same authors + David Brookes(free on Mastering Physics) which is a set of word documents with sequenced activities for EVERY chapter (all solutions are available on MP). Last summer we created the online version fo the ALG, called OALG. It is posted on MP too, in addition the versions of the OALG files with the youtube links are posted here. I was posting them as soon as we made them before Pearson made their links for our videos.

4.We wrote an extensive Instructor Guide for the second edition which is posted on MP and here (also free). Last summer we created Chapter 1 for the ALG and OALG (they did not exist before) - for the beginning of the school year and wrote an addition Chapter 1 for the IG (I posted it here a year ago and reposted a few days ago again). Chapter 1 in all three docs - ALG, OALG and IG is crucial for the beginning for the school year.

5. In addition to the resources associated with Pearson work we have several websites where all materials are free and consistent with the ISLE approach. I am repeating the links here as some of you came to the group after I wrote about them. Here are the links, feel free to explore:
http://pum.islephysics.net/. - ask for teacher access
http://islephysics.net/pt3/
https://islephysics.net/
https://sites.google.com/site/scientificabilities/

https://www.facebook.com/groups/320431092109343/posts/1005607196925059/?__cft__[0]=AZXyRICBUJJJCd-jISh7AX1Skm_oOAef50K2WJ-oY6AVhcj_JL2tG1OFH9D2KjGotWW18c3A-Vq9oVqQUAYRCbdoEOs6_NnsVa9dNIWouc2q4z-_zxqn1QUDoiaCBN-pLPjIIAyRsUD07EiUIG-myrsT&__tn__=%2CO%2CP-R

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31. August 2021.

Hi all, some fo you invite friends to the group and they do not answer the question for being admitted into the group that is very important. They probably do not even know that you invited them. I am asking you to tell your friends about the group and invite them to apply themselves and answer the question. This way we will not have members who are not participating. So far out of 1100 members that we have about 200-300 are not participating (looking at the posts) and it would be great to have everyone participate. Thank you!

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Eugenia Etkina
8. Semptember 2021.

Hi all, over the last 20 years I have given over 300 talks and conducted over 200 workshops about the ISLE approach. At the end of every event, when there is time to ask questions, one question is always present: How do you manage to engage students in such discovery learning and at the same time preserve the amount of material that you teach? We have many unique strategies that address this question, and this Friday, we will have a special session dedicated to it. Those who signed up to attend will benefit if they have the textbook handy and OALG Chapter 1 (it is posted here, the file is called ALG Chapter 1 for online instruction). The link to the zoom meeting is below. It starts at 8 pm EST. If you are new to the group, please reply to the invitation posted by Yulia Turchaninova.

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Eugenia Etkina
11. Semptember 2021.

Hi all, thanks to Yulia Turchaninova we have the recording of the yesterday's meeting. To be able to understand what is going on, you will need access to the folder with the materials. The link to the folder is here: https://drive.google.com/.../1Li7W....
You will need to open the google slides document and follow the video with the slideshow and by opening the relevant documents. Thank you all for coming yesterday!
The link to the video is https://us02web.zoom.us/.../YJaPAnrSYKUagqTbackhbMNCS0nXS...
and the password is ?DDJ3zxC
Please let us know if something does not work. We will announce shortly when the next meeting will be. The topic will be addressing student resistance to this type of learning.
Video Conferencing, Cloud Phone, Webinars, Chat, Virtual Events | Zoom
us02web.zoom.us

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Eugenia Etkina
12. rujna 2021.

Hi all, we have lots of new members joining in. Welcome! Please read Announcements to learn what the group is about, what philosophy of learning we try to promote and what materials are posted here (LOTS). Make sure you go to FILES to download what is posted there. If you do not have the textbook College Physics: Explore and Apply (regular or AP edition), contact your Pearson rep for a free examination copy. All other materials are free on Mastering Physics Platform of Pearson. If you have any issues finding your rep, please email me at eugenia.etkina@gse.rutgers.edu
Starting today, I will post about each chapter what to focus on and how to help students.

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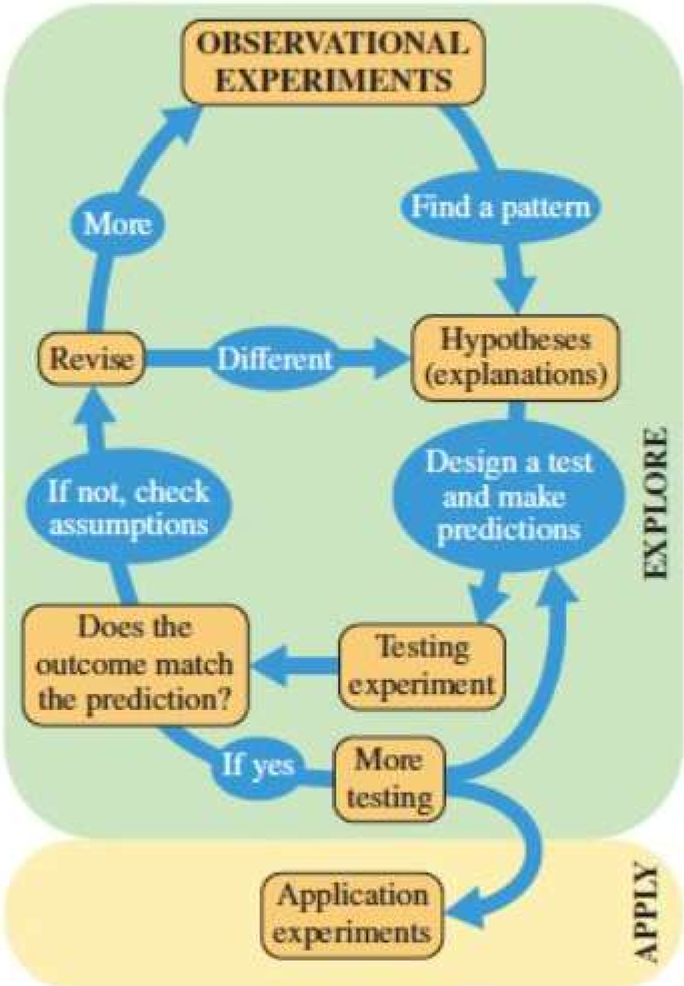
Eugenia Etkina
13. Semptember 2021.

Hi all, two things - please vote for the time for the next meeting - the poll is below. Our last meeting originated from the question that Owen asked, the coming up one will be partly dedicated ot the question that Ilya Yashin asked. However, his question will only take about 20-25 min to work through and we will have more time, thus - please post your questions here so that we can decide what to discuss at the meeting.
Second, I promised to talk about chapters in order .starting from Chapter 1 in the textbook and going on (for the new members, the textbook is College Physics: Explore and Apply by Etkina, Planinsic and Van Heuvelen, both regular and AP editions).
Today I what to focus on in Chapters 1 and 2. Chapter 1 - make sure that you do some of the beginning activities in the OALG or ALG (cameras, wet glass or balloon) so that the students can relate to the representation fo the ISLE process for developing knowledge (page 4, added here). The next important things (all is important, but those - especially) - is "How to use this book to learn physics" section (1.6). There are links to all the videos - in the ALG and he textbook, and instructions on how interrogate the text and solve problems. I suggest returning to this section every time you are working with the students on relevant assignments. (See the slides for our two meetings and the video to learn how to do reading interrogation).
In Chapter 2 three things are important - 1) making sure that the students learn how to draw complete motion diagrams - with the delta v arrows, not just the dots. The delta v arrows are crucial for being able to draw good force diagrams.
2) Making sure that the students understand the role of the Experiment tables in their learning. Some students and teachers skip them and proceed to the ready equations, and this is a big mistake as the nature of physics disappears and the book becomes the textbook similar to many others. Same is true for worked examples.

3) Making sure that the students firmly understand the difference between velocity and acceleration. Asking "contrasting questions" - such as "Please give me an example of the situation when the velocity is zero and acceleration is not?" or "Give me an example of an object speeding up and having negative acceleration", etc. is very important. Lots of such questions are in the End of Chapter Problems and Questions section.
I cannot overemphasize how important it is for the teachers to read our textbook as if they have never studied physics. It is only when you do it this way, you catch all the little (and big!) things we put there to help students learn.
Please ask questions about those two chapters!

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



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Eugenia Etkina
14. Semptember 2021.

Hi all, I continue today with a little bit of Chapter 2 stuff, kinematics - before I move to Chapter 3, forces.
Today I will talk about embodied cognition. Or, in other words, asking students to act out a physical process, a mathematical expression or anything you want them to understand. It is a very useful method when teaching in person, but could be used when teaching online too.
And example from kinematics is asking your students to act out a mathematical description of motion (we have activities like this in the ALG), for example you invite one student in front of the class and ask the rest of the class to give her directions to act out the following mathematical representation: $x = 2\text{ m} + (-1\text{ m/s})t$.
To give directions the students need first to choose the zero x point in the classroom and the positive direction. Then they need to figure out how big 1 m is (not all know) how to move to cover 1 m every second. Then they usually tell the actor to stand 2 m away from the origin and when they say go (zero time), start walking in the negative direction (towards the origin) making 1 m every second.
Is this correct? When I ask my students this question, they all agree that it is correct. I am the only one who disagrees. While the numbers are right, the understanding of what happens at the time zero is not. The actor does not start at this time. At time zero she is ALREADY WALKING AT CONSTANT SPEED! So, how to enact this expression then? The students come up with the following directions: The actor is walking at 1m/s towards the origin being away from it more than 2 meters, while everyone else in class sits with their eyes closed. When she is passing the 2 m mark she claps her hands and everyone opens their eyes and sees her passing the 2 m mark walking at constant speed towards the origin and passing the origin 2 s later.
This simple exercise helps the students understand the difference between the beginning of motion and the beginning of our observations of motion - this is what our traditional "zero" subscripts stand for. Initial speed is not the starting speed, it is the speed when the observer started observing the motion. Read Example 2.5 in the textbook to see this subtle important idea used in the problem solving process.

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Eugenia Etkina
17. Semptember 2021.

Hi all, two things today:

1. Our next meeting is on October 15th at 6 pm EST (the majority voted for this time, I hope that those who voted for 5 pm can join too). We will record it and the slideshow will be in the google folder, the link to which I posed before. We will create the even and post zoom link ASAP.

2. We are starting dynamics. Chapter 2 is about linear dynamics, when forces are exerted in one direction only. There are many important things in this chapter but I will start with one that is absolutely crucial for the ISLE approach - testing hypotheses. In this chapter students have their first opportunity to test an idea that many of them hold: specifically, that air pushes down on objects. This idea comes up when the students are trying to analyze what objects interact with the ball that they are holding in their hand (the first step to inventing the concept of a force). All of them say that air is one of the objects and most say that air pushes down. We have an amazing experiment that tests this idea. The description of the experiment is in the book and I paste here the page where it is done. The video of the experiment is in the ALG, see the link below (the same experiment is on our isle video website too). But the video will not work if the students do not reason to the prediction of the outcome based on their hypothesis, thus it is crucial that you read the page that you post here BEFORE doing it with the students. https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...

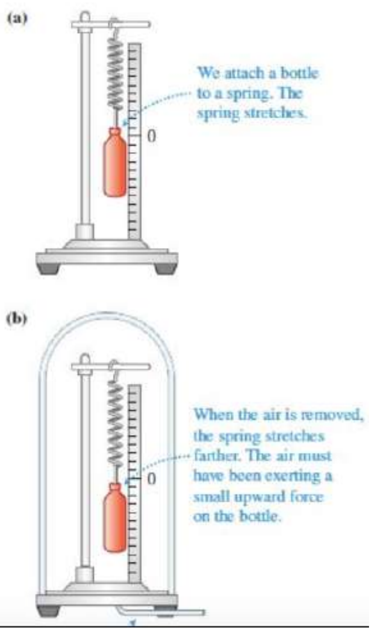
Testing a hypothesis

To test a hypothesis in science means to first accept it as a true statement (even if we disagree with it); then design an experiment whose outcome we can predict using this hypothesis (a testing experiment); then compare the outcome of the experiment and the prediction; and, finally, make a preliminary judgment about the hypothesis. If the outcome matches the prediction, we can say that the hypothesis has not been disproved by the experiment. When this happens, our confidence in the hypothesis increases. If the outcome and prediction are inconsistent, we need to reconsider the hypothesis and possibly reject it.

To test the hypothesis that air exerts a downward force on objects, we attach an empty closed water bottle to a spring and let it hang; the spring stretches (Figure 3.3a). Next we place the bottle and spring inside a large jar that is connected to a vacuum pump and pump the air out of the inside of the jar. We predict that *if* the air inside the jar pushes down on the bottle (the hypothesis), *then* when we pump the air out of the jar, it should be easier to support the bottle—the spring should stretch less (the prediction that follows from the hypothesis).

When we do the experiment, the outcome does not match the prediction—the spring actually stretches *slightly more* when the air is pumped out of the jar (Figure 3.3b). Evidently the air does not push down on the bottle; instead, it helps support the bottle by exerting an upward force on it. This outcome is surprising. If you study fluids, you will learn the mechanism by which air pushes up on objects.

FIGURE 3.3 A testing experiment to determine the effect of air on the bottle.



Reflect

Let's reflect on what we have done here. We formulated an initial hypothesis—air *pushes down* on objects. Then we designed an experiment whose outcome we could predict using the hypothesis—the bottle on a spring in a vacuum jar. We used the hypothesis to make a prediction of the outcome of the testing experiment—the spring should stretch less in a vacuum. We then performed the experiment and found that something completely different happened. We revised our hypothesis—air *pushes up slightly* on objects. Note that air's upward push on the bottle is very small. Therefore, in many situations, and in all situations in this chapter, the effects of air can be ignored.

Drawing force diagrams

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Eugenia Etkina
21. Semptember 2021.

