Learn Physics by Practicing Science: Introduction to ISLE

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Summer 2022

Workshop timeline

Day 1(EDT time zone)

The wet glass: 12:00-12:35 pm

Reflection on the reasoning process: 12:35-12:45 pm

Introductions: 12:45-12:55 pm

Break: 12:55 to 1:00 pm

Example of the ISLE process when no prereq knowledge is needed: 1:00-2:00 pm

Break: 2:00-2:05 pm

Intro. to the ISLE approach: 2:05-2:15 pm

When do students read the textbook?: 2:15-2:45 pm

ISLE approach to circular motion: 2:45-4 pm

Day 2 (EDT time zone)

Video of ISLE in action: 12:00-12:10 pm

First day of class: 12:10-1:10 pm

Break: 1:10-1:15 pm

Expertise Activity: 1:15-1:45 pm

Backwards design: 1:45-2:05 pm

Break: 2:05-2:10 pm

Hints for group success: 2:10-2:20 pm

What do students say?: 2:20-2:27 pm

What do teachers say?: 2:30-3:20 pm

Resources to implement the ISLE approach: 3:20-3:30 pm

What did you learn in this workshop?: 3:30-4:00 pm

Q&A: post time limit

Day 1

https://drive.google.com/drive/folders/1npi7He8rwz5gNwPl-xBdidP4oELHGuPr

New section

OALG 1.1.2

Take a glass (or a transparent plastic cup) and pour ice cold water into it.

a. Carefully observe the glass for a few minutes. Describe what you observe in simple words. Take a photo of the glass to share with the class. If you do not have access to the materials, use the link https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-1-1-2a.

b. Think of different explanations (wild ideas) for the observed patterns. Try to devise as many explanations as possible.

Possible explanations

Through the glass

The glass must be porous (semipermeable) and water is seeping through the glass.

From the air

Water moves over the top of the glass and makes it way to the outer side

This water is exist in the atmosphere and it cool down by ise-water

Some of the water came through the glass to the outside

Water is leaping out of the glass and falling down the outside

Water passed through the glass
The cup collected water

like a magnet collects nails. The water maybe came from the Air air

Students' proposed explanations

1. Water goes out from the surface and settles outside the glass.
2. Water seeps through the glass material.
3. There is water in the material of the glass and the glass material "sweats" and the water comes out.
4. Water comes from outside air.

What do we do with all those explanations?

What do we do with all those explanations?

c. How can you find out which explanation is correct? In science we conduct testing experiments. A testing experiment is an experiment whose outcome you predict before conducting it using the explanation under test. You do not need to agree with the explanation, but the prediction of the outcome must be based on it. After you design the experiment and make predictions based on all explanations that you devised, you conduct the experiment and compare the outcome to the prediction. Think about what testing experiments you can run to test the proposed explanations. Try to propose as many as you can by writing each one with a brief description.

d. For *each* testing experiment, make a prediction for its outcome based on *each* explanation that you proposed in b. Indicate any of your additional assumptions when making the predictions. (Note: The best testing experiments are those that give different predictions for different explanations).

Team 1 Testing experiments and predictions based on each explanation

Experiment:	Prediction based on Explanation 1	Prediction based on Explanation 2	Prediction based on Explanation 3	Prediction based on Explanation 4
Put ice water in the class and cover the top				We would feel the outside wet.
Put the glass filled with cold water on the scale	Scale reading stays same	Scale reading stays same	Scale reading stays same	Scale reading should increase

Team 2 Testing experiments and predictions based on each explanation

Experiment:	Prediction based on Explanation 1	Prediction based on Explanation 2	Prediction based on Explanation 3	Prediction based on Explanation 4
Measure mass before and after the glass gets wet	Mass is equal	Mass is equal	Mass is equal	Mass gets larger
Block the top of the glass	No sweating	Sweating	Sweating	Sweating
New material for cup			No sweating	

Team 3 Testing experiments and predictions based on each explanation

Experiment:	Prediction based on Explanation 1	Prediction based on Explanation 2	Prediction based on Explanation 3	Prediction based on Explanation 4
* Pour water into a glass. Mass the water and glass together. * After water has collected on the outside of the glass, wipe the water off and remass the glass.				
The top of the glass is covered to prevent water from	Mass of glasss stays the same			

Team 4 Testing experiments and predictions based on each explanation

Experiment:	Prediction based on Explanation 1	Prediction based on Explanation 2	Prediction based on Explanation 3	Prediction based on Explanation 4
Scale exp.	Not changing, if not wiping	Not changing	Scale reading not changing	Scale reading increase
Covering the top				

Team 5 Testing experiments and predictions based on each explanation

Experiment:	Prediction based on Explanation 1	Prediction based on Explanation 2	Prediction based on Explanation 3	Prediction based on Explanation 4


Organic
KIRKLAND
Signature
ORGANIC
STRAWBERRY SPREAD
Whole Milk
KIRKLAND
Signature
Trader Joe's Organic Preserves are

One last final experiment

One of the testing experiments suggested by other students is as follows: you take a glass, put it on a scale, pour ice cold water into it and record the mass. What do the remaining explanations predict what will happen to the mass as the glass sits on the scale?

Now, watch the experiment and compare the predictions to the outcome:

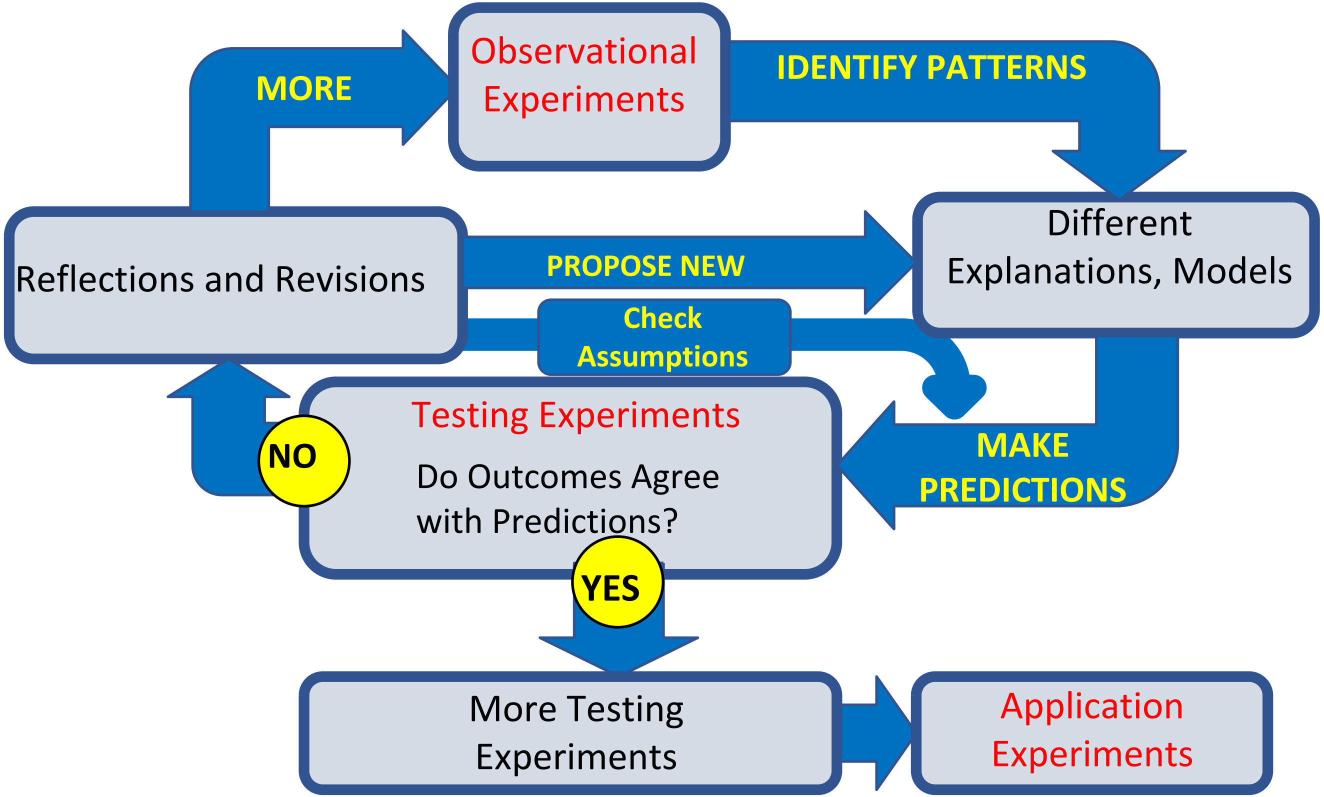
https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-1-1-2b

WatAir Dew Harvesting
System Provides Safe
Drinking Water

New section

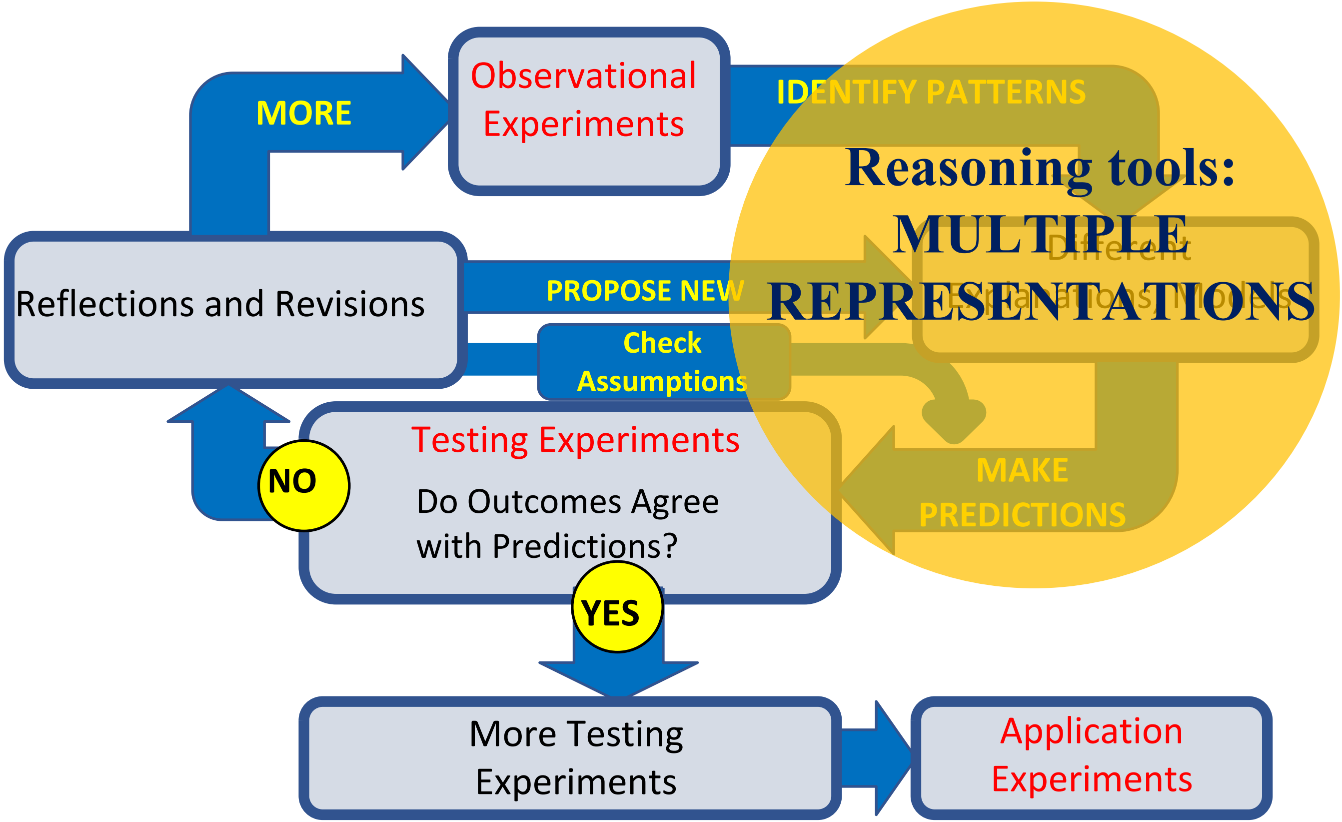
Let’s reflect on the steps we took to figure it all out.