Hi all, today I continue with linear dynamics. The first important thing in this chapter is how the students come up with the concept of force in physics.
A simple kinestetic activity with them holding two objects (one in each hand) - a heavy book and a paper allows the students to physically experience the push that they exert on each object to hold it still. This push is an interaction between their hand and the object of interest - the system (book or paper). It is characterized quantitatively with the quantity of force.
From this simple experiment follow the double subscript notation and the force diagram.
Please read carefully section 1 in Chapter 3 and the activities in the ALG and OALG to have a clear picture of how to help students invent the concept of a force and how to talk about it.
There is no "weight of an object" in our vernacular and no "force of Earth". What we have is "the force that Earth exerts on an object" or "the force exerted by Earth on the object". Why not weight? Because weight is something that belongs to an object, and no force belongs to an object, it is not a property of objects. Why not "force of Earth"? Because Earth does not have a force. Please ask me questions.

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Eugenia Etkina
24. rujna 2021.

Hi all, I continue with dynamics today. One of the main ideas of Newtonian dynamics is that the acceleration of an object is only due to the non-zero sum of the forces exerted on it. If there are no forces exerted on an object or the sum fo the forces is zero, the object should not accelerate. It says nothing about the velocity of the object, only about the change of velocity that is always in the direction of the sum of the forces exerted on the object. This is the essence of Newton's second law. However, this idea makes ABSOLUTELY NO SENSE in everyday life.
We sit in a car and all of a sudden our body jerks forward. It definitely changes its velocity with respect to the car but the sum of the forces exerted on us is ZERO - Earth pulls down and the seat pushes up exerting the force of the same magnitude so that we do not make a hole in the seat or hit the roof.
But we definitely accelerated with respect to the car with ABSOLUTELY NO EXTRA FORCES EXERTED ON US. This experience contradicts Newton's second law. How can this be? To remove the contradiction, there is Newton's first law that says that the car is not a reference frame in which Newton's second law works. It only works for the observers who do not experience what we just experienced in the car. It only works for those observers for whom objects do not change their velocity without additional forces exerted on them.
This different approach to Newton's first law (basically defining the reference frames for which 2nd and 3rd law work) is very different from traditional approaches used in other textbooks. I strongly recommend working with section 3.4 Inertial reference frames and

Newton's first law. There are two videos there that help understand the idea and an Observational Experiment Table that serves the same goal. I am attaching a screen shot of the text for those who do not have the textbook.

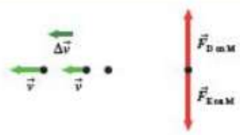
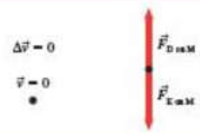
Our description of the motion of an object depends on the observer's reference frame. However, in this chapter we have tacitly assumed that all observers were standing on Earth's surface. Are there any observers who will see a chosen object moving with changing velocity even though the sum of the forces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

Observers in inertial reference frames can explain the changes in velocity of objects by considering the forces exerted on them by other objects. Observers in noninertial reference frames cannot. From now on, we will always analyze phenomena from the point of view of observers in inertial reference frames. This idea is summarized by Isaac Newton's first law.

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Eugenia Etkina
26. Semptember 2021.

Hi people, today we had many new members. First - WELCOME!
Second, and this is for all members - if you wish to benefit from this group, see my announcements - they are on top of the page and go to FILES and download them all. Then

sort by file names to find materials for lessons and labs and research papers about why we are doing stuff the way we do (different from many other inquiry-based approaches).
The materials posted here were created for teaching online! Our ISLE-based materials for in-person teaching are the textbook College Physics: Explore and Apply (sold by Pearson) and FREE materials on their Mastering Physics Website - the Active Learning Guide and the Instructor Guide.
You will only benefit from being a member of this group if you not only read and participate in the discussions but read and use our materials. To get to Mastering Physics website contact your Pearson rep, if you do not have one, please send me an email. Other websites with our free materials are: https://sites.google.com/site/scientificabilities/,
http://islephysics.net/pt3 , http://pum.islephysics.net/
All of them are free and have complete lessons, labs, assessment and self assessment rubrics and so forth. I know it is a lot of work to read and it took us over 20 years to produce all these materials, but they are here and are waiting for you!

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Eugenia Etkina
27. Semptember 2021.

Hi all, from time to time I ask the group if my posts are being read. When there is a group of more than a 1000 people and only 3 or 4 react to the post, it makes me wonder if the posts are useful. I know that we are all busy, but when you read the post, can you please either post a short comment - "read" or use some other response method to let me know that you read it. Once we got over 300 members, Facebook does not tell me anymore how many people saw the post.
Today the post is about Newton's third law. As you all know, traditional statement (which belong to Newton actually) about action-reaction is not helpful for the students and is not used in our book. While the students arrive to the statement that "when two objects interact, object A exerts the force on object B that is the same in magnitude and opposite in direction to the force that object B exerts on object A" - activities are in the textbook, ALG and OALG, this statement sometimes make students think that ANY two forces that are the same in magnitude and opposite in direction are Newton's third law forces. A good question to address this difficulty is Question 8 at the end of Chapter 3. I am attaching the screen shot of the question and I ask you to choose the right answer and explain why other answers are not good.

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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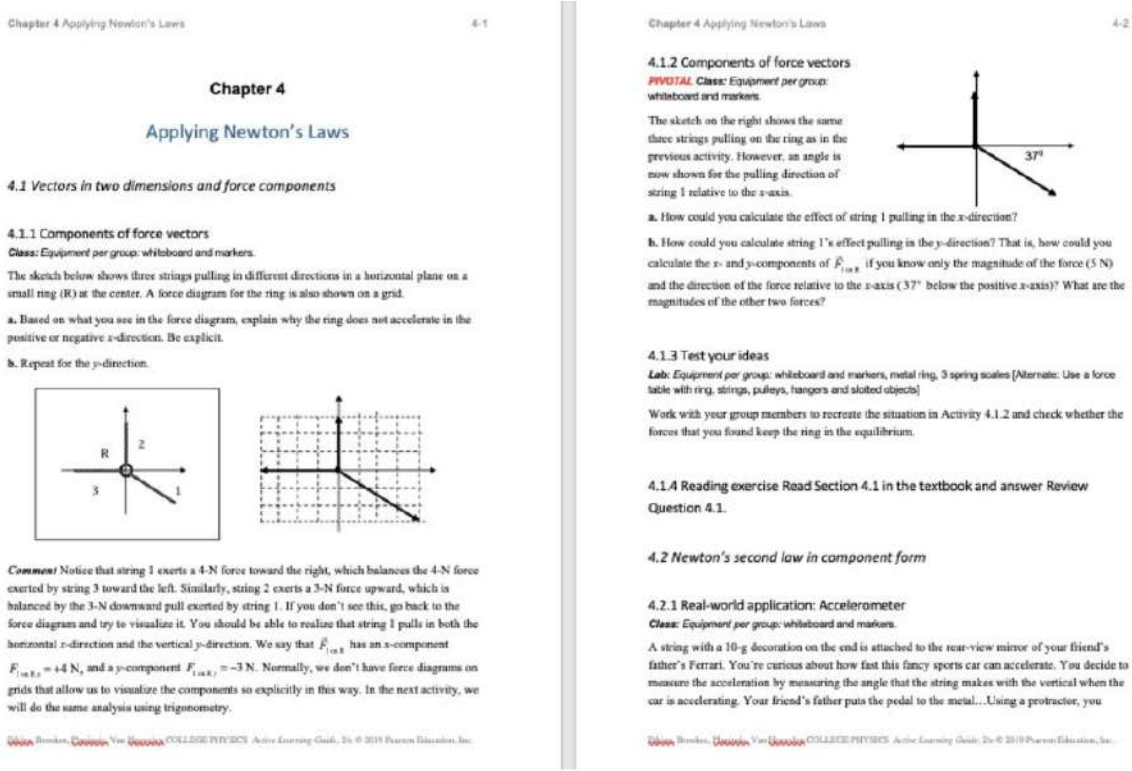
Eugenia Etkina
28. Semptember 2021.

Hi everyone, thank you again for your thoughtful responses to my post. Now I see a problem that can be easily solved. To help people see the posts, those who see the post simply need to say "Read it" or click on liking it or something. When many people respond, more people get the posts in their feeds. Hope it is not too much to ask. We have created a ton of materials and the purpose of my posts is to make you aware of these resources and use them. Please, if you see the post - react, a simple "like" click will help it be more visible. I also ask you to check the group as often as you are on Facebook as I am trying to post every day.
Today my post is about components. It is a difficult issue for the students but extremely useful for solving lots of different problems. We have a unique method helping students learn components conceptually. It is Chapter 4, a few activities in the ALG and OALG. I am pasting the screen shot to help you see what we do and my question is, why this method is very helpful for the students? Tomorrow, I will explain how to connect this knowledge to the invention of the friction force not as a separate force but as a component of the force that the surface exerts on the system.



Chapter 4

Applying Newton's Laws

4.1 Vectors in two dimensions and force components

4.1.1 Components of force vectors

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

The sketch below shows three strings pulling in different directions in a horizontal plane on a small ring (R) at the center. A 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 for the y-direction.

Comment Notice that string 1 exerts a 4-N force toward the right, which balances the 4-N force exerted by string 3 toward the left. Similarly, string 2 exerts a 3-N force 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 $F_{1 \text{ on } R\,x} = +4$ N, and a y-component $F_{1 \text{ on } R\,y} = -3$ 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.

4.1.2 Components of force vectors

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

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?

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.

4.1.4 Reading exercise Read Section 4.1 in the textbook and answer Review Question 4.1.

4.2 Newton's second law in component form

4.2.1 Real-world application: Accelerometer

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

A string with a 10-g decoration on the end is attached to the rear-view mirror of your friend's father's Ferrari. You're curious about how fast this fancy sports car can accelerate. You decide to measure the acceleration by measuring the angle that the string makes with the vertical when the car is accelerating. Your friend's father puts the pedal to the metal…Using a protracter, you

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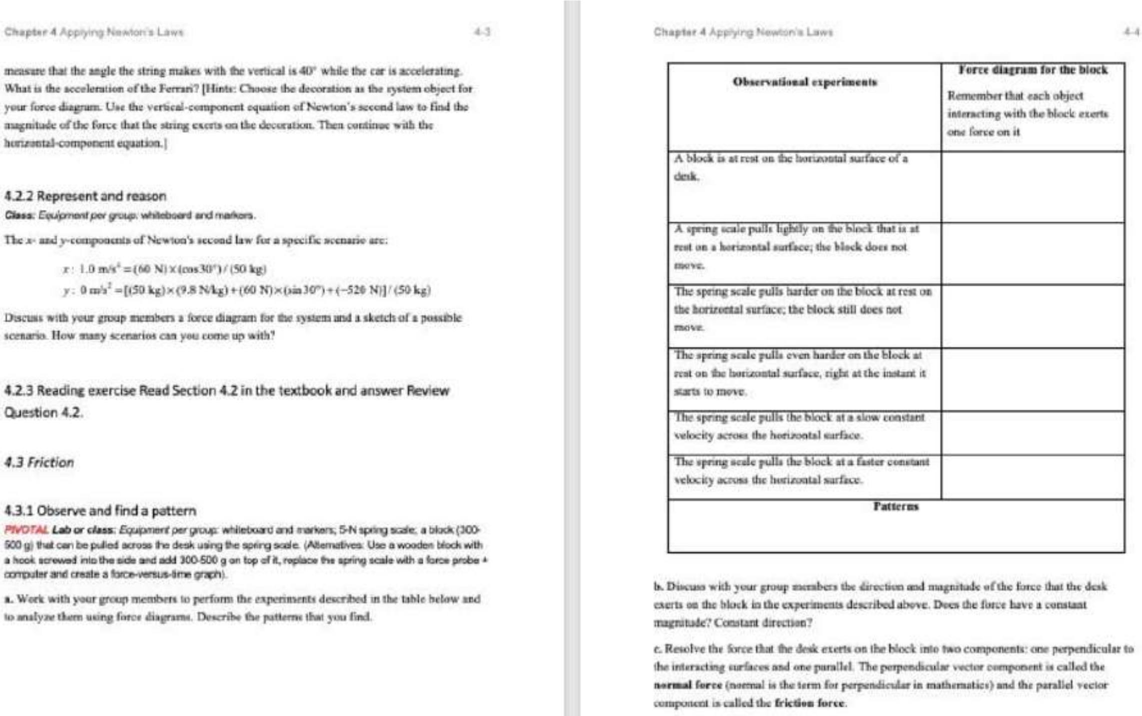
Eugenia Etkina
29. Semptember 2021.

Hi all, thank you for "liking" my yesterday's post and responding to it, let's make it a habit, so that everyone can see the posts, THANK YOU!
Today I continue with the components and focus on HOW the students invent the idea of normal force component and friction force component of the force that the surface exerts on the object. The observational experiment tables and explanations are in the textbook in Section 4.3. Here I will attach the corresponding ALG activity and explain why and how to do it.
Research found that students have lots of difficulties with the concept of a normal force. Rightly so - there is no such thing! The normal force does not exist. What we call a normal force in physics is just a PERPENDICULAR TO THE SURFACE VECTOR COMPONENT of the force that the surface exerts on the object, while the other PARALLEL TO THE SURFACE VECTOR COMPONENT of this force is the friction force. As they are the components of the same force, they are mathematically related to each other through a simple coefficient that is just a tan of the angle between them. However in AP physics those components are considered separate forces and they require the students to draw them separately on the force diagrams. This is not a problem actually as we help students see what those forces are through a very simple exercise attached here.

Please read the attached activity (ALG 4.3.1) and ask questions here. The most important part in the activity is to emphasize that when one object in the environment exerts one force on the system. Once students draw the force diagrams, they can resolve the force that the surface exerts on the system into two components - perpendicular to the surface, and parallel. At this point you can give them the names and after this when necessary, treat them as separate forces. If you are teaching online, there is a parallel activity in the OALG Chapter 4. After you finish reading, please do not forget to acknowledge it so that the post appears in the feeds of all group members! Thank you!



Chapter 4 Applying Newton's Laws 4-3

measure that the angle the string makes with the vertical is 40° while the car is accelerating. What is the acceleration of the Ferrari? [Hints: Choose the decoration as the system object for your force diagram. Use the vertical-component equation of Newton's second law to find the magnitude of the force that the string exerts on the decoration. Then continue with the horizontal-component equation.]