The Investigative Science Learning Environment (ISLE) approach



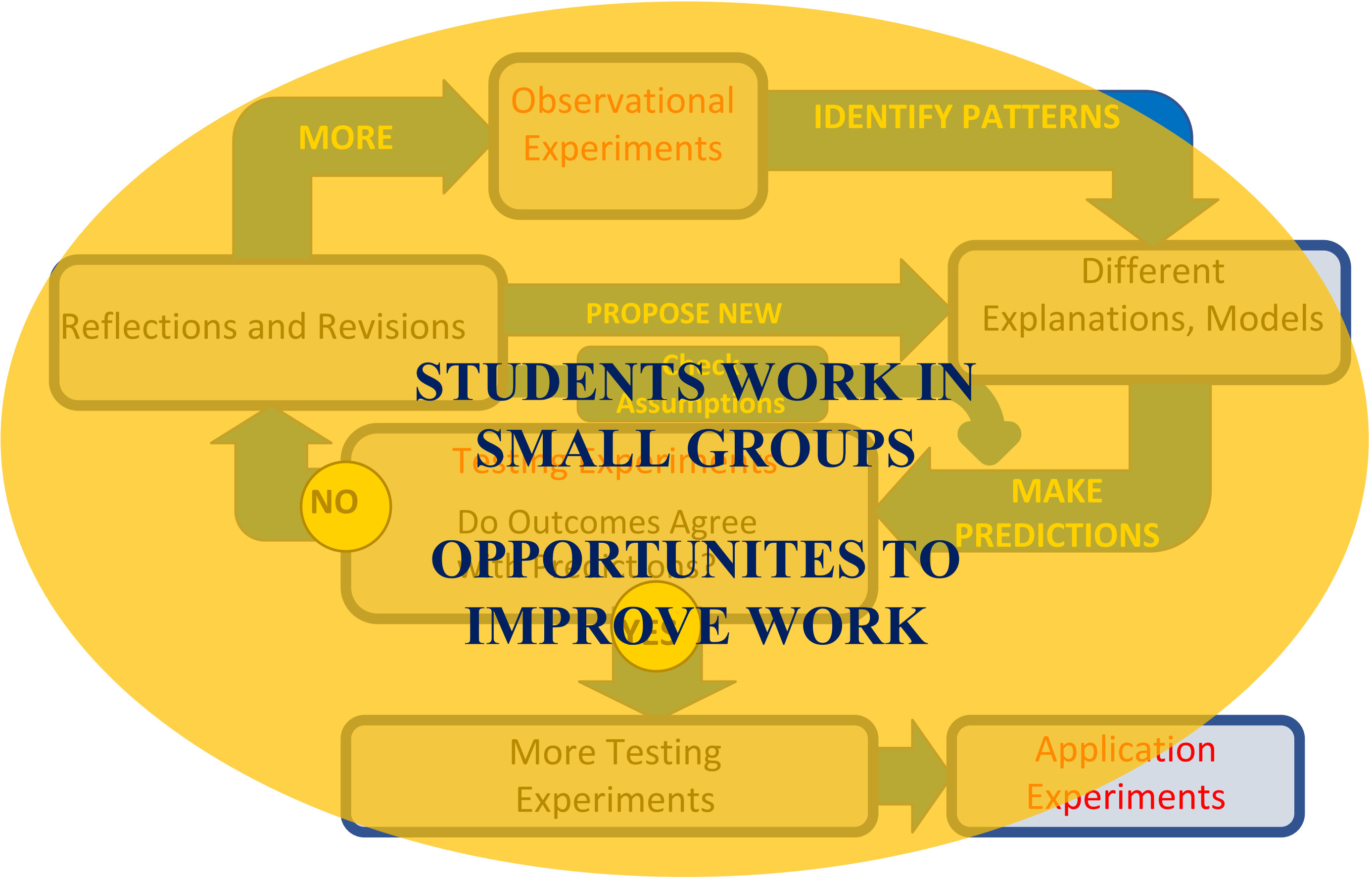
Etkina and Van Heuvelen, 2001, 2007; Etkina, 2015

The Investigative Science Learning Environment (ISLE) approach



Etkina and Van Heuvelen, 2001, 2007; Etkina, 2015

The Investigative Science Learning Environment (ISLE) approach



Etkina and Van Heuvelen, 2001, 2007; Etkina, 2015;
https://docs.google.com/document/d/1EGJAPCHBIJGLLt7NS0B0WkimPbbFyf5225vFss1567s/edit?usp=sharing

New section

Introductions

Break!

New section

Example of the ISLE process when no prereq knowledge is needed

Need to know

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-22-1-6

OALG 22.1.1 (homework)

OALG 22.1.1 Observe and explain

Go into a room that is completely isolated from all external light sources—natural and artificial. Turn off the internal lights and wait in the dark room for several minutes. Record your observations and propose an explanation.

OALG 22.1.2

OALG 22.1.2 Observe and explain

Equipment: laser pointer and a spray bottle or chalk dust.

Take a laser pointer and point it at a wall. Can you see the beam of light it sends or only the shiny spot on the wall?

a. What path did the light follow to reach the wall? You can find it by trial and error - by trying to block the light with a small piece of paper at several locations along its path to the wall, or by using the water spray bottle.

b. What can you say about the path of the light from the laser to the wall? Represent that light path by a long line with an arrow, called a ray. A ray is not real; it is just a way to show the direction that light is traveling.

c. Explain why the water droplets (or chalk dust) makes it possible to see the light beam that was previously not visible.

d. Discuss the conditions needed for us to see something.

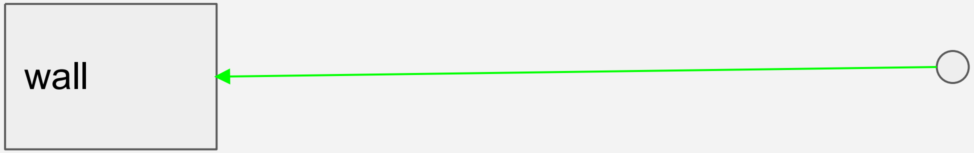
Video alternate if you can’t find the equipment:
https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-51

Team 1 OALG 22.1.2

a. What path did the light follow to reach the wall?

We see the light in a straight line

b. What can you say about the path of the light from the laser to the wall?



Team 2 OALG 22.1.2

Take a laser pointer and point it at a wall. Can you see the beam of light it sends or only the shiny spot on the wall?

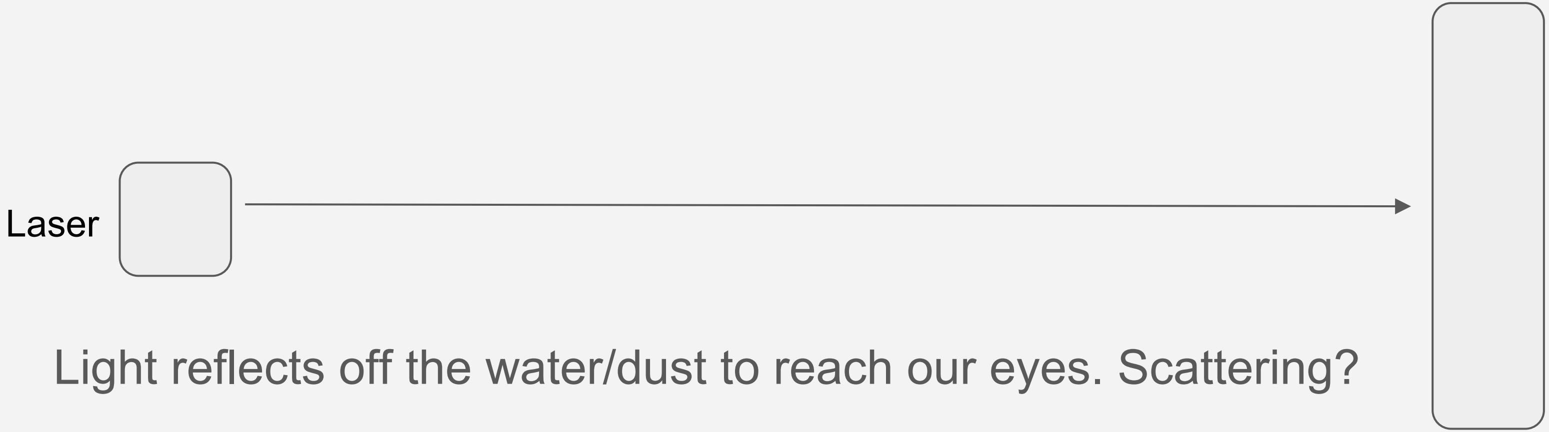
a. What path did the light follow to reach the wall? You can find it by trial and error - by trying to block the light with a small piece of paper at several locations along its path to the wall, or by using the water spray bottle. - dotted broken straight line across room

b. What can you say about the path of the light from the laser to the wall? Represent that light path by a long line with an arrow, called a ray. A ray is not real; it is just a way to show the direction that light is traveling.

c. Explain why the water droplets (or chalk dust) makes it possible to see the light beam that was previously not visible.

Team 3 OALG 22.1.2

Team 4 OALG 22.1.2

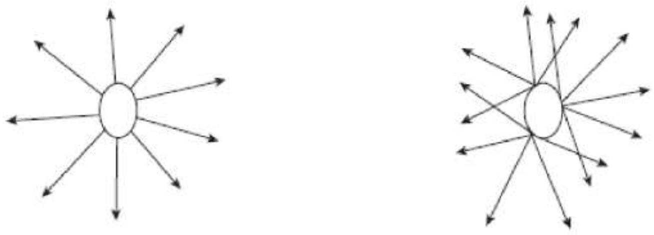


Light reflects off the water/dust to reach our eyes. Scattering?

Team 5 OALG 22.1.2

OALG 22.1.3 CREATE new where they come up with models

Tovi (a.) and Jaeline (b.) draw two ray diagrams to try to model how a light bulb's light can reach the walls and the ceiling in the room.



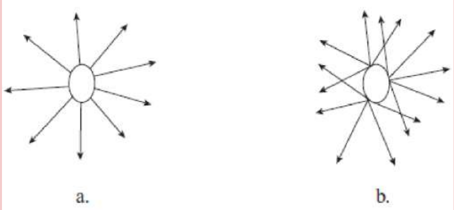
a. b.

a. Compare and contrast the two diagrams. Consider how each point of the bulb emits light according to each diagram.

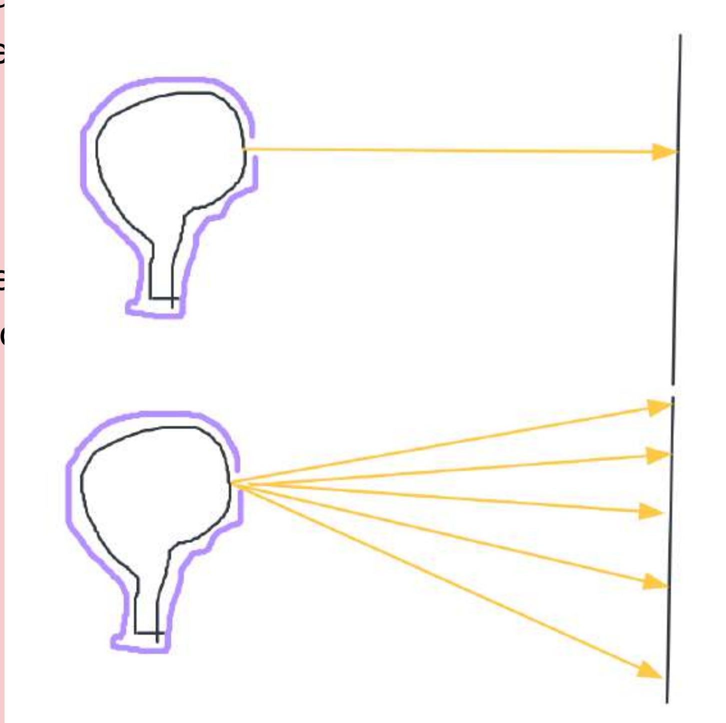
b. Design an experiment to test which of the diagrams represents the way a light bulb emits light—does each point emit one ray, or does each point emit rays in all directions? Describe the experiment with a picture and write a prediction of the outcome of the experiment based on each diagram.

c. Perform the experiment and decide which diagram led to the prediction that did not match the outcome. Which diagram will you use to represent how each point of the bulb emits light?