4.2.2 Represent and reason

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

The *x*- and *y*-components of Newton's second law for a specific scenario are:

$$x:\ 1.0\ \text{m/s}^2 = (60\ \text{N}) \times (\cos 30°) / (50\ \text{kg})$$
$$y:\ 0\ \text{m/s}^2 = [(50\ \text{kg}) \times (9.8\ \text{N/kg}) + (60\ \text{N}) \times (\sin 30°) + (-520\ \text{N})] / (50\ \text{kg})$$

Discuss with your group members a force diagram for the system and a sketch of a possible scenario. How many scenarios can you come up with?

4.2.3 Reading exercise Read Section 4.2 in the textbook and answer Review Question 4.2.

4.3 Friction

4.3.1 Observe and find a pattern

PIVOTAL **Lab or class:** *Equipment per group: whiteboard and markers; 5-N spring scale; a block (300-500 g) that can be pulled across the desk using the spring scale. (Alternatives: Use a wooden block with a hook screwed into the side and add 300-500 g on top of it, replace the spring scale with a force probe + computer and create a force-versus-time graph).*

a. Work with your group members to perform the experiments described in the table below and to analyze them using force diagrams. Describe the patterns that you find.

Chapter 4 Applying Newton's Laws 4-4

Observational experiments	**Force diagram for the block** Remember that each object interacting with the block exerts one force on it
A block is at rest on the horizontal surface of a desk.	
A spring scale pulls lightly on the block that is at rest on a horizontal surface; the block does not move.	
The spring scale pulls harder on the block at rest on the horizontal surface; the block still does not move.	
The spring scale pulls even harder on the block at rest on the horizontal surface, right at the instant it starts to move.	
The spring scale pulls the block at a slow constant velocity across the horizontal surface.	
The spring scale pulls the block at a faster constant velocity across the horizontal surface.	
Patterns	

b. Discuss with your group members the direction and magnitude of the force that the desk exerts on the block in the experiments described above. Does the force have a constant magnitude? Constant direction?

c. Resolve the force that the desk exerts on the block into two components: one perpendicular to the interacting surfaces and one parallel. The perpendicular vector component is called the **normal force** (normal is the term for perpendicular in mathematics) and the parallel vector component is called the **friction force**.

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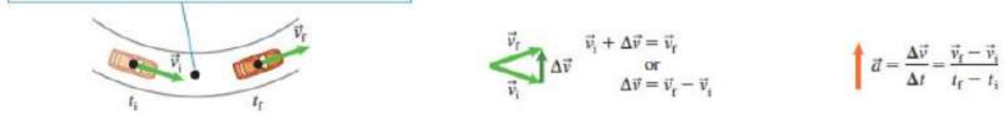
Eugenia Etkina
2. October 2021.

Hi all, first, let's welcome our new members from Uruguay today, WELCOME!!! Make sure you read the announcements to see how to benefit from the group!
Second, I would like to continue with circular motion at constant speed. We only came up with an idea that the sum of the forces is towards the center, we have not tested it and we do not know any quantitative stuff yet. The testing experiments for the idea are in Testing Experiment Table 5.2 with the video, and there is a parallel activity in the ALG and OALG (posted here) Chapter 5.
But the most interesting question is WHY this net force towards the center is needed? And what does it depend on? To answer these questions we first help students learn that although the speed of the object is constant, the velocity is not. To help them see it, use the

following experiment. Take a meter stick and hold it co that is points in the direction of your motion (the students should say that it points in the direction of your instantaneous velocity). Then walk around a circle that you draw in advance on your classroom floor. The students will observe that the direction of your velocity vector changes continuously, and this means that the velocity is changing although the speed does not. Cool, right?
To find the direction of the acceleration, we use the method similar to finding the direction of the delta v arrow on the motion diagram, but slightly different. I am posting the shot of the tool box in the book. From that follows the activity in the ALG on determining the direction of the delta v arrow for an object moving in a circle at constant speed. The students com up with the direction towards the center at every point of the circle. That is why the sum of the forces points towards the center!!!
This logical progression is beautiful in many ways, but the most important is the the students connect kinematics and dynamics for the new type of motion, this way building the coherence of physics! Make sure that you go through the logical steps of this progression several times before you do it with the students. Tomorrow I will post the quantitative part.
Do not forget to like the post or comment on it to make it visible for other members of the group! Thank you!



To estimate $\Delta\vec{v}$, place the $\vec{v}_i$ and $\vec{v}_f$ arrows tail to tail (Step 2 in the Tool Box) without changing their magnitudes or directions. $\Delta\vec{v}$ starts at the head of $\vec{v}_i$ and ends at the head of $\vec{v}_f$. The car's acceleration $\vec{a}$ is in the direction of the $\Delta\vec{v}$ arrow (Step 3 in the Tool Box) and is the ratio of the velocity change and the time interval needed for that change:

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$$

PHYSICS TOOL BOX 5.1 Estimating the direction of acceleration during two-dimensional motion

1. Choose the point at which you want to determine the direction of acceleration and draw velocity vectors at equal distances before and after the point.

2. Place the $\vec{v}_i$ and $\vec{v}_f$ arrows tail to tail. Draw a $\Delta\vec{v}$ arrow from the head of $\vec{v}_i$ to the head of $\vec{v}_f$.

3. The acceleration arrow $\vec{a}$ is in the direction of $\Delta\vec{v}$.

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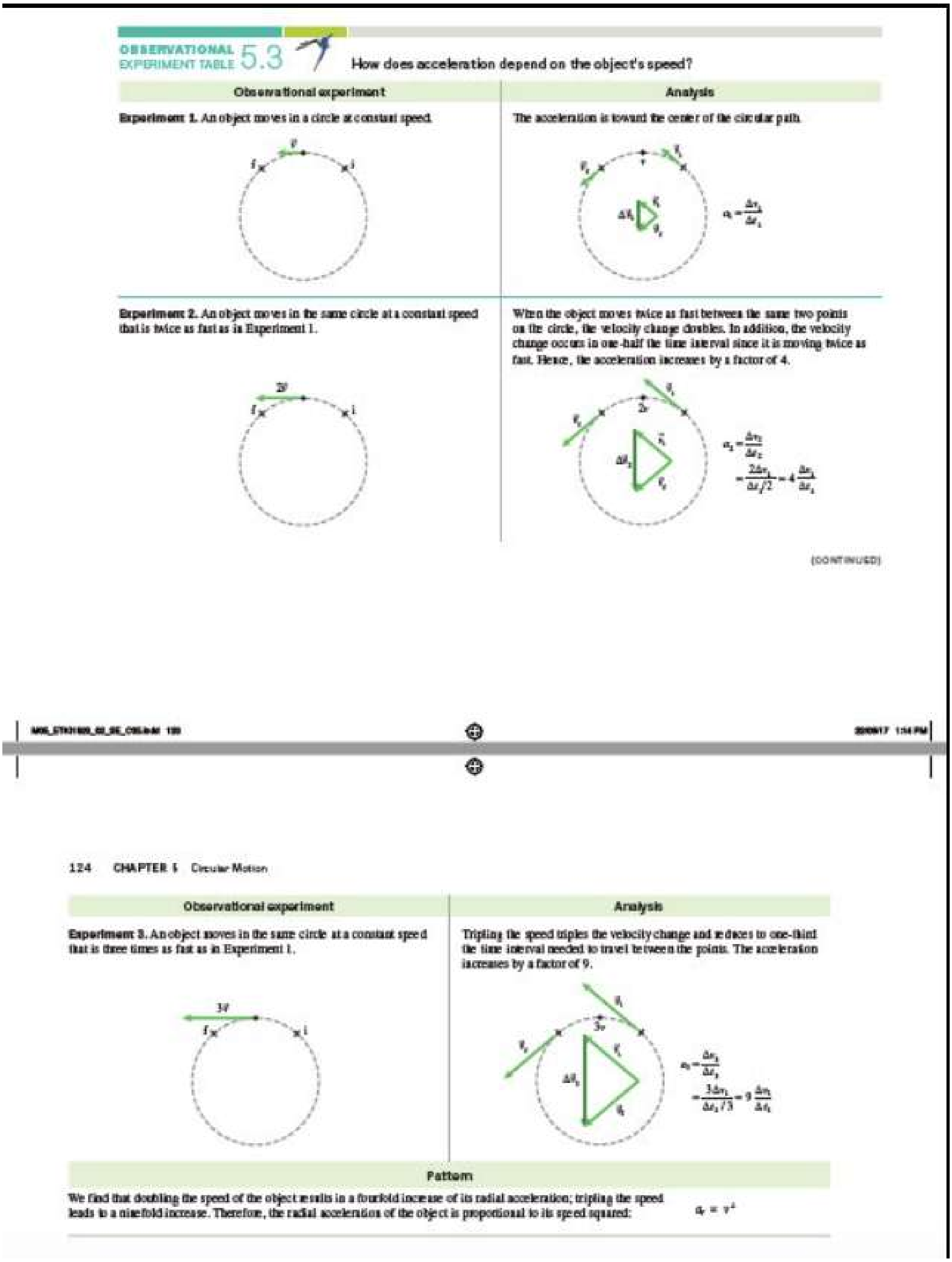
Eugenia Etkina
5. October 2021.

Hi all, this is a belated post as Facebook was down all day today.
I wanted to show you the full progression for circular motion at constant speed. The students constructed and tested the idea that the sum of the forces exerted on an object moving in a circle at constant speed is towards the center and figured out why it is this way - this sum is

needed to provide the radial acceleration. However, they do not know yet, what this acceleration depends on. The following two activities allow the to figure it out. I am pasting two observational tables form the textbook, you can find parallel ALG/OALG activities in the respective files.



OBSERVATIONAL EXPERIMENT TABLE 5.3 How does acceleration depend on the object's speed?

Observational experiment	Analysis
Experiment 1. An object moves in a circle at constant speed.	The acceleration is toward the center of the circular path. $a_1 = \frac{\Delta v_1}{\Delta t_1}$
Experiment 2. An object moves in the same circle at a constant speed that is twice as fast as in Experiment 1.	When the object moves twice as fast between the same two points on the circle, the velocity change doubles. In addition, the velocity change occurs in one-half the time interval since it is moving twice as fast. Hence, the acceleration increases by a factor of 4. $a_2 = \frac{\Delta v_2}{\Delta t_2} = \frac{2\Delta v_1}{\Delta t_1/2} = 4\frac{\Delta v_1}{\Delta t_1}$

(CONTINUED)

124 CHAPTER 5 Circular Motion

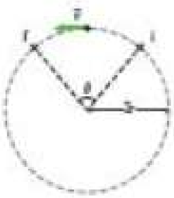
Observational experiment	Analysis
Experiment 3. An object moves in the same circle at a constant speed that is three times as fast as in Experiment 1.	Tripling the speed triples the velocity change and reduces to one-third the time interval needed to travel between the points. The acceleration increases by a factor of 9. $a_3 = \frac{\Delta v_3}{\Delta t_3} = \frac{3\Delta v_1}{\Delta t_1/3} = 9\frac{\Delta v_1}{\Delta t_1}$

Pattern

We find that doubling the speed of the object results in a fourfold increase of its radial acceleration; tripling the speed leads to a ninefold increase. Therefore, the radial acceleration of the object is proportional to its speed squared: $a_r = v^2$

OBSERVATIONAL EXPERIMENT TABLE 5.4 How does acceleration depend on the radius of the curved path?

Observational experiment	Analysis
Experiment 1. An object moves in a circle of radius r at speed v. Choose two points on the circle to examine the velocity change from the initial to the final location. 	 $a_1 = \frac{\Delta v}{\Delta t_1}$

Observational experiment	Analysis
Experiment 2. An object moves in a circle of radius $2r$ at speed v. Choose two points so that the velocity change is the same as in Experiment 1. This occurs if the radii drawn to the location of the object at the initial position and the final position make the same angle as in Experiment 1. 	To have the same velocity change as in Experiment 1, the object has to travel twice the distance because the radius is twice as long. Since the speed of the object is the same as in the first experiment, it takes the object twice as long to travel that distance. Hence, the magnitude of the acceleration is half that in Experiment 1.  $a_2 = \frac{\Delta v}{\Delta t_2} = \frac{\Delta v}{2\Delta t_1} = \frac{1}{2} a_1$

Pattern

When an object moves in a circle at constant speed, its radial acceleration decreases by half when the radius of the circular path doubles—the bigger the circle, the smaller the acceleration. Therefore, the radial acceleration of the object is proportional to the inverse of the radius of its circular path: $a_r \propto \frac{1}{r}$

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Eugenia Etkina
6. October 2021.

Hi my people, thank you for liking and responding to my posts, this is great!
Today is the conclusion of the circular motion "saga". I wanted to show you all the steps of the logical progression in the ISLE approach. Remember, yesterday we discussed activities that help students come up with the idea that radial acceleration is proportional to v^2/R. But what is the coefficient of proportionality? Occam razor-based reasoning suggests that is could be 1 - the simple possible coefficient. But how do we test this idea? This is exactly the

question that we post to the students: design an experiment to test that a=v^2/R for circular motion at constant speed.
To help them with the task we provide them with a conical pendulum, a distance measuring instrument, a force measuring scale and of course, they have stopwatches on their phones.
What experiments do you think students design and what assumptions do they need to make predicting their outcomes using the idea under test? In order to help you think about it, I am posting our Testing Experiment Rubric for scientific abilities involved in designing, running and analyzing results of a testing experiment.

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Eugenia Etkina
7. October 2021.