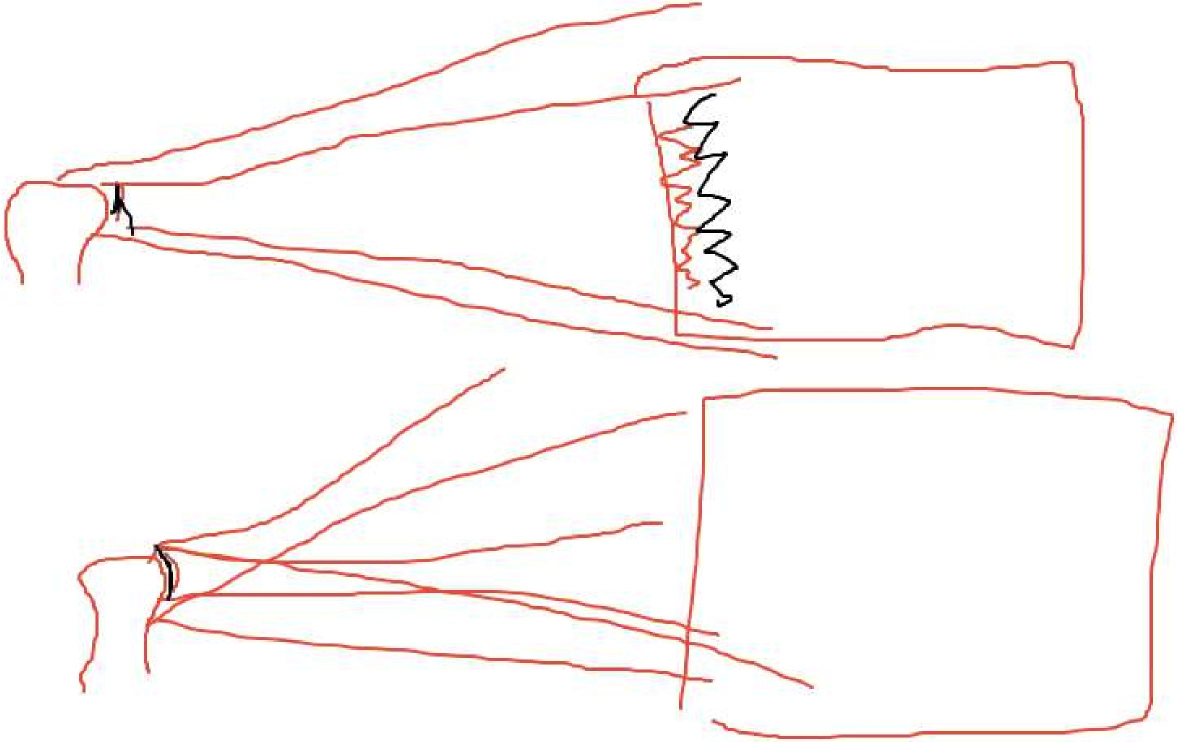
Team 1 OALG 22.1.3 parts a-c



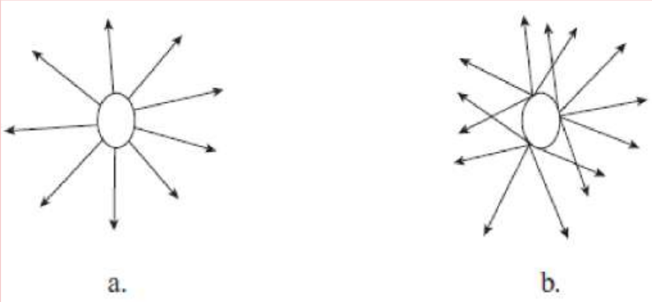
b. Design an experiment to test which of the diagrams represents the way a light bulb emits light—does each point emit one ray, or does each point emit rays in all directions? Describe the experiment with a picture and write a prediction of the outcome diagram.



c. Perform the experiment and decide which diagram led to the outcome. Which diagram will you use to represent how each



Team 3 OALG 22.1.3 parts a-c



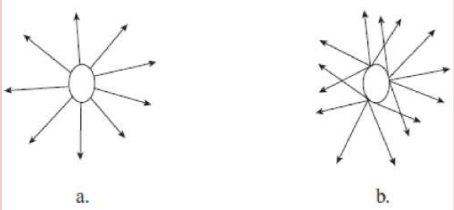
Exp-1 Cover up different parts of the bulb

EE: What are your predictions based on two models?

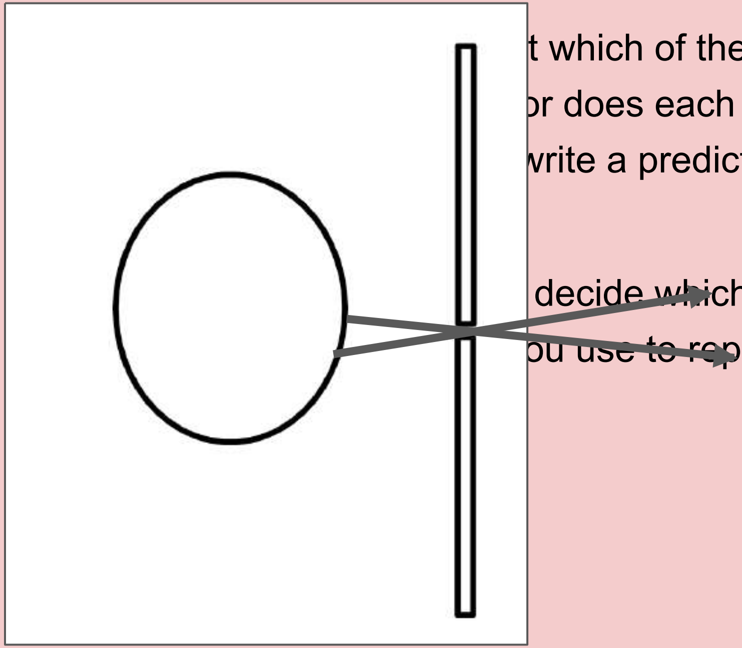
If a) is true: We will see shadow in the shape of the cover, if b) then there shouldn’t be a shadow. (perhaps depends on how large the cover is or what shape it makes on the wall?)

Or If b) is true, then the intensity should differ at different points on the wall

Team 4 OALG 22.1.3 parts a-c



Compare and contrast the two diagrams. Consider how each point of the bulb emits light according to each diagram.



t which of the diagrams represents the way a light bulb emits light—
or does each point emit rays in all directions? Describe the
write a prediction of the outcome of the experiment based on each

decide which diagram led to the prediction that did not match the
ou use to represent how each point of the bulb emits light?

OALG 22.1.3 part d

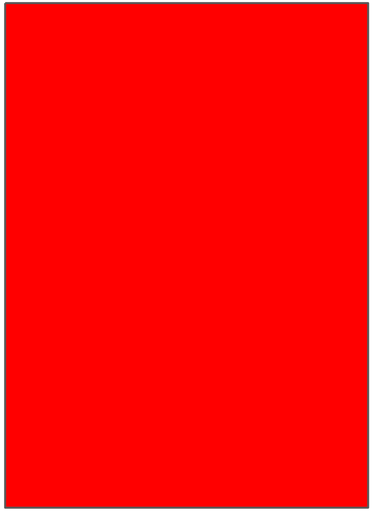
d. Watch two experiments at https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-52. Which model predicts their outcomes? Draw ray diagrams to support your answer.

OALG 22.1.4 (All together)

Imagine that you put a candle (or bulb) on a table and place a piece of thin cardboard between the candle and a nearby wall. Use the figure to draw a ray diagram to predict what you will see on the wall if you make a tiny hole in the cardboard. Then predict what you will see if you poke two holes.

Then light the candle (or turn on the bulb) and turn off the room lights to observe the outcome of the experiment(s). If you do not have the equipment, use the video at https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-22-1-6. Make sure that you examine the image on the screen carefully. The candle flame is narrow on top and wide at the bottom. What do you see on the screen?
Then revise your diagram if necessary.

Crank up your screen brightness to full, turn out the lights in your room and close the blinds if you can. (This is not essential, but a darkened room does help.) Step a bit away (1-2 meters) from your computer screen for best viewing.



Break!

New section

The ISLE approach– an intentional approach to curriculum design and learning

Based on: “the medium is the message” - If we want students to learn the process of physics they have to be engaged in that process.

Based on: Theories of human motivation: People will only learn if they enjoy it (c.f. Flow), see the value in their personal lives, experience learning as an opportunity for mental and spiritual growth.

Intentionalities* of ISLE

Students learn physics by practicing it

Students’ well-being is enhanced.

*Intentionality = a purposeful mental state that guides all of our decisions about assessment, activity design, course goals, classroom set-up and even how we interact with students in the classroom on a minute-by-minute basis.

Brookes, D. T., Etkina, E., & Planinsic, G. (2020). Implementing an epistemologically authentic approach to student-centered inquiry learning. Physical Review Physics Education Research, 16(2), 020148.
https://doi.org/10.1103/PhysRevPhysEducRes.16.020148

Reflection: How did we use intentionalities of the ISLE approach here?

Process of knowledge construction?

Students' well being?

New section

When do students read the textbook?

Go to page 686 in the textbook (section 22.1) and spend 15 minutes reading it. Make sure that you watch all the videos and answer Review Question 22.1.
https://drive.google.com/file/d/1bTJqJB38802ulsrBEk6xKiYn7QGbZTYe/view?usp=sharing

Videos for the textbook and ALG are at:

https://media.pearsoncmg.com/aw/aw_etkina_cp_2/videos/

If you have a hard copy of the book, the link to all textbook videos is on page 10 (see Observational experiment tables).

Questions to ponder:

1. What non-traditional STRUCTURAL elements in the text did you find?
2. Why did we ask you to read the book AFTER we did all the activities, not before?

New section

Example of a sequence for another concept

Imagine that your students studied kinematics and dynamics of linear motion (three Newton's laws and their applications).

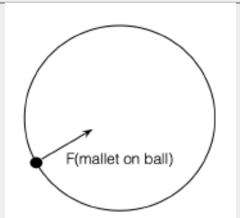
Need to know

OALG 5.1.1 Observe and find a pattern

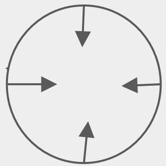
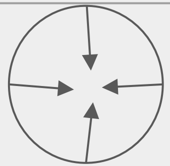
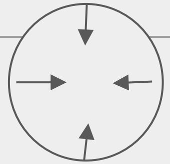
Watch the videos of the following three experiments: https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-5-1-1. For each experiment, fill in the blanks in the table that follows. Assume that the frictional forces exerted on all three objects are negligible and that the objects move at constant speed.

Do not forget double subscript notation that you learned as homework!

Team 1

Experiment; the circling object is in bold.	**List objects that interact with the circling object.**	**Draw a side view force diagram for the circling object.**	**List forces or force components that add to zero.**	**Indicate the direction of the sum of the forces exerted on the object.**
a. Tapping a **bowling ball.** So it moves in a circle on the floor.	Mallet Floor Earth		F(floor on ball) and F(Earth on ball)	Towards center (same dir. As F(mallet on ball)
b. Swinging a **bucket** in a horizontal circle.				
c. Pulling a rope attached to a moving **rollerblader** so she moves in a circle.				

Team 2

Experiment; the circling object is in bold.	**List objects that interact with the circling object.**	**Draw a top view force diagram for the circling object.**	**List forces or force components that add to zero.**	**Indicate the direction of the sum of the forces exerted on the object.**
a. Tapping a **bowling ball.** So it moves in a circle on the floor.	Mallet Floor Earth		$F_{E\ on\ B}$, $F_{F\ on\ B}$	Towards the center of the circle
b. Swinging a **backpack** in a horizontal circle.	Arms - vertical and horizontal, Earth		$F_{Earth\ on\ B}$, $F_{Arms\ (vertical)\ on\ B}$	Toward the center
c. Pulling a rope attached to a moving **rollerblader** so she moves in a circle.	Rope Floor Earth		$F_{E\ on\ R}$, $F_{F\ on\ R}$	Towards the center of the circle

Team 3

Experiment; the circling object is in bold.	**List objects that interact with the circling object.**	**Draw a side view force diagram for the circling object.**	**List forces or force components that add to zero.**	**Indicate the direction of the sum of the forces exerted on the object.**
a. Tapping a **bowling ball.** So it moves in a circle on the floor.	Floor Hammer Earth		Floor on the ball and Earth on the ball 	Sum of forces results in the circular path of the object
b. Swinging a **bucket** in a horizontal circle.	Hands Earth Backpack		Component of hand on the backpack and Earth on the backpack	Toward the center of the circular path

Team 4

Experiment; the circling object is in bold.	**List objects that interact with the circling object.**	**Draw a top view force diagram for the circling object.**	**List forces or force components that add to zero.**	**Indicate the direction of the sum of the forces exerted on the object.**
a. Tapping a **bowling ball.** So it moves in a circle on the floor.	Mallet Earth Floor	Force pointing to the center	F Earth on Ball = F floor up on the ball	Pointing toward the center (from the mallet)
b. Swinging a **bucket** in a horizontal circle.	Person's hands Earth	Force pointing to the center AND upward	F Earth on Bucket = F floor on Bucket	Pointing toward the center
c. Pulling a rope attached to a moving **rollerblader** so she				

OALG 5.1.2 Find a pattern

Review your analysis recorded in the table for Activity 5.1.1. Based on your observations and on the analysis, find a pattern for the direction of the sum of the forces exerted on the objects moving at constant speed in a circle in all three experiments. Summarize your pattern in words and compare to the pattern identified in Observational Experiment Table 5.1 on page 119 in the textbook.

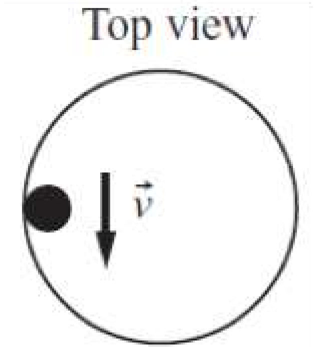
OALG 5.1.3 Test your explanation (ALG 5.1.4)

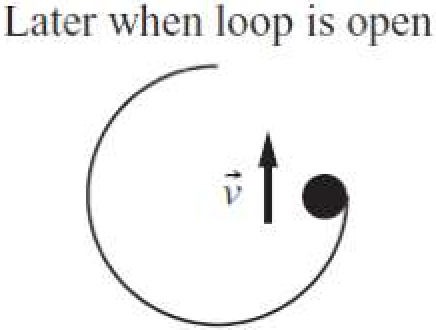
For the following testing experiment, use the pattern that you formulated in Activity 5.1.2 and Newton's laws to predict the outcome of the experiment. Do not watch the video until you finish part **b** of this activity.

a. Inside a metal ring, a person rolls a small ball or a marble on a smooth horizontal surface. The marble rolls along the ring. Is the motion of the ball consistent with the pattern formulated in Activity 5.1.2? Explain.

b. Use the pattern you found in Activity 5.1.2 (not your intuition) to predict what will happen to the ball if, after the ball rolls for a couple of turns, the person removes a quarter of the ring as shown in the figure. Justify your prediction in words and with a force diagram before you watch the video of the experiment.

c. After you make your prediction, watch the video, and compare the outcome to your prediction. What judgment can you make about the idea that you're testing? Does the outcome support, prove, or disprove the idea you're testing?





Testing experiment outcome

Note: Do not watch the video until you have worked with your group and have a clear prediction with justification based on the hypothesis you’re testing and any additional assumptions you need to make.

https://youtu.be/BOkX_BnNKzU

OALG 5.2.1 Represent and reason

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

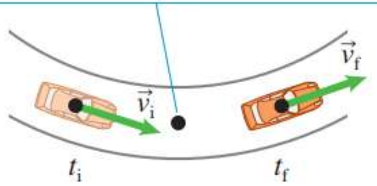
a. Draw the velocity vectors for such an object at four different points on the circle. What is the direction of the velocity vector? What is its magnitude?

b. What can you say about the motion of the object? Is it motion with constant velocity? If not, how can you determine the acceleration at each point during the motion? Think of the definition of acceleration ( ) and how you determined the direction of the acceleration in Chapter 2 for objects moving in a straight line.

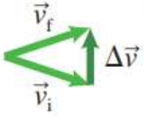
c. Read and interrogate Section 5.2, especially Physics Toolbox 5.1 in the textbook (page 121) to learn the technique for determining the direction of acceleration of an object that is not moving along a straight line.

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 $\vec{v}_f$.



$$\vec{v}_i + \Delta\vec{v} = \vec{v}_f$$

or

$$\Delta\vec{v} = \vec{v}_f - \vec{v}_i$$

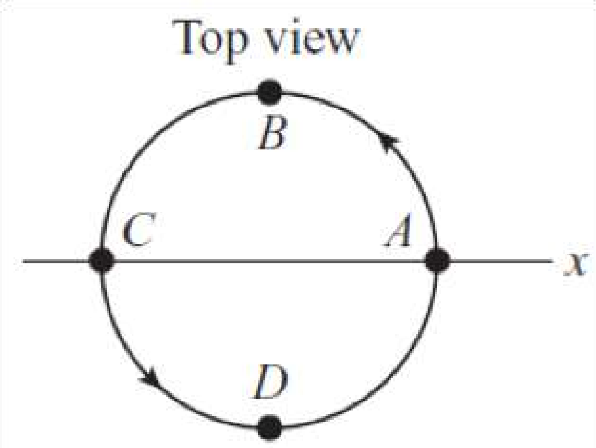
3. The acceleration arrow $\vec{a}$ is in the direction of $\Delta\vec{v}$.

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i}$$

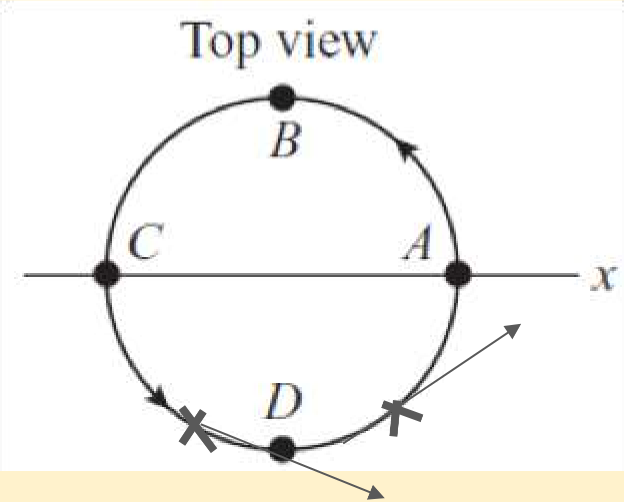
OALG 5.2.2 Represent and reason

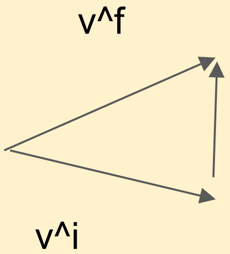
An object moves at constant speed in a circle.

a. Determine the direction of its acceleration at a designated for your team position shown in the illustration. Use what you learned in Physics Toolbox 5.1. *Make sure you take a point right before the point of interest and right after, and use a ruler to make sure the lengths of the velocity vectors remain the same and their directions are tangent to the circle.*



Example Team 1 Point D





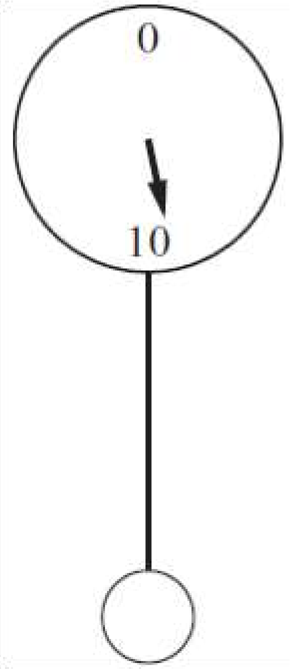
b. Do you see a pattern in the directions of the acceleration vectors? If so, what is it? Summarize your pattern and compare it with the pattern in Conceptual Exercise 5.1 on page 122 in the textbook.

OALG 5.2.3 Explain

Explain how the pattern you found in Activity 5.2.2 is connected with the pattern you found in Activity 5.1.2. Does the relationship between these two patterns make sense?

OALG 5.2.6 Test your ideas

Now that you have figured out how to determine the direction of the acceleration of the pendulum bob at the bottom of its swing, use everything you have learned about circular motion so far to make a prediction of the outcome of the following experiment:



a. A 0.1-kg ball hangs from a 1.0-m long string. The other end of the string is attached to a Newton force measuring scale. The string pulls up on the ball, exerting about a 1.0-N force. The string and ball, in turn, pull down on the scale, exerting a 1.0-N force—the scale reads about 1.0 N. Imagine that you pull the ball to the side and release it so that the ball swings like a pendulum at the end of the string. Predict the scale reading as the ball passes directly under the scale (i.e., is it more than, less than, or equal to 1.0 N?).

Summary of whiteboard discussion

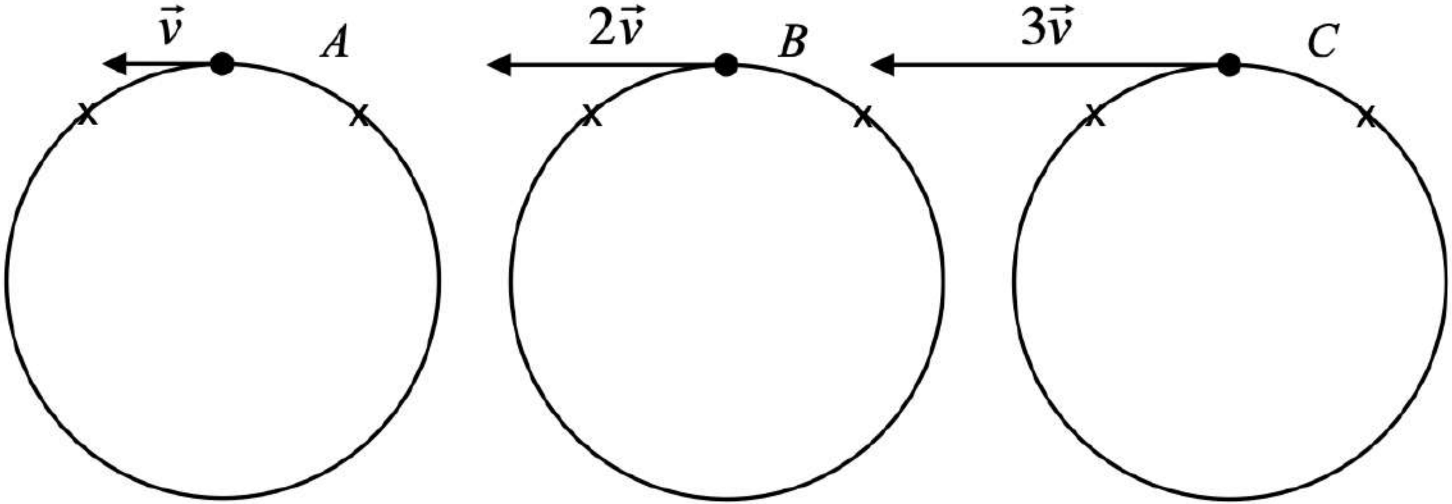
IT should read more

b. Watch the video of the experiment [http://islephysics.net/pt3/experiment.php?topicid=5&exptid=59]; record the outcome, and compare it to your prediction. Did the outcome support the pattern?