Hi my people, thank you for "liking" my previous post. It, however, had a question in it and no one answered it so far, please try!
Today I will finish the series of posts about circular motion. Did you notice that I did not say what to use for "the need to know"? and what to do with 'the need to know"? Here is what I do:
I start the unit with showing the youtube movie of Damien Walters trying to run loop-the-loop - basically run upside down! (see the link here and watch it before you continue to read).
It is a great clip, full of suspension and it also communicates the importance of growth mindset as he tries many times. I do not ask any questions about the movie, but say (rhetorically): How did she know how to predict the speed? Is she correct? Did you notice the speed that he had while he made it? We are not going to answer these questions now, we will first learn about circular motion, and then at the end of the unit, we will come back to all these questions.
And so we do, after all the steps that I described before the students are ready to answer those questions. They google the height of Damien Walters and estimate the radius of the loop. They figure out that the radius of his circle is less and some of his mass is closer to the center. And many other things. And they figure out the speed! Of course it is an estimate but it gives them (and me too) a great feeling of accomplishment.
You need to do this after your students went through all the steps I described over the last week and also practiced applying this knowledge to a few problems in the ALG before attempting this final step. Make sure that the students are ready to tackle this problem so that they are successful. Of course they need to work in groups and then share their estimates with each other. The key here is to be able to explain why the minimal speed is even needed and how to connect it to the knowledge of circular motion. For this they need to draw a force diagram for him at the top of the loop and realize that in the critical case the only force exerted on him is the force exerted by Earth. Thus mv^2/R=mg.
Good luck with the circular motion unit! Please post here how it went.

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Eugenia Etkina
8. October 2021.

Hi people, as we are using Facebook for communication, we should not forget how it informs people about new posts. It all depends on how many people engage with the post- through liking, or though comments. You do not need to really like a post, but clicking "like" makes it more visible for the members of the group, so, please, if you read a post, like it (you can even love it :)) so that more people receive the notice about it. This is how Facebook algorithms work unfortunately. Thank you for understanding.
We will start Momentum on Monday. I was wondering if I am ahead of you with my posts or behind. Should I slow down or speed up?

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Eugenia Etkina
9. October 2021.

Hi all, first, if you read this message, please like it so that more people can see it, I hope it is routine by now but we still do not have enough people doing it.
Second, and the reason for this post: Marianna Anthea Bannon posted yesterday about the expertise activity that she did with our students. I actually planned to do this activity with you during our meeting next week, October 15th which is dedicated to overcoming the barriers implementing the ISLE approach. So, if you wish to experience it, please attend the meeting, I posted the zoom link to it already, but will repost in a few days closer to the meeting. We had a poll about the time and the majority wanted 6 pm EST. This is when we will meet and the activity will be a part of the meeting (there will be more, of course).
If you finished reading, please push the like button!

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Eugenia Etkina
11. October 2021.

Hi all, today my post is about momentum (or beginning of momentum to be precise). Do not forget to "like" after you read it to make it more visible.
We start student learning of momentum with the concept of mass as conserved quantity. To think about the world of conserved quantities, one needs to understand the concept of a system in physics, which is very different from the concept of a system in some other disciplines. In physics, a system is a group of objects (field can also be viewed as an object) that WE decide to include in it, the rest of the world is the environment.
A quantity is conserved when we can always find a system in which it is constant. WHAT??? You must be thinking this is just a game of words. Don't the conserved and constant mean the same thing? They DO NOT. We have a motion with constant velocity, but we never say motion with conserved velocity. WHY???
The answer to this question explains the difference between conserved and constant. Let's say your pocket is the system and you have $20 in your pocket. When you spend $5 on a burger the amount of money in your pocket changes - it is not constant but if you include the burger joint into the system, the amount of money remains the same - $20, as the money did not disappear, it just changed hands. However, if your car moves at 20 m/s East and slows down to 15 m/s, the velocity of 5m/s East does not (or might not) appear anywhere else. We cannot find a system that starts moving at 5 m/s in the same direction to make the amount of velocity constant in the world. Velocity (and speed) are not conserved quantities (think of a temperature - this is also a great example of a quantity that is not a conserved quantity). But mass in classical physics, money (without the printing press), linear momentum, rotational momentum, total energy, and electric charge are all conserved quantities. They do not need to be constant in a particular system, but if they do change, we can always find a system in which they are constant. See the beginning of Chapter 6 in the textbook for the history of the discovery of idea that mass is a conserved quantity.
Stamatis Vokos has an excellent definition of a conserved quantity which is slightly different from what I described above, Stamatis Vokos, can you please chime in? Thank you! If you read the post to the end, please do not forget to respond in some way to make it more visible for the rest of the group!

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Eugenia Etkina
12. October 2021.

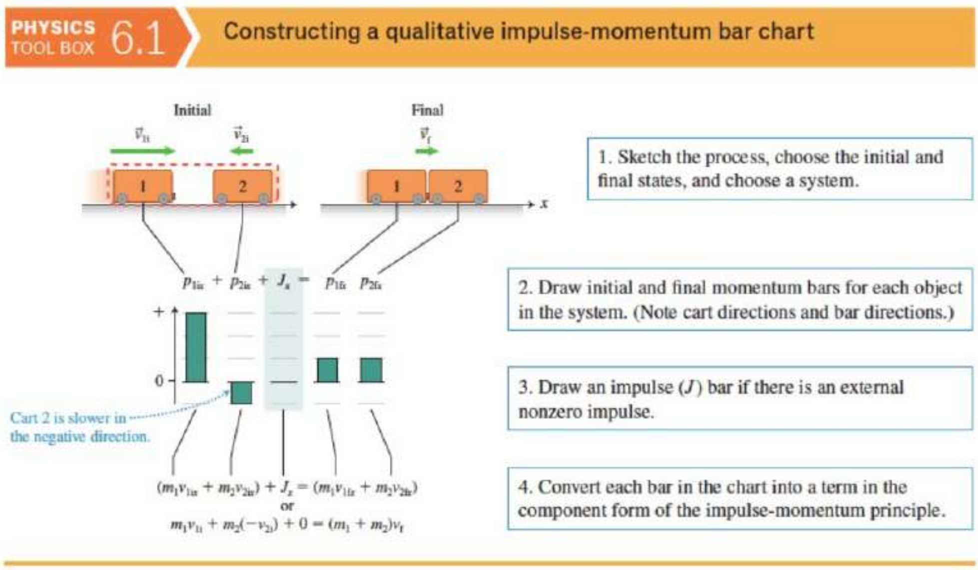
Hi people, what an incredible response to my yesterday's post, thank you! After you finish reading this one, please do not forget to like it. 🙂
I will continue with momentum. The logical progression in the textbook, ALG and OALG (see in the FILES OALG Chapter 6 with video links) follows the ISLE approach - the students

observe simple experiments in which cars of different mass and speed collide, invent a physical quantity of momentum of a system and the idea that it is constant in an isolated system and then test both experimentally. Then the investigate how momentum changes when the system is not isolated and invent the quantity of impulse. The process culminates with the generalized impulse-momentum principle and its representations with the bar charts.

Here the key is that while momentum is a conserved quantity, it is not necessarily constant in every system. If the system is not isolated, the momentum can change (it can be gained or lost), however, if you redefine the system so all interacting objects are included, you will see that the lost or gained momentum is found! This is the same principle as we discussed yesterday for money.

Then the students proceed to problem solving.

As I can only attach one image to the post, I am attaching the screen shot of the physics toolbox for the impulse-momentum bar charts. It is done for the case of an isolated system. Try to draw the bar chart for the same process but when only car 1 is the system. What happens to the momentum of this system? Is momentum still conserved if you only choose car 1? The answer is YES, it is conserved! But it is not constant. If you finished reading the post, PLEASE DO NOT FORGET TO LIKE IT OR TO REPLY, THANK YOU!



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Eugenia Etkina
13. October 2021.

Hi all, three things today:

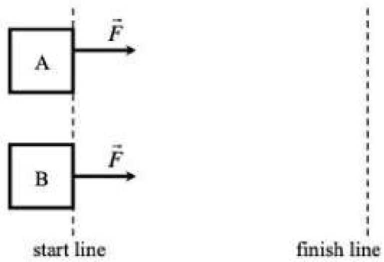
First I wanted to thank Marianna Anthea Bannon for her post. Many of you focused on different ways to help students learn the components of projectile motion using Pivot. This is great, however, I want you also to focus on another aspect of her post - the idea that in the

ISLE approach we do not ask students to make prediction before observational experiments. We do not "elicit, confront, resolve" or "predict, observe, explain". We do it very differently - observe, think about it, come up with as many explanations as possible and then test these new explanations experimentally (using hypothetico-deductive reasoning that I described in my post a few weeks ago). How is our method different? We do not put students' intuition that they developed in the real world to the test. We do not ask them to predict "cold" when they have no context or no means to analyze the situation critically. If we did that, the students would start thinking that physics is different from the real world and that they are not good at it. The idea of cognitive disequilibrium as the cause for learning is good when the learners have confidence in themselves, but when they do not (an this is especially true for women who have a very strong impostor syndrome), continuous challenge of their intuition does not help. It harms. That is why in the ISLE approach students do make predictions, but make them using their "crazy ideas" not their gut feeling. And this approach teaches them to think systematically, slowly, which involves a different processing path in the brain than the quick "what do you predict?" when they know nothing about the situation.
The second thing that I was going to talk about is reminding you that we have a meeting dedicated to a question raised in the previous meeting - how do we help our students be comfortable with the ISLE approach and how do we help other teachers adopt it? The meeting is on Friday at 6 pm EST. The link to the zoom meeting is in the announcement for the meeting, but I will post it again on Friday, closer to the meeting time.
Finally, I would like to continue with momentum and I am sharing one of the activities in the ALG and OALG. Please read it carefully and post your answers! Thank you, if you read to the end, do not forget to react to the post - like it or comment. This makes the post more visible for other group members.

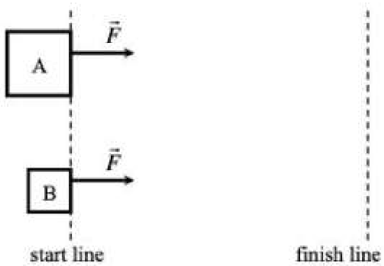
OALG 6.3.3. Reason

Answer the following questions.

a. You continuously push equally hard on identical blocks A and B from the start line to the finish line. Block B is initially at rest whereas block A is initially moving right. Which block has the greater change in momentum in moving from the start to the finish line? Explain your answer.



b. Suppose that both blocks in the previous problem start at rest, but that block A has four times as much mass as block B. Which block has the greater change in momentum in going from the start to the finish line? The blocks are pushed with equal-magnitude forces.



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Eugenia Etkina
14. October 2021.

Hi all, today I am posting the link to tomorrow's meeting - we will be discussing how to reduce resistance to learning and teaching with the ISLE approach. The meeting is at 6 pm EST. We will record it and post the recording. Here is the link. I know that there is nothing to like about it, but remember, if you like it, more people will see the post. Maybe somebody who missed our previous announcements will see it and join the meeting. As always, the question during tomorrow's meeting will determine the topic for the next meeting, so, please bring your questions (ANY questions!). If you are not familiar with the ISLE approach yet, do not worry, we will review it at the beginning of the meeting so that we are all on the same page. Tomorrow I will start the sequence about energy. Our approach to energy is drastically different from traditional and is very effective, do not miss! If you got to the end of this message - make sure that you react. Thank you!

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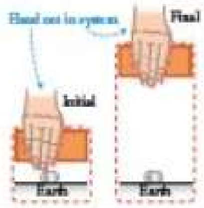
Eugenia Etkina
15. October 2021.

Hi people, two things today (do not forget to like or reply).
1) the reminder of the meeting at 6 pm EST, the link to the zoom is in my yesterday's message.
2) We are starting energy. As I said before - our approach to energy is very different form traditional. Three main differences: a) we use the concept of a system to analyze any energy situation and we show how the change of the system affects the solution. The objects inside the system do not do work on each other, only external objects (environment) do. The system does not do work on the environment, but the work of the environment on the system can be positive or negative.
b) we discuss total energy and conservation of total energy, not mechanical energy only (as mechanical energy is not a conserved quantity), therefore internal energy change is included in all analyses, thus we use the SAME approach to energy throughout all physics topics, including thermodynamics, electricity, optics, atomic and nuclear physics. This approach eliminates work-energy theorem (that external work done or a particle leads to the increase of its kinetic energy) and leaves us with the generalized work-energy principle: external work done on a system is equal to the change in total energy of the system.
c) Because of b) we do not need the concept of conservative and non-conservative forces. Therefore they are not present in our materials.
To have an image of how to start energy, I am pasting the first observational experiment table form the textbook, parallel activities are in the OALG Chapter 7 posted here or ALG Chapter 7 posted on Mastering Physics. If you finished reading the message please click like or reply to make the post more visible for the group members. Thank you!

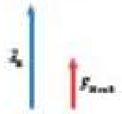
OBSERVATIONAL EXPERIMENT TABLE 7.1 External forces and system changes

Observational experiment | **Analysis**

Experiment 1. You hold a heavy block just above a piece of chalk (the initial state) and then release the block. The chalk does not break. Now you lift the block about 30 cm above the chalk (the final state). When you release the block from the higher elevation, the block falls and smashes the chalk.

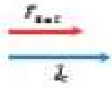


The force you exerted and the block's displacement while being lifted were in the same direction and caused an increase in the block's elevation and in its ability to break the chalk.

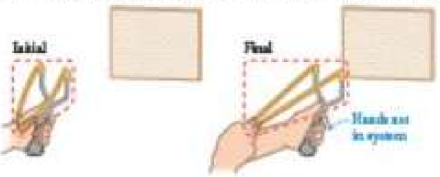


Experiment 2. You push a cart initially at rest (the initial state) until it is moving fast about two-thirds of the way across a smooth track (the final state is where you stop pushing the cart). A piece of chalk is taped to the end of the track. The fast-moving cart (no longer being pushed) collides with the piece of chalk and breaks the chalk. When you repeat the experiment with a slow-moving cart, it does not break the chalk.

The force exerted on the cart and the cart's displacement were in the same direction and increased the cart's speed so it could break the chalk.