Please do the next two activities together and then report to the group

OALG 5.3.1

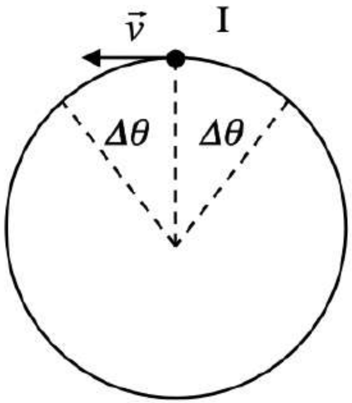
Imagine three small toy cars travel at constant speed in identical-radii horizontal circular paths (a top view is shown below). Car *A* moves at speed v, car *B* at speed $2v$, and car *C* at speed $3v$. Use the velocity technique (Physics Toolbox 5.1 in the textbook) to determine how the magnitude of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

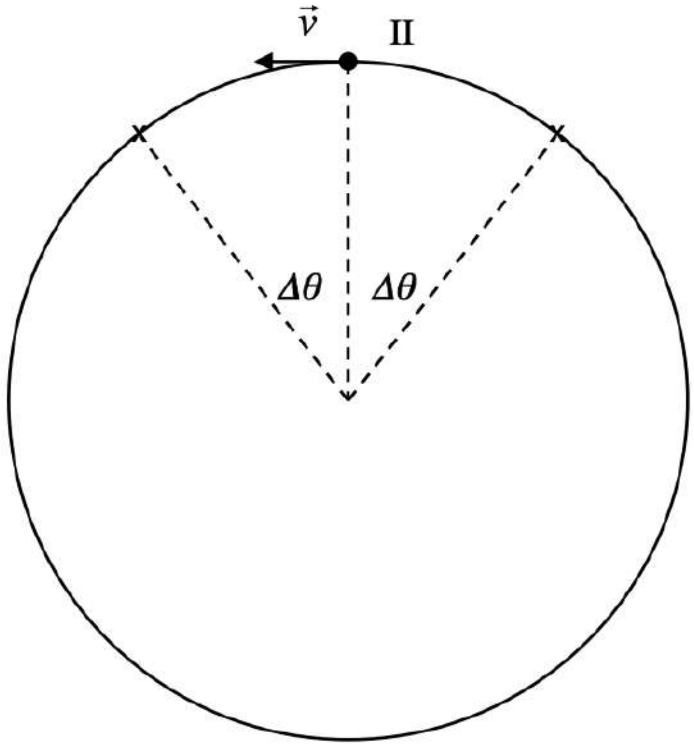


OALG 5.3.2

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

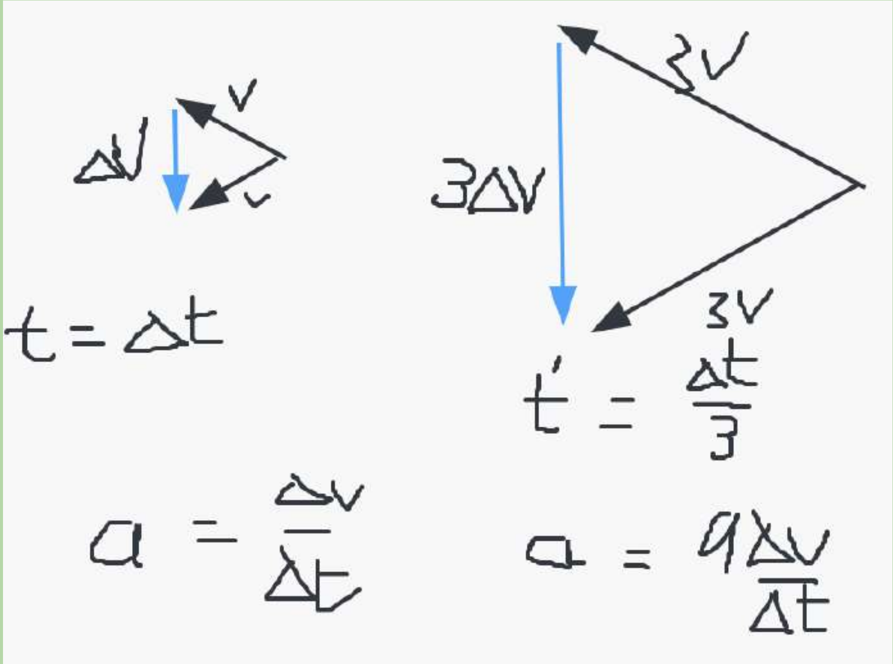
a. Use the velocity technique (Physics Toolbox 5.1 in the textbook) to determine how the magnitudes of the accelerations of the cars depend on the radii of the circles. Do not forget to consider the time intervals needed for the velocity changes.

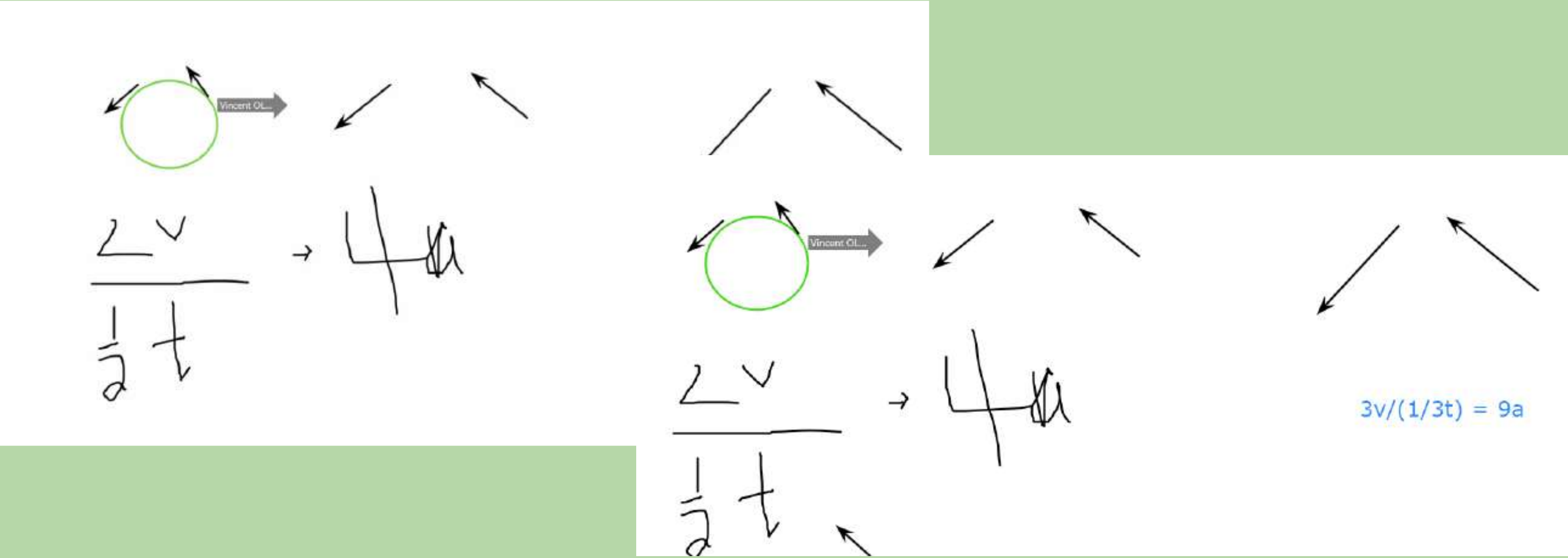


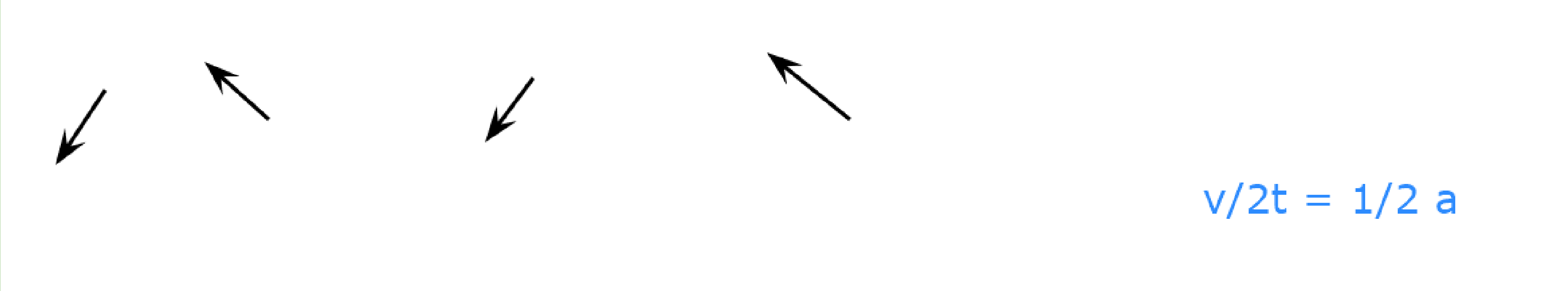


b. Combine the results from Activities 5.3.1 and 5.3.2a to write a general expression for the magnitude of the acceleration during constant-speed circular motion.

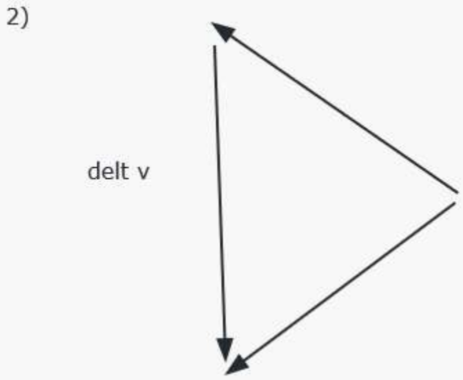
Team 1

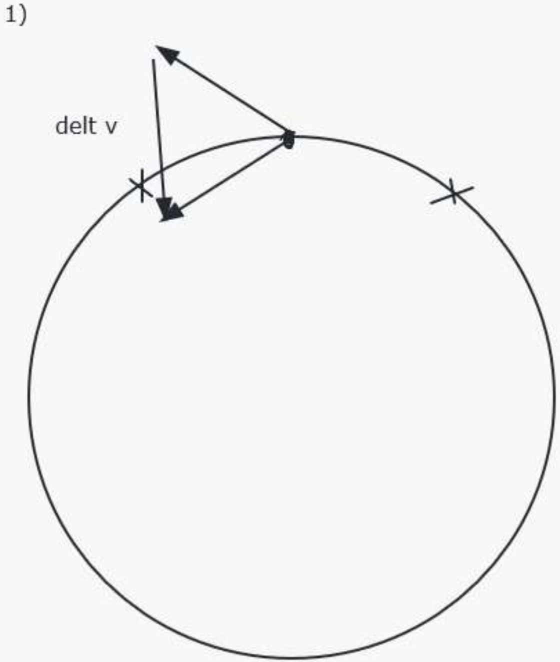



Vincent OL...
Vincent OL...
3v/(1/3t) = 9a

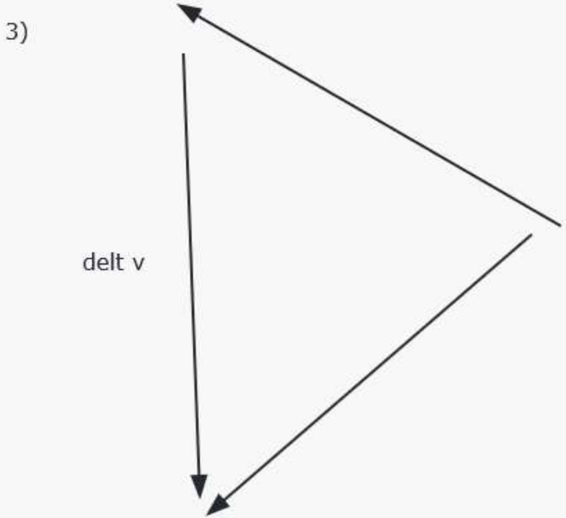

v/2t = 1/2 a

Te

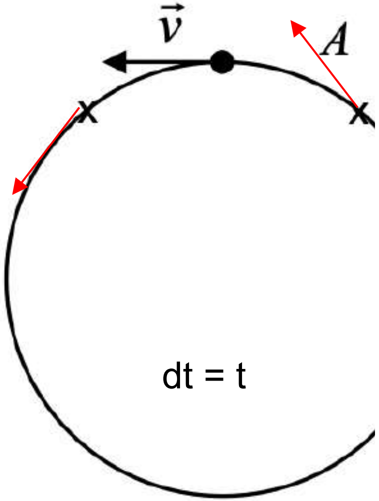




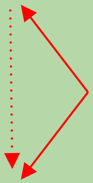
Delta T will be 1/2, and 1/3 for second and third scenario.

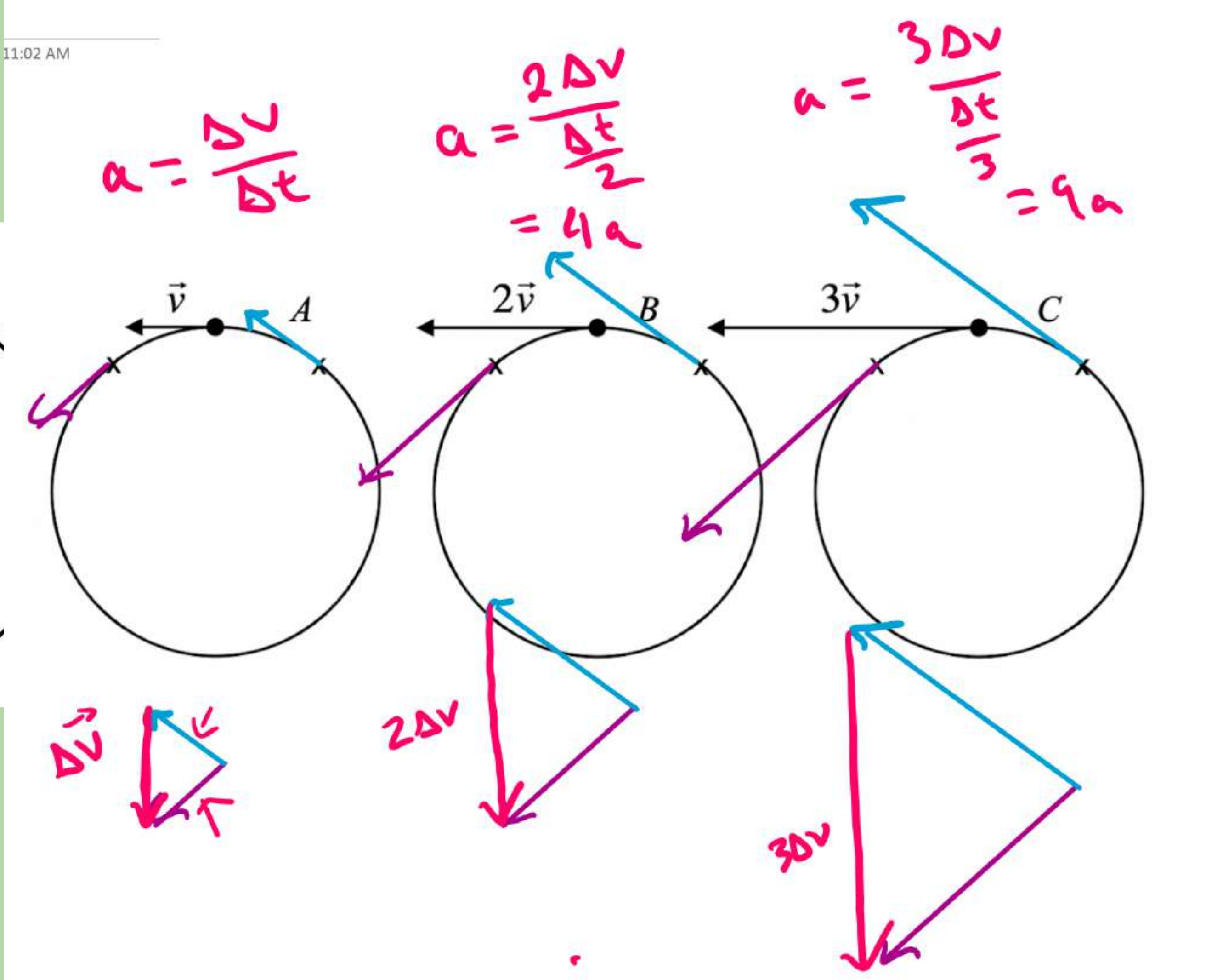


Team 4



v
A
dt = t





11:02 AM
a = Δv / Δt
a = 2Δv / (Δt/2) = 4a
a = 3Δv / (Δt/3) = 9a
v
A
2v
B
3v
C
Δv
2Δv
3Δv

Team 5

OALG 5.3.3 Test the relation

Equipment: a ruler, a protractor.

Use the video https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-5-3-3 to test whether Newton's second law works for circular motion, namely . For this experiment, you will need a ruler and a protractor.

a. Watch two spheres A and B of different masses move in a circle (mA=29 g and mB=89 g). What do you notice about their motion? Write all your observations below (do not measure anything). Draw force diagrams to explain the tilt of the strings qualitatively.

b. Use the data in the video for sphere A to determine whether the angle is consistent with the equation under test. What other quantities do you need to determine to make this judgment? Describe how you will model the objects, interactions, and processes that you will use in your mathematical model. Construct force diagrams as appropriate.

c. Consider the uncertainties in your data. How do they affect your judgment?

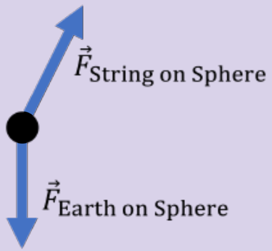
d. How can you explain that the tilt of the string for sphere B is the same as for sphere A although sphere B has about three times larger mass?

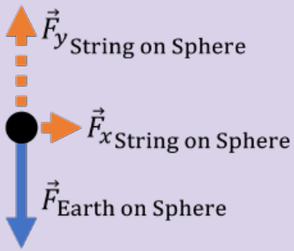
Model solution

a.

Both spheres swing outwards so that their strings tilt at an angle to the vertical. Both strings seem to form the same angle with the horizontal, even though the spheres have different masses.

The string is angled so that the the vertical components of both forces cancel out, leaving the sum of the forces to point in the horizontal direction.





This is qualitatively consistent with what we've learned since that would leave the sum of forces pointing towards the center of the circle through which the sphere is moving.

Model solution

b. & c.

Hypothesis: Newton's 2nd Law applies to circular motion and the coefficient is 1 ($a = \frac{v^2}{r} = \frac{\Sigma F}{m}$).

Prediction: We can predict the angle the string will make with the vertical if we measure the period and radius of the sphere's swinging:

> **Period** is measured to be 40 frames (the spheres go around from 340 to 380) or 1.33s. The uncertainty in this measurement is 1 frame (1/30 s)
>
> **Radius** of the circle was measured to be 27cm by counting pixels. The uncertainty in this measurement is about 1 cm.

Model solution

b. Apply Newton's 2nd Law in the x- and y- directions:

$$a_x = \frac{\Sigma F_x}{m} = \frac{v^2}{r}$$

$$\frac{F_{x\,\text{String on Sphere}}}{m} = \frac{\left(\frac{2\pi r}{T}\right)^2}{r}$$

$$\frac{F_{\text{String on Sphere}} \sin\theta}{m} = \frac{\left(\frac{2\pi r}{T}\right)^2}{r}$$

$$\sin\theta = \frac{m\left(\frac{2\pi r}{T}\right)^2}{F_{\text{String on Sphere}} \cdot r}$$

$$a_y = \frac{\Sigma F_y}{m} = 0$$

$$F_{y\,\text{String on Sphere}} - F_{\text{Earth on Sphere}} = 0$$

$$F_{\text{String on Sphere}} \cos\theta = mg$$

$$\cos\theta = \frac{mg}{F_{\text{String on Sphere}}}$$

$$\tan\theta = \frac{\sin\theta}{\cos\theta} = \frac{\left(\frac{2\pi r}{T}\right)^2}{gr}$$

$$\theta = \tan^{-1}\left(\frac{\left(\frac{2\pi(.27\text{m})}{1.33\text{s}}\right)^2}{\left(9.8\frac{\text{N}}{\text{kg}}\right)(.27\text{m})}\right) = 32° \pm 2°$$

Model solution

b. & c.

Outcome & Judgment: The angle of the string, as measured in the video, is 33°. This is within the bounds of our prediction, 32°±2°, so from this experiment we cannot reject our hypothesis that Newton's 2nd Law applies to objects moving in circles.

Model solution

d.

The angle is the same for both spheres for the same reason the freefall acceleration is the same for all objects regardless of mass: All forces exerted on the spheres in this experiment depend linearly on their mass, so the mass cancels out when using Newton’s 2nd Law.

Let’s go back to Damien Walters! In your teams…

1. Useful data: Damien Walters has a **height of 5’11” (1.80 m)** and the **radius of the loop is roughly 1.5 m**, estimated with his height.

2. Draw a force diagram for Damien running **upside down at the top of the loop**.

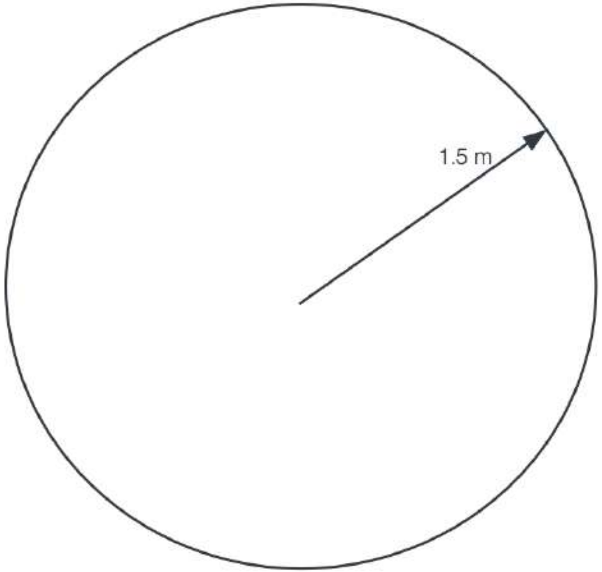
3. Represent your force diagram mathematically using Newton’s 2nd Law and what you now know about objects moving in uniform circular motion.

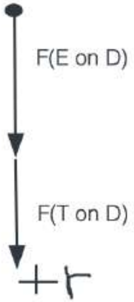
4. Can Damien run the loop at any speed? Or there is some minimum speed that he needs to stay in contact with the loop? Why?