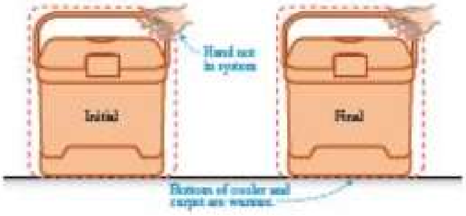


Experiment 3. A piece of chalk rests in the hanging sling of a slingshot (the initial state). You then pull it back until the slingshot is fully stretched (the final state). When released from the stretched sling, the chalk flies across the room, hits the wall, and smashes.



The force that you exerted on the sling and its displacement were in the same direction and made it possible for the stretched sling to cause the chalk to break.

Experiment 4. A heavy cooler sits on a shag carpet (the initial state). You pull the cooler across the carpet to a position several meters from where it started (the final state).



You exerted a force on the cooler in the direction of its displacement. After several meters of travel across the carpet, the bottom became warmer.

(CONTINUED)

Patterns

In each of these experiments, you exerted an external force $\vec{F}$ on an object in a system. The force $\vec{F}_{\text{You on Object}}$ and the object's displacement $\vec{d}_{\text{Object}}$ were in the *same direction* and caused the system to change so that it could do something that it could not do before, such as break the chalk or warm up the carpet. Specifically:

1. The *block at higher elevation* above Earth could break the chalk, but the block at low elevation could not.
2. The *fast-moving cart* could break the chalk, but the slow-moving cart could not.
3. The *stretched slingshot* could break the chalk, but the unstretched slingshot could not.
4. The *cooler and the carpet it was pulled across* became warmer than they were before the cooler was pulled across the carpet.

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Eugenia Etkina
16. October 2021.

Hi my people, here is the link to the recording of our meeting today and the passcode. To access the slides that we used, use the link pasted below. I will post when we have our November meeting. The topic will be kinestetic activities.
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Eugenia Etkina
16. October 2021.

Hi all, I continue with the energy development. The following activity helps students construct the idea of internal energy change. Remember to "like" the post when you finish reading it to help others see it.
Prior to that they should have constructed the concept of work done on a system - positive, negative or zero (though a series of activities, see the OALG Chapter 7 posted in the FILES). They learned that external work changes kinetic, potential or spring energy of a system. By the way, in our approach the system has gravitational potential energy only when Earth is included in the system. It Earth is not included, then it does work on the system but the is no GPE. This means that an apple lifted 5 m above ground DOES NOT HAVE ANY GPE.
The following activity help the students figure out what happens when work is done on the system but none of the above energy types change. To see the whole progression, either read the textbook chapter 7 or work through the activities preceding 7.1.5 in the OALG.
Research shows that students have tremendous difficulties with the concept of internal energy as it is invisible. The infrared cameras help us "see" the changes. They are relatively cheap now and attach to your phones. A good investment! If you got to the end of this post, do not forget to react!

7.1.5 Observe and find a pattern

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

A system consists of a heavy cooler and a rough horizontal surface on which it sits. You (outside the system) pull on the handle of a cooler so that it moves slowly along the surface at constant velocity. You do positive work by pulling the cooler for about 5 m. Your friend takes a photo of the cooler and the surface using a thermal camera (see photo at right below). Describe how the system (cooler and surface) is different after you do the work than before the cooler started moving. Notice that the chalk-crushing ability of the cooler did not change ($\Delta CCA = 0$), and yet you did work on it. Does this fit with the equation you just invented in Activity 7.1.4? Discuss with your group how you could modify the equation you came up with in Activity 7.1.4 to account for this anomalous result. *Hint*: You may need to invent a new physical quantity. Put your group's revised equation on a whiteboard and compare your ideas with those from another group.

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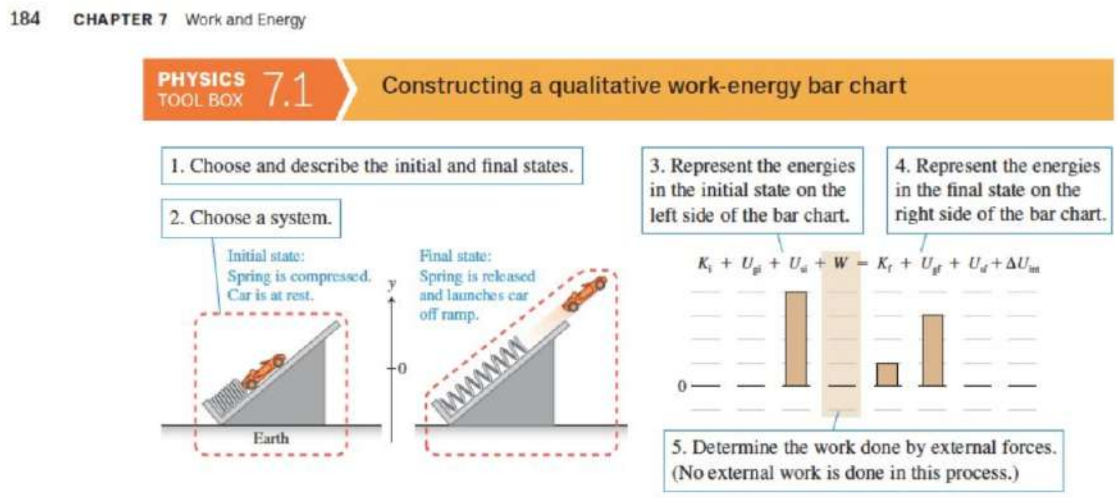
Eugenia Etkina
19. October 2021.

Hi all, we have several new members today - WELCOME! Please read the announcements to learn how to use the resources available for the members of this group.
Today I will continue with the energy (please do not forget to respond to the post after you finish reading it to help other see it). Remember impulse-momentum bar charts? The same approach can be used to analyze energy processes. Choose the system first and the initial and final states (all of those decision will affect what the bar chart looks like). The bars on the left represent the energies in the system (except the internal energy), the bars on the right side - the final energies. In the middle there is a bar for work - the work changes the energy of the system (later, in thermodynamics, we will add a bar for heating - the means of

transferring energy to the system without doing work). On the right side there is an additional bar for the internal energy change (see the reasoning tool box attached here).
People often ask why we do not have initial internal energy bar on the left and final internal energy bar on the right, just like all other energies? I am leaving this questions for you to ponder - when you finish reading this post please do not forget to "like" it and then respond to the question. Thank you!



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Eugenia Etkina
20. October 2021.

Hi all, two things. First, our next meeting will be November 12th, 6 pm EST. The topic of the meeting - kinestetic activities. I will post the even today, please sign up there. Thank you.
I will continue with the energy. I am repeating my question, posed 2 days ago - why don't we include initial internal energy on the left side of the chart and final on the right just as we do with all other energies? Why do we put delta U int on the right? What is such a difference between the treatment of mechanical energies in the system and the internal energy?
So far nobody attempted it. Please share your thoughts (and do not forget to like the post to make it more visible). Thank you.

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Eugenia Etkina
21. October 2021.

Hi all, I am continuing with the energy. Jose Garcia in his reply to my post about the absence of initial and final bars for the internal energy on the bar chart used the example of a ball landing on the floor and stopping. If we choose the ball (let's take a metal ball) as the system, then before the collision it has kinetic energy and after the collision this energy is gone. Where did it go?
You might think that the floor did negative work on it, but the floor did not move (let's say it is a hard cement floor), so how could it have done work? If we want to avoid the concept of pseudo work here, the only way to explain what happened is to redefine the system, include the floor in the system and say that the kinetic energy of the moving ball was converted into the internal energy of both the ball and the floor. (Actually, a video of a lead ball landing on a hard surface shows it (see the attached infrared video, made by Gorazd Planinsic).
The same approach is helpful when analyzing our walk up the stairs (you and Earth are the system) and down the stairs. As the stairs do not move, they cannot do work on us, the question is - where does the kinetic energy and gravitational potential energy come from? Or where do they go when you are going downstairs? And in general, what energy conversions happen when we go up and down?
I challenge you to think about these questions using you and Earth as the system. Also, it helps to listen what happens when you go up and down, especially when many people do at once, the effect if very pronounced. If you read the post to the end, please do not forget to like it so that more people can see it, thank you!

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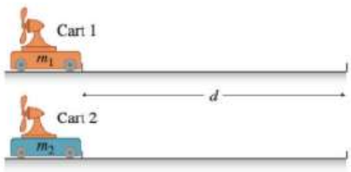
Eugenia Etkina
25. October 2021.

Hi my people! Two things (Please do not forget to like the post or comment on it to make it more visible):
First, I would like to thank everyone who participated and is participating in the discussion of internal energy, real and pseudowork and the mechanisms of conversion of one form of energy to another (notice that I am not using the word transformation, but the word conversion. Why? Energy is not transformed into another quantity, it is merely converted from one form to another).
Second, I would like to focus your attention on the differences between momentum and energy. We have this excellent activity described in the textbook which I am posting below. Please read it and think what your students can learn from it. I usually set up two carts loaded with different number of blocks for the students to see to help with their imagination, let them observe how the carts move across the same distance on the floor and then let them work in groups answering the questions in the table (in the file I posted here the questions are answered). Some of the answers come very unexpected for the students and

lead to a great discussion. For example, how can a cart that is heavier and moving slower have a greater change of momentum compared to a lighter car that moves faster? Check it out and do it with your students! And, if you read to this point, please do not forget to like the post to make it more visible. Thank you!

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



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

TABLE 7.5 Physical quantities describing the motion of two fan carts

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

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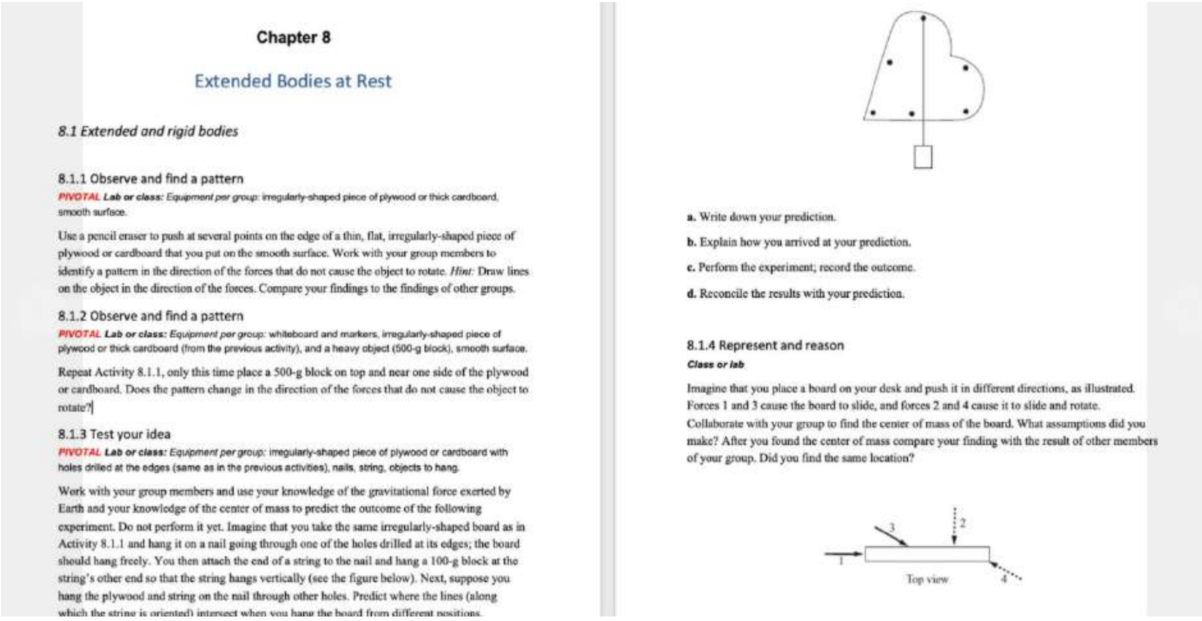
Eugenia Etkina
27. October 2021.

Hi all, I think we need to take a break from energy - we will come back to it when we get to Chapter 15 - thermodynamics. For now, we are moving to Chapter 8 in the textbook - static

equilibrium. Please do not forget to like the post once you finish it - this will make it more visible for other group members.
The book follows the ISLE logical progression very carefully. It starts with the idea of the center of mass as a point on an extended rigid objects through which pass the lines of forces that do not rotate the object. How do students construct this very important idea?
See the attached document - a screen shot of the ALG Chapter 8 activities to have an idea of the progression of activities. Once the concept of the center of mass is established, the students can progress to the physical quantity of torque. The question is - why is the center of mass come before torque in our textbook?
Do not forget to respond to the post - either like it (or even love it) or make a comment. Thank you!



Chapter 8

Extended Bodies at Rest

8.1 Extended and rigid bodies

8.1.1 Observe and find a pattern

PIVOTAL Lab or class: *Equipment per group:* irregularly-shaped piece of plywood or thick cardboard, smooth surface.

Use a pencil eraser to push at several points on the edge of a thin, flat, irregularly-shaped piece of plywood or cardboard that you put on the smooth surface. Work with your group members to identify a pattern in the direction of the forces that do not cause the object to rotate. *Hint:* Draw lines on the object in the direction of the forces. Compare your findings to the findings of other groups.

8.1.2 Observe and find a pattern

PIVOTAL Lab or class: *Equipment per group:* whiteboard and markers, irregularly-shaped piece of plywood or thick cardboard (from the previous activity), and a heavy object (500-g block), smooth surface.

Repeat Activity 8.1.1, only this time place a 500-g block on top and near one side of the plywood or cardboard. Does the pattern change in the direction of the forces that do not cause the object to rotate?

8.1.3 Test your idea

PIVOTAL Lab or class: *Equipment per group:* irregularly-shaped piece of plywood or cardboard with holes drilled at the edges (same as in the previous activities), nails, string, objects to hang.

Work with your group members and use your knowledge of the gravitational force exerted by Earth and your knowledge of the center of mass to predict the outcome of the following experiment. Do not perform it yet. Imagine that you take the same irregularly-shaped board as in Activity 8.1.1 and hang it on a nail going through one of the holes drilled at its edges; the board should hang freely. You then attach the end of a string to the nail and hang a 100-g block at the string's other end so that the string hangs vertically (see the figure below). Next, suppose you hang the plywood and string on the nail through other holes. Predict where the lines (along which the string is oriented) intersect when you hang the board from different positions.

a. Write down your prediction.

b. Explain how you arrived at your prediction.

c. Perform the experiment; record the outcome.

d. Reconcile the results with your prediction.

8.1.4 Represent and reason

Class or lab

Imagine that you place a board on your desk and push it in different directions, as illustrated. Forces 1 and 3 cause the board to slide, and forces 2 and 4 cause it to slide and rotate. Collaborate with your group to find the center of mass of the board. What assumptions did you make? After you found the center of mass compare your finding with the result of other members of your group. Did you find the same location?

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Eugenia Etkina
29. October 2021.

Good morning (afternoon, evening) everyone! I am continuing my posts related to static equilibrium. Specifically about the center of mass. Before you read on, do not forget to like the post or comment on it to make it visible for more people.
The term "center of mass" is a bad term. Similarly to the term "weight" that makes people think that weight is something that belongs to them, and as we insist that weight is a force, consequently, forces belong to objects. I am using this example to show how OUR language, the language of physics teachers and physicists in general contradicts the very essence of

the concept that we want our students to learn. That is why we do not use the term weight in our textbook or other materials.
But this post is not about weight. It is about the center of mass (it is also at the same location as the center of gravity if the object is in the uniform gravitational field, close the a black hole these two locations are not the same). So, the term CENTER of mass makes our students think that the mass of an object is symmetrically distributed around the center of mass. How can they learn that this is not the case and masses of the parts of the object on different sides of the center of mass are not the same?
Here is the sequence of activities that we suggest (pasted below as copied from the ALG). They come after the students have constructed the concept of a torque and of conditions of static equilibrium. It is important that the activities are done in the order shown in the document. Try doing both of them and describe what you learned. Once you finish reading this post and the document I pasted below, do not forget to like it or to reply in some other way.
8.4.1 Design an application experiment
PIVOTAL Lab: Equipment per group: whiteboard and markers, meter stick, 100-g object.
You have a meter stick of unknown mass and a small 100-g object. Design an experiment to determine the mass of the meter stick using your knowledge of static equilibrium.
a. Draw a picture of the experimental set-up.
b. Describe the procedure in words.
c. Apply the concepts of equilibrium to develop equations that can be used to predict the mass of the meter stick. Then predict the mass.
d. Use a scale to measure the mass and compare the result to the predicted value.
e. How can you explain the difference between the predicted and the measured value?
8.4.2 Test an idea
Lab: Equipment per group: whiteboard, markers, meter stick, variety of objects of different mass, masking tape, platform scale.
Your friend says that the mass of any object is distributed evenly around its center of mass. Design an experiment to test your friend’s idea. You have a meter stick, a set of small objects of different masses, masking tape, and a mass measuring scale. Describe your experiment and predict the outcome based on your friend’s idea. Then conduct the experiment, collect and analyze data. What can you say about your friend’s idea?

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Eugenia Etkina
1. November 2021.

Hi all, we are moving on to rotational kinematics and dynamics. While rotational quantities are much more abstract than linear quantities, we have a great way for the students to experience some of them through kinestetic activities (this is just one of the many activities

that we have in the book/ALG/OALG and will be discussing during our next meeting. Please do not forget to respond to the post once you finished reading it to make it more visible.
Here is the first activity in Chapter 9 (Rotational kinematics and dynamics, ALG):
9.1.1 Observe and find a pattern
Class or lab: (but here two groups need to work together to form one large group) Equipment for two groups: 2 1-meter sticks or 1 2-meter stick.
For this activity you need two meter sticks connected together to form a 2-m long stick, or a 2-m stick. Have one group member hold one end of the meter stick and stand at the same position at all times, another one hold it at the 50-cm mark, the third one at the 1-m mark, the fourth at 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 outer end of the stick runs in a circle at a comfortable constant speed.
a. Observe the motion 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? Discuss with your group.
What physical quantities will the students "notice" in this activity and how? As always, please like the post to make it more visible. THANK YOU!
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Eugenia Etkina
7. November2021.

Today my post is not about rotational motion, it is about how we can better help students learn (do not forget to respond when you finish reading to make the post more visible).
You know the expression "practice makes perfect", right? We all do, but unfortunately, this is not a good statement. Practice of a wrong strategy many times does not make the right strategy, right? That is why we have research that solving a 1000 physics problems does not increase students understanding of physics concepts.
What kind of practice makes it perfect? The answer to this question comes from the work of Anders Ericcson and colleagues on deliberate practice. Deliberate practice has several important components, if one of them is not present, the results will not lead to improvement. I am listing these components (I am using their interpretation by Angela Duckworth in her book on Grit). Here are these 4 crucial components:
1. A clearly defined stretch goal.
2. Full concentration and effort
3. Immediate and informative feedback
4. Repetition with reflection and refinement.

Thinking about a good learning environment, I mean the ISLE-based environment, 3 and 4 are present by default (these are built into our learning system), but not the first 2. How do we help our students set their own goals while learning physics and how to we create

conditions for them to fully concentrate on the task and give it their 100% effort? I am inviting you all into the conversation about these issues.
If you read to the end, you know what to do - you have to like it 🙂
And do not forget about our meeting on Friday, 6 pm EST. I see a lot of people going, it is GREAT!!!!

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Eugenia Etkina
10. November2021.

Hi all, we have a few new members today. Welcome all, please read the announcements to learn how to navigate the group and how to get the most out of it. I am reminding that we will have a meeting on Friday, 6 pm EST focused on the kinestetic activities. The link to the zoom meeting is in the meeting announcement. I will post it again on Friday morning. I am not posting any new stuff today, as only 19 people responded to my previous post yesterday. Please read and respond to it if you have not done so yet. We are moving forward with vibrational motion but I want to make sure that people see the post before I continue. Thank you!!!

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Eugenia Etkina
13. November2021.

Hi all, here is the recording of our yesterday's meeting. To understand what is going on you will need to use the google slide show, I am posting the link too.
Our next meeting in December will be dedicated to the essential elements of the ISLE approach. What should you do for sure in order for your students to learn physics through ISLE? To set the date, I will post the poll so that we can accommodate the largest number of people. The time will be the same - 6 pm EDT, 3 pm PST. (US time zones). As always, the topic of the meeting came from the participants.
During the meeting Andrew Yolleck asked a good question and I did not answer it well. He said, can we have a meeting to discuss how to help others believe that the ISLE approach works? And I said that we do not need a meeting for this, as there is so much written about it, that the meeting would just be a repeat of these papers and books. But this was not a good answer. A good answer is that if you wish to convince your colleagues that the ISLE approach is superior to not only to traditional teaching, but also to most reformed

approaches, you need to invite them to observe your classroom and see for themselves. And then, it is a very important "then", you need to share the work that your students do - real examples of our questions and your students' responses. I believe that it is the best start of the conversation. Then the can read the papers... Sorry, Andrew Yolleck for my bad answer yesterday.
Here is the link to the recording:
https://rutgers.zoom.us/.../8K7wO8d-Qb_Mgt... Password: 73z$K=2q
And here is the link to the slides
https://docs.google.com/.../1HXYbf4xzMdOXOLsLn84C.../edit...
If you read to the end of the post, please respond to increase the number of people who see the post. Thank you.

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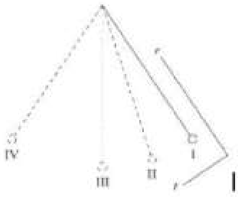
Eugenia Etkina
16. November2021.

Hi all, today I continue with vibrational motion. Do not forget to like the post when you finish reading (who knows, maybe you will even love it 🙂
For many years I taught vibrational motion of a simple pendulum as vibrational motion, focusing on the tangential components of the net force and acceleration. It did not occur to me, that it was also circular motion at changing speed.
Many generations of my students never learned that the acceleration fo the pendulum bob is not along the tangent to the circle and is not towards the center of the circle but has a variable directions that can be determined by drawing a good force diagram (forces to scale) and even better - by drawing a good motion diagram. Here is the activity that allows your students to figure it out.
Only a small percentage of physics graduate students can draw the direction of acceleration of a pendulum at different points of the arc (research by late Lillian McDermott). Your students will be able to! The answers to the questions in the activity are in the textbook on page 297. If you need them, I can post as a separate post. If you read to the end, you know what to do next!

OALG 10.5.1 Represent and reason

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. Complete the table that follows for the positions shown in the figure.

Use the graphical velocity method to estimate the direction of the 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 r-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
Construct an energy bar chart.	Position I K U_g Other + 0 –	Position II K U_g Other + 0 –	Position III K U_g Other + 0 –	Position IV K U_g Other + 0 –

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Eugenia Etkina
17. November2021.

Hi all, two things: 1) It looks like December 10th for the meeting is a clear winner so far. If you have not voted and you wish to learn more about essential elements of the ISLE approach, then vote!

2) I am going to talk about waves today. This is chapter 11. Again, it is important to distinguish between a physical phenomenon of wave motion and mathematical description of a traveling sinusoidal wave. To start , a week before you start waves, ask your students to go to a nearest pond, drop a small rock and video what happens. They will record circular disturbances coming out from the drop place. show the best video to the class. The question is - what is happening? - is the water rushing out or parts of water merely move up and down and pull the neighboring parts? It is a great opportunity to test these two crazy ideas. Think of what testing experiments students come up with and how to run them. One experiment is in the ALG and OALG Chapter 11 section 1: https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...
Once the students construct the idea that in that wave the material does not move outwardly but moves up and down, they are ready to investigate wave motion in more detail. We continue with pulses and use slinkies to help the students actually "see" how a pulse propagates and how individual coils pull on each other. making the disturbance travel.
Make sure you have a long slinky and three students (the best is when the students are in groups of three and each group has a slinky and a phone). Attach some colorful ribbon to one of the coils. Have the two students hold the end of the slinky and stretch it on a smooth floor. Sitting on the floor one student moves his hand holding the end of the slinky very quickly to the side and back, the second student holds the opposite end steady. The third student takes a slow motion picture of the pulse focusing on the location of the coil with the ribbon. Here they will see two phenomena - propagation of the pulse and reflection off the other end. Focus their attention on the pulse without reflection first. What is traveling? Clearly something is but the coils do not travel along the slinky, what does?
This is how the students come up with the idea that it is the energy that is transferred in the wave, not the material. And it is only being able to transfer because of the interactions of the adjacent parts. So the not only the person that makes the pulse is important (the source) but also the medium through which the pulse travels. These are two crucial ideas here - the source and the medium. More tomorrow. If you read to the end, do not forget to like the post to make it more visible!

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Eugenia Etkina
24. November2021.

Hello everyone! I took two days off posting as I wanted you to follow Gorazd Planinsic's posts about making a standing wave. But in order for the students to understand HOW a standing wave (or an interference patterns) can be produced, they need to construct superposition principle for waves. Please do not forget to like the post to make it more visible.
We have an excellent sequence for this not only because the experiments are simple and cool but because it allows the students to participate on one of the most important aspects of

the ISLE process - devising and RULING OUT multiple explanations. Being accustomed to ruling out ideas is one of the most important features of doing physics.
I am attaching a screen shot of the sequence of activities, and I am inviting you to share two (at least two!) different explanations that students might come up with for the initial observational experiment. They ALWAYS come up with them, that is why we videoed the testing experiments. I am posting the links to the experiments separately below but they are not helpful if you do not do the activities yourself (they are all in the OALG file for chapter 11 posted here). And please do not forget to respond to the post! Thank you!
https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...
https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...
https://youtu.be/XUPHgm9dLIE].

OALG 11.6.1 Observational and explain

a. Go to [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-11-6-1]. Observe and describe what happens. What do you see when two pulses coming from opposite directions meet?

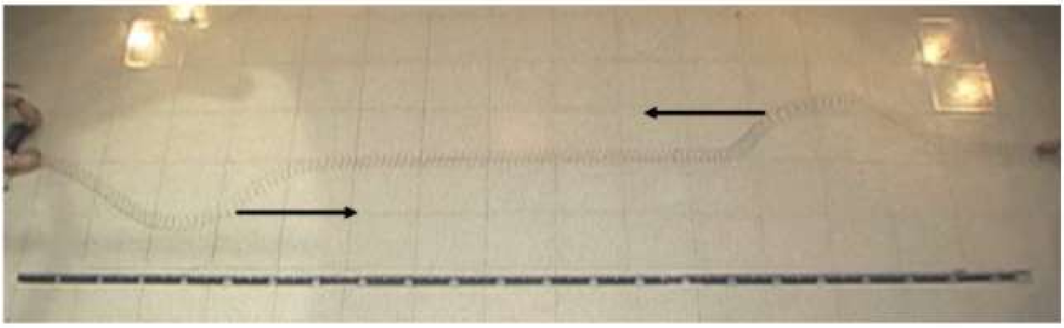
b. Brainstorm one or two ideas to explain what is happening when the two pulses meet each other.

c. If you come up with two competing ideas as to what happened, brainstorm ways in which you could conduct a testing experiment to decide which of these two ideas is correct.

OALG 11.6.2 Test your ideas

Before you watch the video, answer the following questions:

In this video, two oppositely oriented pulses approach each other from opposite directions as shown in the snapshot below:



a. Use each explanation you developed in Activity 11.6.1 part **b.** to make a prediction about what the Slinky will look like just *after* the two pulses meet. (One prediction based on each explanation.) Sketch them in your notebook.

b. Now that you have sketched out your predictions, watch the following video [https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-phys-egv2e-alg-11-6-2] to see which explanation best explains the behavior in this video. (Which prediction was consistent with the actual outcome of this experiment?)

c. How can it be that two pulses arrive to the same place at the same time and the spring appears to be flat? Where did the energy of the system go in the instant when the spring is flat?

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

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Eugenia Etkina
28. November 2021.