5. Predict the minimum speed Damien will need to run at the top to make it through the loop without falling.

6. State any assumptions you make.

Team 1





$$a = \frac{\text{Sum of Forces}}{m}$$

$$\frac{v^2}{r} = \frac{+F_E + F_T}{m}$$

v(min) under the condition that F(T on D) >0

$$F_T = \frac{mv^2}{r} - F_E > 0$$

$$\Rightarrow \frac{mv^2}{r} > mg$$

$$v > \sqrt{rg}$$

$$v > \sqrt{(1.5)(10)}$$

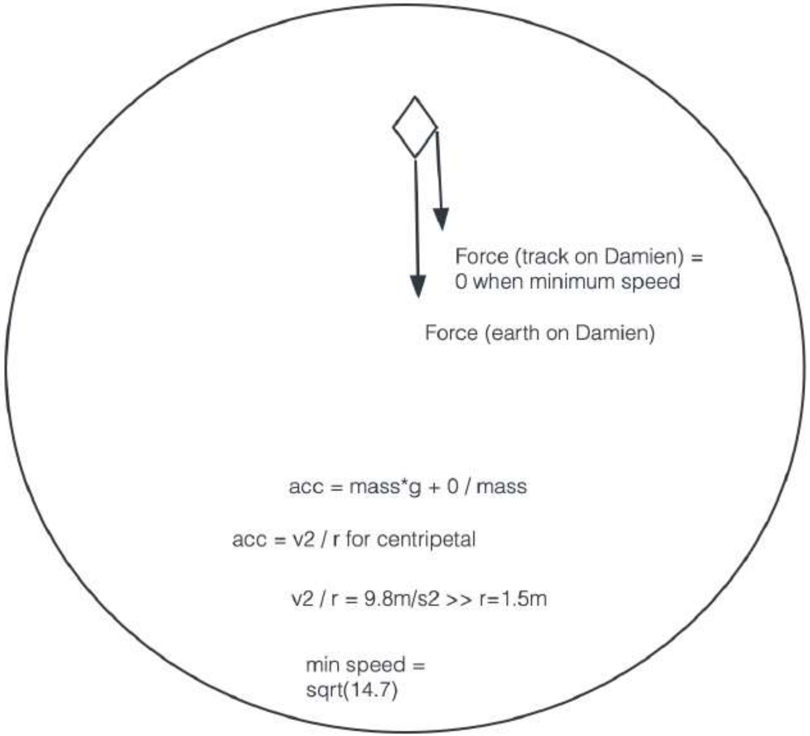
$$v > 3.8\ m/s$$

But if we consider his Center of mass? He's 1.8 m, halfway is 0.9m, so his CoM loop radius is 0.6 m, which gives:

$$v > \sqrt{(0.6)(10)}$$

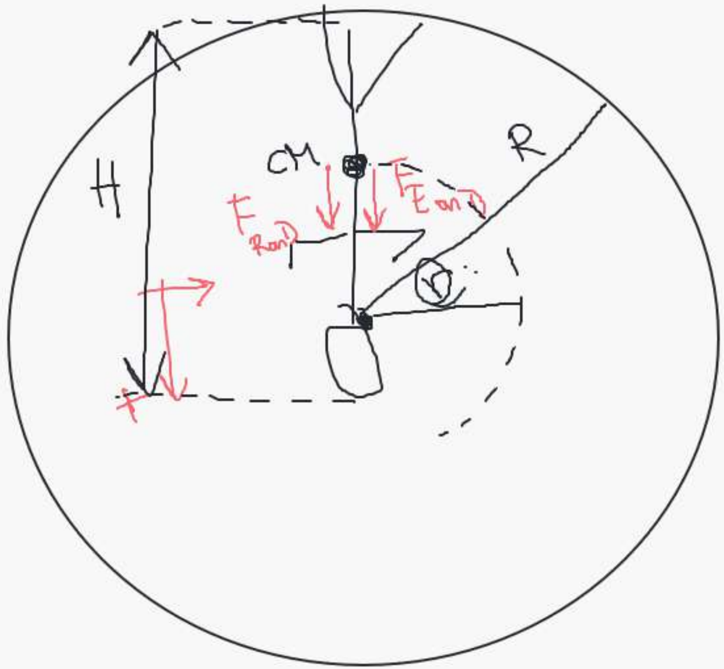
$$v > 2.4\ m/s$$

Team 2


Force (track on Damien) =
0 when minimum speed
Force (earth on Damien)
acc = mass*g + 0 / mass
acc = v2 / r for centripetal
v2 / r = 9.8m/s2 >> r=1.5m
min speed =
sqrt(14.7)

I can ☺

$r = H - D(\text{TOE} \rightarrow \text{BELLY})$ $F_{E\,on\,D}$ is min



a = sum{F(E on D)+F(R on D)}/ mass of D

a=v x v/R > or = F (r on D)/m = g

So, v (mini) = sqr (g x R)

Or, = sqr(g x r)

v (min) = sqr(9.8 x 0.6)=2.4 m/s

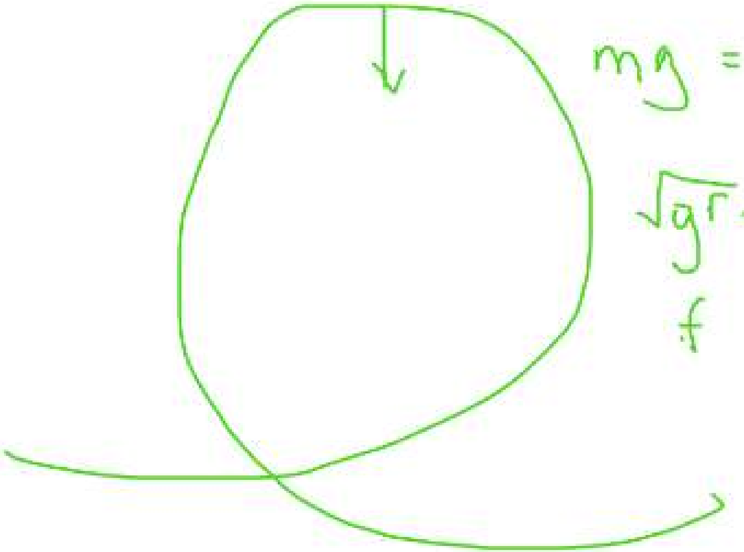
Team 4

If r= 0.6 m (1.5-0.9), v = 2.42 m/s (A point at his midpoint)

If r = 1.5, v = 3.8 m/s (A point at his feet)

Both are assuming a point. Assuming zero force of the ramp on him.

Team 5

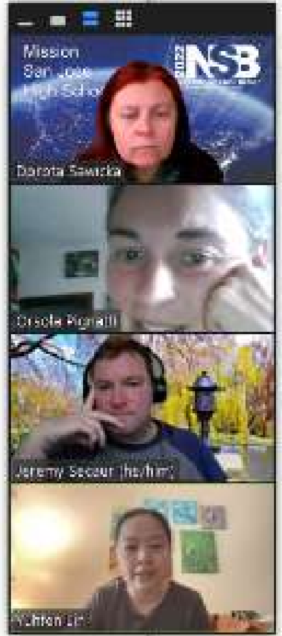


$$mg = \frac{mv^2}{r}$$

$$\sqrt{gr} = v$$

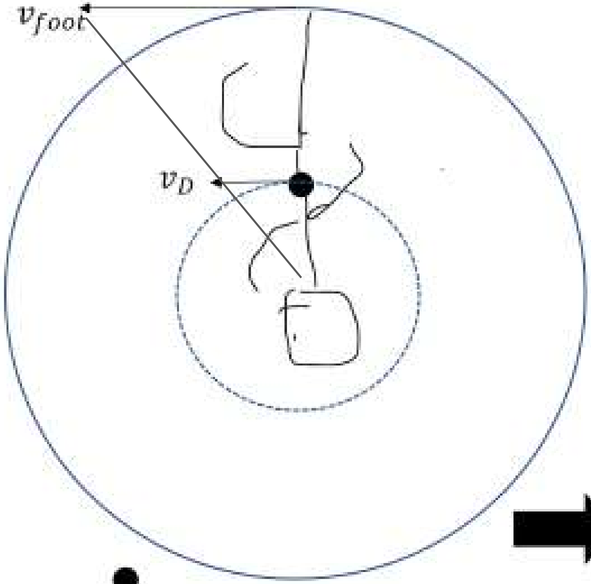
f $r = 0.75\,m$

$$v = 2.71\,\frac{m}{s} \sim 6\,\frac{N}{hr}$$



Will it be possible? - Start at 01:24

Solution: Damien (D) Walters



$$a_D = \frac{\sum F_{on\,D}}{m_D} = \frac{F_{E\,on\,D} + F_{T\,on\,D}}{m_D} \geq \frac{F_{E\,on\,D}}{m_D}$$

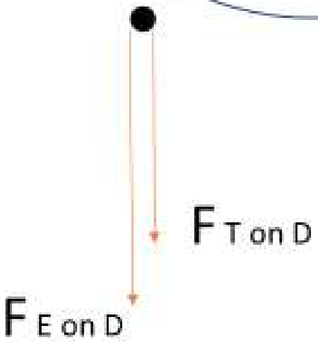
Also known,
for a uniform circular motion:

$$a_D = \frac{v_D^2}{r_c}$$

Where r_c is radius of the circle that Damien's center of mass is going around.

$$\frac{v_D^2}{r_c} = \frac{F_{E\,on\,D} + F_{T\,on\,D}}{m_D} \geq \frac{F_{E\,on\,D}}{m_D} = g$$

r_c is ~0.6 m, estimated by the given height of Damien.



Downward as positive direction

The minimum speed of Damien's center of mass $v_D^{mini} = \sqrt{g \times r_c} \approx 2.4$ m/s

OALG 5.3.5 Read and interrogate

Read and interrogate Section 5.3 in the textbook. In your own words, explain why the expression for radial acceleration makes sense.

Homework: Use the next slides to put your questions for students who learned physics through the ISLE approach and teachers who have been using the ISLE approach. Also, please read the following paper

Link to paper for homework reading:
https://journals.aps.org/prper/abstract/10.1103/PhysRevPhysEducRes.16.020148

Folder where all the workshop activities and resources are located

https://drive.google.com/drive/folders/1npi7He8rwz5gNwPl-xBdidP4oELHGuPr?usp=sharing

Homework: Questions for students who learned physics through the ISLE approach

- Can you compare the traditional approach to learning physics with the ISLE approach?
- Do you have friends who went only through traditional approach of learning physics? Have you compared your experiences?
- Have you had a longer term interest and knowledge of physics?
- How does the workload and reading compare to other classes? Did the ISLE approach make sense right away or did you struggle to adapt to the new style the first few lessons?
- What was it like doing ISLE for physics while I assume your other science classes were more traditional? Was it confusing to move between the two environments and vocabulary?

As I mentioned on the next page, I consider myself having gone through both the traditional approach of learning physics and also the ISLE approach when I began teaching AP Physics 1 because I learned about the Etkina book at that time. I am a chemist, so I feel that I often have a student like experience when I use the ISLE approach because I am a little outside my field and many years have passed since I took physics as a high school and college student. I find the ISLE approach much more friendly to my own learning of physics. I feel that it is kinder and gentler than the traditional approach. However, since my school district uses Giancoli as the textbook, I am often surprised when the students praise Giancoli because I myself did not find it conducive to self learning physics. I am lucky that my school is an extremely high performing school and many students come into my class either having self studied physics to prepare for physics olympiad or having taken extra curricular classes through tutors in their community. However, as a result of this pressure cooker environment, students that have not self studied or had previous tutoring in physics feel underprepared and I need to help them feel like they too can be successful and I think ISLE helps with this. I enjoy reading books on physics directed towards a general audience like the Dancing Wu Li Masters and Cycles of Time.

Homework: Questions for a teacher who has been using the ISLE approach

- Are you the only physics teacher in your school using ISLE approach? If yes, why? If no, how come?
- Are you the only teacher from STEM field in your school using ISLE approach? If yes, why? If no, how come?
- Did you learn physics through ISLE during your schooling? If not why did you switched to it and can you describe your path from traditional approach to full ISLE approach?
- How do you approach the time problem with ISLE?
  - I'm a little concerned about time as well. I'm worried that students may not have enough time to get through the needed/required curriculum if we spend a lot of time doing observations and experiments for every topic. I wonder if there is some compromise approach.
- Do you assign homework? If yes, how does your typical homework look like?
- I am one of nine Physics teachers in my school, and I can't veer too far away from what they are doing because we all have to give the same exam within a week of each other. Any tips on how to implement this in such a situation (when others are not open to change) would be helpful. I try to "close my door and teach" as much as possible, but it can be a struggle to do new things.
- I am the only teacher at my school currently using ISLE but I am recruiting my colleagues to learn and use it to by sharing the info on the Facebook page and telling them about the workshops.
- Has class ever gone in an unexpected direction? Was it positive or negative?