Hello to everyone! Three things today: first we have a few new members - WELCOME! please read the message at the top of the group page to learn how to benefit from the materials posted here.
Second - if you read the post to the end, do not forget to respond in some way.
Third, we are done with waves for now and I am moving on. The next chapter in the textbook is Chapter 12 - gases. The beginning of this chapter shows the first (chronologically, in terms of when it was invented) ISLE progression for the development of a concept - with all major attributes of the ISLE process - a simple observational experiment, noticing patterns, coming up with MULTIPLE explanations and immediately testing them and finally arriving to one of the MOST IMPORTANT IDEAS OF PHYSICS (all by the students themselves) - that matter is made of particles and move chaotically and have spaces between them. I am pasting the sequence here with all the videos for you to see, but all of them can be done in person if you are teaching in person. All crazy ideas that are tested in the activities, came from the students.
12.1 Structure of matter
OALG 12.1.1 Observe and explain
Equipment: 90% isopropyl alcohol, strips of paper.
Dip a piece of paper in rubbing alcohol (or rub the paper with alcohol) and place it on a table. Observe what happens. Describe your observations in simple words. Note that you should observe the paper with rubbing alcohol for several minutes. Alternatively, you may view the experiment by watching the following video. [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]
One of your friends described theirs in the following way: "The alcohol disappeared gradually". What do you need to assume about the internal composition of alcohol to explain that the alcohol disappeared gradually rather than all at once?
OALG 12.1.2 Develop multiple explanations
Mindy, Marc, Alex, and Nina are working on Activity 12.1.1. They agree that alcohol must be made of small parts to enable the paper to gradually dry. However, they disagree on the mechanism that allows these small parts to disappear. Brainstorm possible reasons for how and why the small parts of alcohol disappeared from the paper. Come up with at least four different mechanisms.
OALG 12.1.3 Test multiple explanations
Below are four testing experiments that Mindy, Marc, Alex, and Nina decided to perform. Predict the outcome of each experiment described below based on each of the four mechanisms you came up with in Activity 12.1.2. (For example, if the small parts soaked into the table through the paper and we hold the paper between our fingers when drying, then the paper should not dry—the table is not there to absorb the alcohol.) Remember that each testing experiment needs four predicted outcomes, one based on each mechanism.
Predict the outcome of each experiment below using all four explanations:
a. Hold the paper that has been dipped in alcohol between your fingers without putting it on the table while it is drying.
b. Weigh the paper before the experiment, when it is wet, and then again when it is dry. [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]

c. Take two identical pieces of paper and put the same amount of alcohol on each. Then, place one piece of paper under a vacuum jar and the other one just outside the jar. [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]
d. Pour some alcohol into a beaker. Place a small drop of colored alcohol (alcohol to which you added some dye and stirred to mix) into the beaker with clear alcohol, but do not stir it. [https://mediaplayer.pearsoncmg.com/.../sci-phys-egv2e-alg...]
After you have your predicted outcomes on a whiteboard, perform the experiments (or watch the videos of them) and decide which experimental outcomes are consistent with which predictions. Then, make judgements as to which mechanisms you have gained confidence in and which ones you can reject." Check your reasoning with the reasoning in Testing Experiment Table 12.1 on page 353 in the textbook.
OALG 12.1.4 Explain
The only explanation for drying alcohol that could not be rejected by testing experiments was the explanation that alcohol consists of tiny particles (called molecules) that move randomly. How do you need to modify this explanation to account for the fact that not all of the particles leave instantly?

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Eugenia Etkina
30. November2021.

Hi all, I am continuing with Chapter 12, Gases (check out the OALG file posted here for it for all of the activities). Please do not forget to respond to the post to make it more visible.
As the first two activities that I posted two days ago showed, this chapter is ripe for opportunities to practice our unique ISLE-based reasoning - inventing multiple explanations for the observed phenomenon, and learning to systematically reject them by systematic testing. The next two activities that I am posting today allow for similar steps but even better. They relate to the development of the concept of pressure that moving microscopic particles exert on the walls of the container. I am posting the first activity below and AFTER I will share my experience with the students that leads to the second activity. So, here is the first one:
OALG 12.2.1 Observe and explain
Equipment: a balloon.
Blow up a balloon and carefully observe how its shape changes during the process. Use the idea of moving particles to explain why it expands when you blow air into it. Explain why the balloon does not expand any more when you stop blowing. Describe an experiment you can perform to test your explanation(s).
The idea here is that not only the stretched rubber of the balloon stops its expansion due to the hits of the air particles inside it, but also the particles or the outside air bumping from outside. It is this exact idea that one of my students (who never had physics before) expressed in in class. Immediately after, another student (I even remember his name, although it was 20 years ago, Jabari), Jabari, says: Wait a minute. If this is true and the

particles of air are preventing the balloon from further expanding, then the un-inflated sealed balloon should expand by itself if we put it in a vacuum! But this will never happen, how can a balloon inflate by itself?
Luckily, I had a vacuum jar and a balloon handy, so we did the experiment and voila! the balloon inflated! There was this audible gasp of the whole class. Jabari predicted this crazy thing! They clapped and smiled and Jabari became my best student that year. Now, Jabari's idea is implemented in our materials. See the next activity below.
OALG 12.2.2 Test multiple explanations
In the experiment in the video [https://mediaplayer.pearsoncmg.com/.../secs-egv2e-testing...], a partially inflated (and tied) balloon will be placed in the bell-jar and the air will be removed by the vacuum pump. Use each of the ideas you came up with in Activity 12.2.1 to make predictions about what the balloon will do when the air is pumped out of the bell-jar (state one prediction for each idea being tested). Write down your predicted outcome(s). Then watch the experiment. Which of your predictions was consistent with the experimental outcome? What is your judgment on each of the ideas you were testing?
If you read to the end, please do not forget to like the post to make it more visible.

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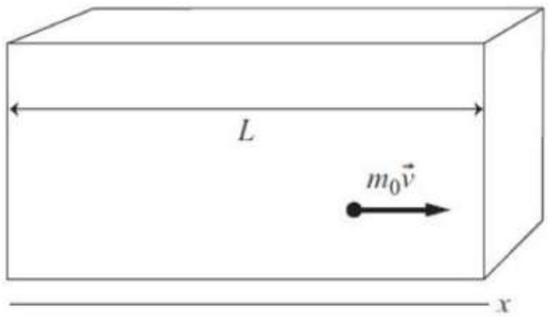
Eugenia Etkina
2. December 2021.

Hello everyone, I continue with gases today. My post is about how we do derivations in the ISLE approach. Many of my posts are about conceptual reasoning and experiments, they might cause you to wonder: what about deriving stuff? How do students do it? We have many different approaches engaging students in deriving mathematical relations. One of them is by giving them tables of data to find patterns (I showed those for Newton's second law) and have them in lots of chapters. But sometimes, we actually let students derive complicated mathematical relations. One of those relations is the dependence of the ideal gas pressure on the number of particles in unit volume, their mass and speed.
It is important to remember that this derivation simplifies even more the model of ideal gas - in the ideal gas particles are point-like objects that only interact with each other in direct collisions and obey Newton's laws. To derive the above relation, one also needs to assume that the particles to not collide with each other but only with the walls of the container and by default move with different velocities.
Here is how we guide the students through the derivation: We ask them a small question, tell them what they should have as an answer and let them figure out how to get to that answer. Then we ask the next question and again give them the answer and ask them to figure out how to get to it. Please take a look and see if your students would be able to follow.
Note, that we do not ask the students to read the book before they come to class, instead we ask them to struggle with the derivation and only AFTER that read the textbook. This approach is orthogonal to the flipped classroom approach that encourages the students to

read the textbook first and then engage in discussions in class. Our approach to derivations is based on the innovation-efficiency corridor introduced by Schwartz and Bransford. I can talk more about it if people are not familiar with it. Please, if you read to the end, do not forget to respond - like it, post comments, anything that will make the post more visible.

OALG 12.3.2 Derive

Imagine that the gas inside a container has such low density that its particles almost never collide with each other; they collide only with the walls of the container. Assume a model of the gas as tiny moving billiard balls obeying Newton's laws. We wish to derive an expression for the pressure that the gas exerts on the walls of the container.



a. Start with one of the "balls" of mass m_0 traveling at speed v parallel to the x-axis at speed v_x. The ball bounces back and forth between the two walls of the container that are separated by distance L and that are perpendicular to the x-axis. Use your knowledge of the impulse–momentum principle to show that the impulse of the ball, as a result of one collision against one wall, has magnitude $2m_0v_x$.

b. Show that the time interval between impacts for the one ball against that same wall is $2L/v_x$.

c. Use the results from parts **a.** and **b.** to show that the average force that these collisions exert on the wall over the time of several passages of the ball (F_{avg}) is $m_0v_x^2/L$ and that the average pressure that N balls, or particles, will exert on a wall is $P = N(m_0v_x^2)/L^3$.

d. The v_x^2 in the expression for average pressure in part **c.** should more properly be designated as the average of the square of the x-components of the velocities $\overline{v_x^2}$. The N particles inside the container move at different speeds and in different directions. How is $\overline{v_x^2}$ related to the average of the square of the speeds $\overline{v^2}$? *Hint:* Assume that one-third of the particles move in each of the three directions (x, y, z).

e. Now consider the pressure that these particles exert on the walls of the container. Show that the pressure that they exert is equal to $P = \frac{1}{3}\frac{N}{V}\left(m_0\overline{v^2}\right)$.

f. Read and interrogate Section 12.3 in the textbook and compare your derivation to the one in the book.

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Eugenia Etkina
4. December2021.

Hi all, please if you read this post, do not forget to like it or reply to it! My post today is a response to Bor Gregorčič who asked about Schwartz and Bransford's innovation-efficiency corridor. Here is a brief summary. S&B investigated whether students can learn better if they first struggle with the problem and then are told how to solve it or when they are lectured on the subject and then are given a problem to solve. Struggling with a problem is innovation and telling students how to do stuff correctly is efficiency (in simple words). It turns out that struggle first and learning the right approach later is much more productive for learning that the other way around. By for learning, I mean future learning - student ability to learn new stuff based on the stuff that they struggled with and then learned about. Efficiency first and innovation next is the traditional approach to teaching as well as the flipped classroom approach. Innovation first and efficiency second is the ISLE approach.
The corridor is the right balance of innovation and efficiency - if you let people unsuccessfully innovate for too long, they become frustrated novices, if they know all the rules but are never challenged to innovate, they become bored. So the balance of a little innovation and then little efficiency, and then again little innovation and little efficiency is the way to go. This is exactly how the OALG activities are structured - almost each activity starts with innovation and ends with efficiency when the students are asked to compare their findings with what is written in the book (or with the summary that the teacher does - we call is "time for telling" - also from B&S terminology.
B&S did not explain why the innovation first, efficiency next is better but we can speculate. When the information comes first, there is no need to know for the students, so they do not pay attention or they do not even know what to pay attention to. The students also have no image of what the lecture/text is about, so the brain does not engage properly. They do not have an opportunity to form their own hypotheses, so the brain cycle breaks (for all of the above see J. Zull, The Art of changing the Brain book).
There is also such thing as a concept of "productive failure" - researchers who work with this concept found that it is more useful for the students to try a problem (activity) and not be successful in it and later learn how to do it properly, than be told how to do it properly without trying and failing first. I think all the arguments in Zull's book (those who have not read it, need to get it!) explain all those findings. If you read to the end, please like this message or reply to it, thank you!

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Eugenia Etkina
5. December2021.

Hi all, thank you for your comments yesterday. I will post tomorrow the continuation of the conversation focusing on why it is important for students to struggle first but it is not any struggle that helps them grow. In fact, some struggles develop "learned helplessness" and

are bad! Hang in till tomorrow! Today I want to share a project that was initiated by Hrvoje Miloloža and on which we are working with him together now.
Hrvoje Miloloža suggested making a google folder where we would collect all the posts on the group page in different categories. It will take a long time to copy and paste years of posts there, but we are making progress. Please save the link to the folder that I am about to post here and start reading when you have time. And PLEASE like the post to make it more visible .(or comment on it).
Here is THE link:

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Eugenia Etkina
6. December2021.

Hi all, two days ago I posted about innovation-efficiency corridor and Warren Collier responded that some students do not want to struggle. Could these students be telling us something? Studying books about growth mindset and grit, I think I have an answer to this question, specifically, what kind of struggle is productive and why productive struggle is essential for our students.
Here is what I found. Overcoming adversity (meaning difficulties, failure) is crucial for the development of growth mindset, which in turn is the foundation of grit, which, means perseverance towards big goals in your life. This grit towards achieving big goals not grit towards little things is the quality that determines success in life.
Assuming that we all want our students to be successful in life we need to know (this is vitally important!) what kind of adversity leads to the development of growth mindset and what kind of adversity leads to the development of learned helplessness. Here is the research answer. Are you ready?
It turns out that when you feel that you have control over what is happening, adversity makes you stronger, it makes you want to overcome it, it makes you want to struggle. But when you do not feel that you have any control over the situation, adversity (difficulties, failure) make you want to quit, sends a message that you cannot do it and there is no point in trying (it develops learned helplessness). Therefore to help students learn to embrace adversity and develop growth mindset, we need to give them the feeling of control over their learning.
What??? Give them control?? This sounds ridiculous! I am the teacher, I should be in control, right? Turns out that it is WRONG! Our students need to feel that they have control over their learning. How can we give them this feeling of control while still guiding them through the learning process? I would say that the ISLE approach has the answers naturally embedded in it.
First, the students have conceptual control of their learning - they devise their own explanation for the observed phenomena and they learn how to test them. They design their own experiments and they make their own judgments about the results (of course we guide them through it by carefully choosing observational experiments and tools for reasoning but it is them who make final decisions).

MORE! The important part of the ISLE approach is giving the students an opportunity to improve their work on quizzes, lab reports, etc. It gives them control over how far they wish to go, how much they want to improve. Stopping at the first earned grade for the assignment leads to fixed mindset - I did not do well, or well, there is nothing to do about it.
MORE YET! Just creating the feeling of control is not enough. What else is needed? HIGH EXPECTATIONS! Not only do we need to expect a lot from our students, we need to explicitly tell them that we expect a lot because we believe that they are capable of achieving these high expectations. Just writing on a piece of student work after making comments: "See my comments. I know it is a lot to work on but I believe that you are capable of meeting my high expectations," makes a huge difference in what students do after receiving the comments.
Bottom line: let students struggle but when they struggle make them feel that they have control of their own learning and that you have high expectations of them. We can talk more during our meetings how to do it in detail. I have lots of examples of how to do both. If you read to the end, please do not forget to like the post of reply to it.

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Eugenia Etkina
7. December2021.

Hi people, Sundeep Portia and Hilary Smith asked a question about how to learn about the ISLE approach. I wrote a reply to Sundeep Portia but I think everyone will benefit from what wrote. If you wish to learn about ISLE (the original goal of this group was to support those who use the ISLE approach and our textbook but starting with the pandemic I opened it up to all physics teachers who are interested.) So, to learn more about the ISLE approach, visit islephysics.net (read about it and check out the papers), watch my talks about ISLE at https://www.youtube.com/watch?v=BKsAGu7RN9k or at https://www.youtube.com/watch?v=HjPgDbbvnE0 and watch my Millikan lecture about ISLE at https://drive.google.com/.../0B5AI1VazSD5ac0RQajR.../view... as well as join our meetings - the next one is coming up on Friday or the workshops when they are announced. so, this coming Friday at 6 pm EST we have a meeting about essential elements of the ISLE approach. If you are not familiar with ISLE and wish to attend the meeting, try to read the postings on the islephysics.net website and watch a few talks. This will get you started. If you read to the end, please like the post to make it more visible.

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Eugenia Etkina
7. December 2021.

Hi people! I wanted to continue our conversation about creating growth mindset and developing grit. Yesterday I wrote about the balance of high expectations and giving the students the feeling that they have a choice. As well as to allow them to fail, but to use failure as the reason to grow not despair.

As you probably know, I taught physics and astronomy as a high school teacher for a long time before getting my PhD and starting as an assistant professor at Rutgers, Graduate School of Education. Although it was very long time ago and the terms such as growth mindset, grit, formative assessment and so forth did not exist (or were unknown to me) I intuitively felt that development of all these qualities was necessary. So, this is what I did (and now many of my former students, now high school physics teachers, do it too). I also did it teaching physics at Rutgers and forever when I was in the GSE preparing high school physics teachers.

Every lesson in my classes started with a short quiz. 1-3 simple questions that allowed me to see where my students were. The questions were based on the previous lesson and homework. If you did the homework, you would finish the quiz in 5 minutes, if you did not do it - you would not finish. The time was strict. It would take me about 20 seconds to grade each quiz, I had 100 students every day, so it was 2000 seconds of grading for me every day, which is about 35 minutes. Honestly, it was around 40-50 minutes every day as some would take slightly longer. Every morning coming to class each student would receive yesterday's quiz and see what needed to be fixed. They could come to me after school once a week or every morning before school (I came 45 min before the first bell) and retake the quiz (a different problem) or talk to me to convince me that they learned. It was their choice to improve. I had a slogan "No grade is ever final". If they showed me that they learned, they would get a 100% no matter which attempt it was - first or 5th. The message that they got was that it was learning that mattered.

This system not only allowed students to learn continuously but it also made me see what common issues arose and what to do tomorrow to fix them. I always knew where my students were and I NEVER collected or graded their homeworks although I assigned them every day. All my students knew that if they did not do the homework, they would just fail the quiz and needed to come early to improve it.

The same rule of improvement applied to lab reports and even unit tests. But it is those daily quizzes that I want to emphasize.

This is just one example of how to help students deal with failure with the feeling of control. It was THEIR choice to improve and it was their choice HOW to improve. If you read to the end, please respond to the post in some way - like it or comment. Thank you!

And do not forget about our meeting on Friday!

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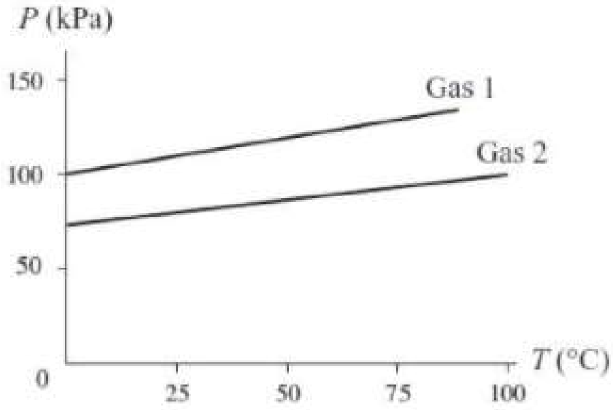
Eugenia Etkina
9. December2021.

Hi all, three things today: 1) a reminder that we will have a meeting tomorrow at 6 pm EST, about the essential elements of the ISLE approach; 2) when you read the post, make sure you respond to it in some way and 3) I am continuing with gases (Chapter 12). I know that some of you are not teaching gases, but those who teach at a college level do and those who do AP2 do, so I will just go through the book chapters and you can save the post for the future if you do not need it right this minute.
We have a unique way to help students first to find out the value of the absolute zero temperature and then to connect it to the average kinetic energy of particles of ideal gas. The students get both ideas from experimental data. I suggest that you do the activities yourself to see how the relationship emerges. I am pasting a screenshot of two activities, I had to shrink them to make them appear on the same page, but you can find them in the OALG (posted here). There is a typo in the file - it should be argon instead of nitrogen, I fixed it in the file in the screenshot but you will need to fix it in the downloaded OALG file. Slipped through the cracks...

OALG 12.4.1 Observe and explain

A sealed metal container with a low-density gas is successively placed in baths of water at different temperatures. Then, a different gas is placed in the container and the procedure is repeated. Data related to the pressure and the temperature of the gases inside the containers are shown in the graph below.

a. Find the lowest possible temperature that the two gases can have. What assumptions did you make?



b. Use the lowest temperature value you determined in part **a.** to make a new temperature scale with the same temperature interval as in the Celsius scale, but with the new zero point that you determined. This new scale is called the *absolute temperature scale*.

c. Use the expression in Activity 12.3.3, part **c.**, $P = \frac{1}{3}\frac{N}{V}\left(m_0 \overline{v^2}\right)$, to discuss how the temperature on the absolute scale is related to the average kinetic energy of gas particles.

OALG 12.4.4 Reason

The table below represents data collected when a constant-volume metal container with 1 mol of argon ($N = N_A = 6.02\times10^{23}$ molecules) is placed in baths of very different temperatures. If we assume that the ratio $\frac{PV}{N}$ is proportional to the absolute temperature of the gas (i.e., $\frac{PV}{N} = kT$), we can find the coefficient of proportionality, k. Solve for the proportionality constant k for the two sets of data.

Known physical quantities	$\frac{PV}{NT} = k$	Known physical quantities	$\frac{PV}{NT} = k$
$P = 1.01\times10^5\ \text{N/m}^2$	$k =$	$P = 1.38\times10^5\ \text{N/m}^2$	$k =$
$T = 273\ \text{K}$ (melting ice)		$T = 373\ \text{K}$ (boiling water)	
$V = 22.4\times10^{-3}\ \text{m}^3$		$V = 22.4\times10^{-3}\ \text{m}^3$	

a. Is the value of k independent of gas temperature? Explain.

b. Find a relationship between the absolute temperature of the gas and the average kinetic energy of its particles. *Hint:* Use the results of Activities 12.3.2 and 12.3.3 to help.

c. Find the total kinetic energy of all the particles of argon at the two different temperatures.

d. Does the absolute temperature of the nitrogen depend on the total number of particles in the container? Explain.

e. Does the total thermal energy due to the motion of argon particles depend on the number of particles in the container? Explain.

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Eugenia Etkina
11. December2021.

Hi all, I am very sorry but there is no recording of yesterday's meeting. At first I forgot to start it and then I think I accidentally paused it a few minutes later. I am very sorry. I am pasting the link to the slides. Those who will read the slides (all information is there actually) and have questions can post them here, and if there is enough people who could not attend yesterday, I am willing to run one more meeting for this topic, in January. Jut let me know, please. Here is the link to the slides. sorry again, I got too excited about the topic and we lost the recording.
The next meeting will be about resubmissions - what system do you use to help students improve their work and you not losing your life? As all other topics, this one came from the participants. We will have a meeting in January or February to share how different people do it. If you are doing resubmissions or any improvement of work, please sent me an email so that we can make a list of people to make teams during the meeting. It was Carolyn Sealfon's idea. sorry again.

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Eugenia Etkina
13. December 2021.

Hi everybody! Three things today: please vote for the date of the repeat meeting for the essential elements of the ISLE approach, I only see a few people who voted. This group was originally created for those who follow the approach and use our textbook. We opened it up for any interested physics teacher during the pandemic but still, I would day that the main goal of the group is to help people implement the approach. So, please vote!!! Second, I am going to present a problem that is very useful for students learning gas laws but very different from anything that you saw before (unless you learned physics in Russia). And third - please do not forget to reply to the post if you read it. OK, here is the problem (attached).
You read it and wonder: What is so special about it? I have seen graphs of cyclical processes before! The truth us that you probably did not (unless you have been using our textbook or learned physics in Russia where such problems were common). Traditionally in the US textbooks the cyclic processes are only used in thermodynamics and only is P(V) coordinates. What his problem offers is - all coordinate systems and true understanding of the iso processes. Note the positions of the graph axes for the other two sets of axes - why are they positioned in this way? Why are there short lines on the axes? What do missing graphs look like and what aspects of the new graphs are important? I will wait for your ideas and then share my answers. There is another problem like this in the OALG - 12.7.2. The same problems are in the ALG Chapter 12.

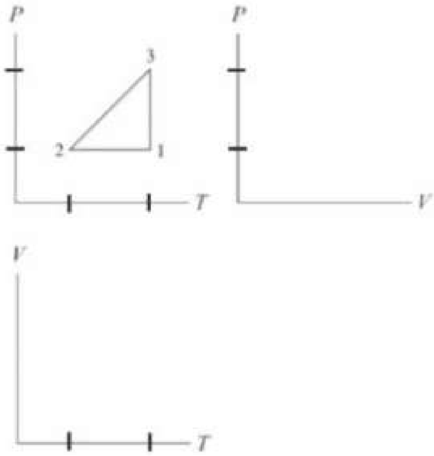
OALG 12.7.1 Represent and reason

The *P*-versus-*T* graph in part **b**. describes a cyclic process comprised of three hypothetical processes. The mass of the gas is constant.

a. Describe the processes represented on the *P*-versus-*T* graph in part **b**. by completing the table that follows.

Process	**Describe what happens to the pressure of the gas.**	**Describe what happens to the temperature of the gas.**	**Describe what happens to the volume of the gas.**
$1 \rightarrow 2$	Remains constant		
$2 \rightarrow 3$		Increases	Remains constant (the line passes through the origin)
$3 \rightarrow 1$			

b. Use the information in the table to represent the processes in *P*-versus-*V* and *V*-versus-*T* graphs. Notice that we placed the *P*-versus-*V* graph to the right of the *P*-versus-*T* graph to keep the same scale for pressure, and the *V*-versus-*T* graph under the *P*-versus-*T* graph to keep the same scale for temperature.



For help, use Table 12.6 in the textbook on page 370.

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Eugenia Etkina
14. December 2021.

Hi all, we have a few new members today, welcome!! We have posts here related to the chapters in the textbook College physics: Explore and Apply , comments about the

implementation of the ISLE approach (the foundation of the textbook and all our supporting materials) and teaching of physics in general and discussions generated by the members. The old posts are being compiled in a google folder with the address below. In the FILES section here (see the top of the home page) you will find free curriculum materials for teaching on-line and papers describing what the ISLE (Investigative Science Learning Environment) approach is. We also have monthly meetings dedicated to the questions of the members. The next meeting is coming soon - probably January 8th, I am still waiting for the responses to the poll, feel free to fill the poll out too (it is a few posts below). Here is the link to the google folder: https://drive.google.com/.../10qn...
Please like the post to make it more visible! And welcome again, it is great to see how our group is growing!

https://www.facebook.com/groups/320431092109343/posts/1073870193432092/?__cft__[0]=AZUJq0S1FAx-hov8yaLPxg_clQsJtwS02cW_NZNaDl31pHxNRf1LSAHmRxY3ajjtTtS8VJCLbtZzofMySN37Tz0v-2bbT3dWeWNWX3g7Ke55iEc-8hpKvtrF_y-iQBHfDmyR0VVndGyJK4l3R_AN7jf-&__tn__=%2CO%2CP-R

Eugenia Etkina
15. December 2021.

Hi all, I am not seeing any answers for my post from December 13th. Oh, well... maybe later? Today I am starting Chapter 13 - fluids at rest. There are two major ideas that students construct in this chapter - the idea that pressure depends on the height and density (not the mass or weight) of a fluid above the level at which we are measuring and that a fluid exerts an upward net force on an object on Earth (the object cannot be in free fall). We have excellent ISLE progressions for both ideas, I will not repeat them today. But I wanted to share with you an activity to do with the students after they have constructed P=Patm+ro g h. I pasted it below, you can do it at home now and see how great it works! The idea belongs to Gorazd Planinsic.

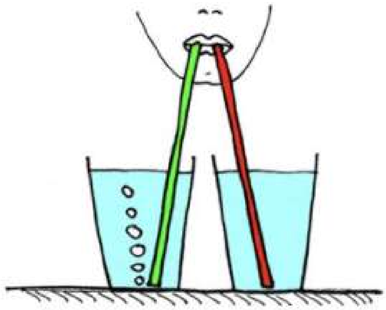
OALG 13.3.5 Observe and explain

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
24. December 2021.

Hi all, we have several new members who joined in the last couple of days. Welcome all! The instructions how to use this group is in the announcement on the top of the page and in the few previous posts. This group is focused on the approach to learning physics described at islephysics.net. Check it out! For everyone - Happy Holidays! Whatever you celebrate! I am going to take a break from posting for a few days - I want to let you enjoy the break that everyone has now. I will be back on January 2nd and we will continue with Fluids in motion and Thermodynamics. However, if anyone has a question - please post! I am reminding you about our repeat meeting on January 8th. Please sign up!

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