- I did not learn physics through ISLE during my schooling. I am a chemist that was asked to teach physics by my principal so I had to relearn physics as I was teaching it. The first year I taught physics the school used Hewitt and then 15 years passed before I taught physics again at a school that used Giancoli. I had a hard time relearning physics from Giancoli so I was looking for other resources. I initially used Knight as my lecture notes but after attending an AP Physics 1 summer institute, Etkina was recommended by the instructor so I started using it this academic year even though the school textbook is Giancoli
- I read the textbook first, then I read through all the lecture notes and add my own materials to them like directing students to practice problems on Physics Aviary. We do the observation and testing experiments together during class time. I provide a copy of my lecture notes on Google Classroom so that the students have access to them. I use the Etkina testbank from Pearson and I look for questions that are conceptual rather than the generic plug and chug questions that are also in the testbank. I appreciate the free response questions from the testbank because I believe they are similar to the questions on the AP 1 Exam. My daily homework is typically from Physics Aviary and the end of chapter problem sets are from Giancoli and TIPERS. I include the recommended Etkina homework problems (from the Active Learning Guide (ALG)) in my set of lecture notes so that the students have access to them. Often we do not discuss all of these in class, but students sometimes will ask me to explain the solutions to these because I do include them on their tests as they often appear in the Pearson Etkina test bank.
- A time when my class went in an unexpected direction was when I was trying to describe the set-up for the conical pendulum activity that is described in the ALG. A student suggested an alternative set up for data collection. Here is his lab report.

- How do you handle teaching a student who is absent when they miss the need to know introductions or live discussions
- Do you prefer live demos for need to knows or other activities or do videos work just as well

When a student is absent I tell them to read the lecture notes and/or ask other students what happened in class.

I prefer live demos for need to knows or other activities but I use the videos when I do not have the equipment available.

Day 2

Video of ISLE in action

- Watch the following video. Prepare a commentary - how does this video represent learning physics through the ISLE approach
  https://youtu.be/RMyQD27t0oY

First day of class

OALG 1.1.1 Observe, explain, and test your ideas

Watch the video at https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-1-1-1.

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

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

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

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

Wild ideas

1. She’s likes to spy on the neighbors
2. She’s a professional photographer
3. She sells cameras
4. She fixes cameras
5. She’s a camera thief
6. She’s a hobbyist camera collector.

Proposed testing Experiments

1. Follow Eugenia and watch her activities.
2. Search to see if Eugenia has a criminal record.

Design a better testing experiment!

Search the house for receipts (testing experiment needs to be specific to eliminate the thief hypothesis, for example.)

OALG 1.1.5 Team 1 OALG Chapter 1 Final.docx

Elements of scientific reasoning Sentence numbers	**Elements of scientific reasoning Sentence numbers in the text (1, 2,3, etc.)**
Observations/identifying patterns	*1*
Proposing a hypothesis/explanation	2
Designing/planning a testing experiment	4
Making a prediction of the outcome of the testing experiment	5
[illegible]	[illegible]

OALG 1.1.5 Team 2 OALG Chapter 1 Final.docx

Elements of scientific reasoning Sentence numbers	**Elements of scientific reasoning Sentence numbers in the text (1, 2, 3 ETC.)**
Observations/identifying patterns	1,
Proposing a hypothesis/explanation	2,
Designing/planning a testing experiment	4
Making a prediction of the outcome of the testing experiment	5

OALG 1.1.5 Team 3 OALG Chapter 1 Final.docx

Elements of scientific reasoning Sentence numbers	**Elements of scientific reasoning Sentence numbers in the text (1, 2,3, etc.(**
Observations/identifying patterns	*1, 3, 6*
Proposing a hypothesis/explanation	2,
Designing/planning a testing experiment	4
Making a prediction of the outcome of the testing experiment	5

OALG 1.1.5 Team 4 OALG Chapter 1 Final.docx

Elements of scientific reasoning Sentence numbers	**Elements of scientific reasoning Sentence numbers in the text (1, 2, 3, etc.) 3?**
Observations/identifying patterns	1
Proposing a hypothesis/explanation	2
Designing/planning a testing experiment	4
Making a prediction of the outcome of the testing experiment	5

OALG 1.6.1 and 1.6.2 - whole class activity

https://docs.google.com/document/d/1Zr87t_CyY18WzAUh1XcBbczH_yHkQ-2c/edit?usp=sharing&ouid=107135625647765509755&rtpof=true&sd=true

Reflection questions:

1. What does it mean to interrogate the text?
2. How is the interrogation reading different from reading of fictional texts?

Break!

New section

Expertise activity

Students are experts in learning. We need to help them see that!

The process to become an expert in your field

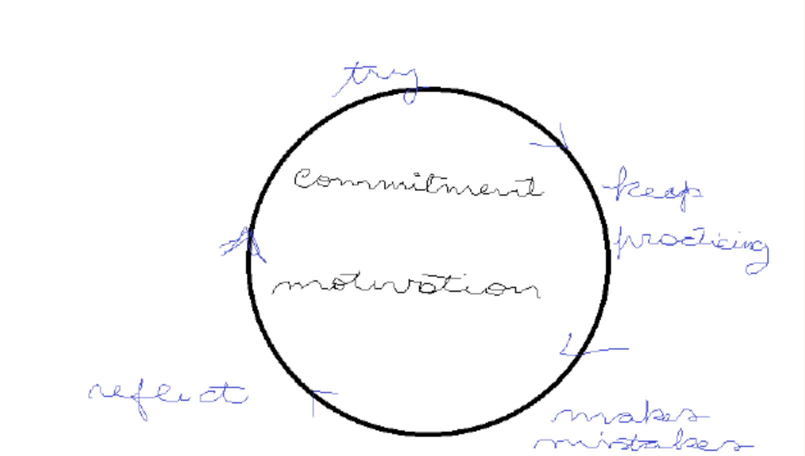
a. How did you become an expert in this area? What specific step(s) do you need to take in order to get to where you are right now? (Think about time commitment, the detailed cognitive process of learning. Try and be as specific as possible, use examples.)

b. Were there ever times that you didn't accomplish your goal during practice or competition? How did you feel when that happened, and what did you do next?

c. Now that you are an expert, do you still make mistakes? Do you know when you are making a mistake? How do you know? What do you do when you know you have made a mistake?

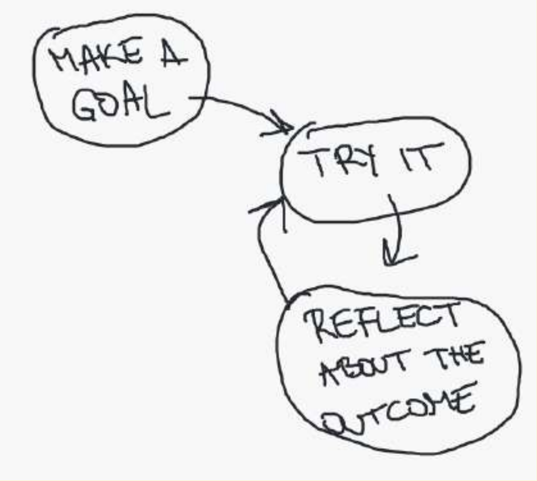
d. As a group, make a diagram on your whiteboard. This diagram should be a learning cycle that connects together a set of repeatable elements that could be used to become better at your chosen field. In other words, describe a repeatable process should you engage in to become more and more expert-like at ________ (sports/cooking/computer gaming etc etc)

Goal: became an expert in…



Room 1. Sports.

A. . Attempt the activity/ skill
B. Repeating the activity over and over.
C. Having fun doing the activity especially with others who share the same activity.
D. Makes mistakes
E. Figure out what went wrong, and hopefully not make that mistake again
F. Do it again and make new mistakes



Room 2 Expert Musician

A) Choosing songs and pieces to play. Intentional Practice. Record and Listen critically. Listen to other good musicians. Youtube tutorials. Teachers and other outside observers.

B)

Try

Try Again

Make a Goal - what do you want to be able to do.

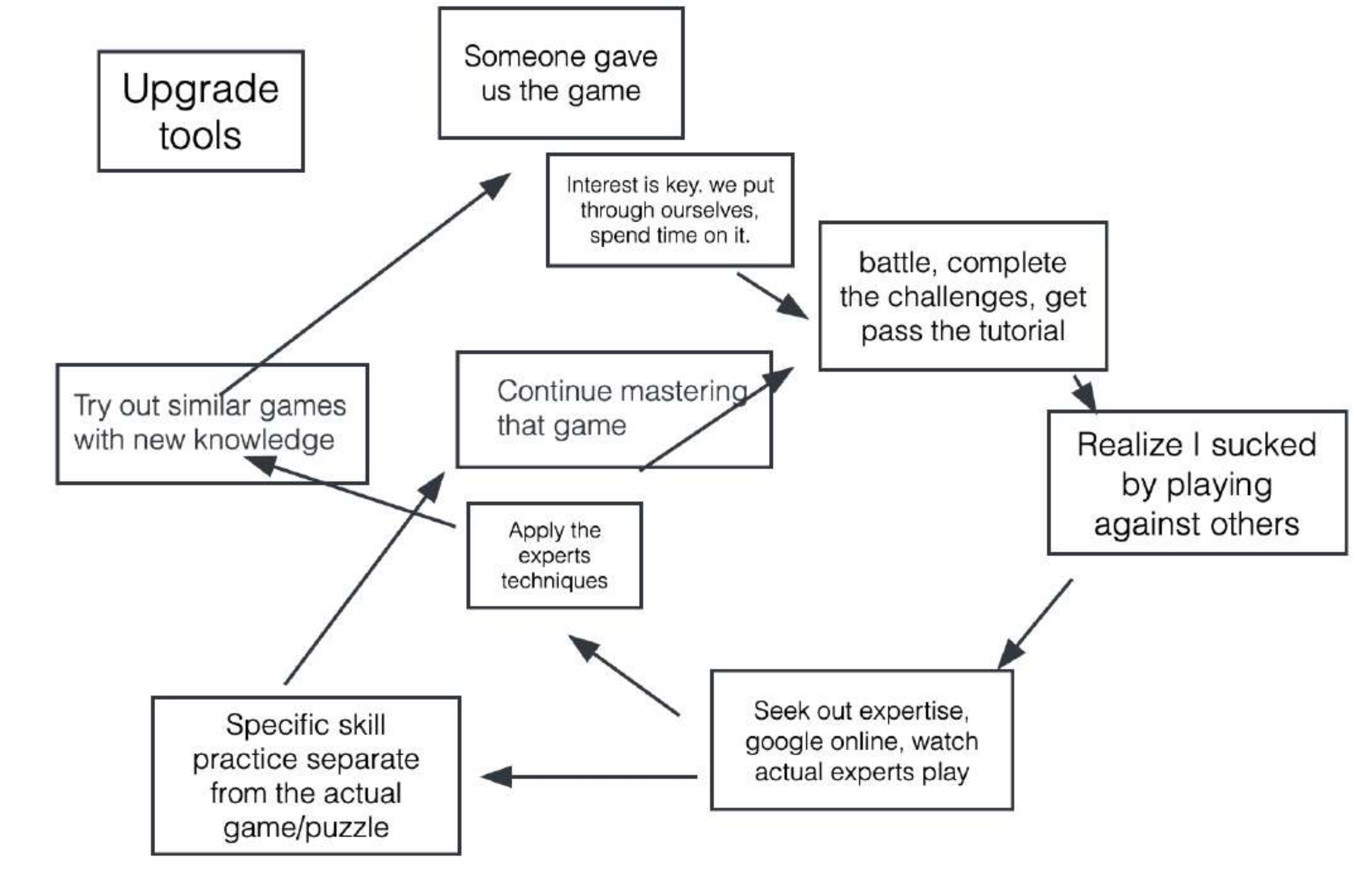
Ask for outside opinion

Reach a Goal - what do you want to be able to do.

Make a harder goal AND reach your last goal at a higher level.

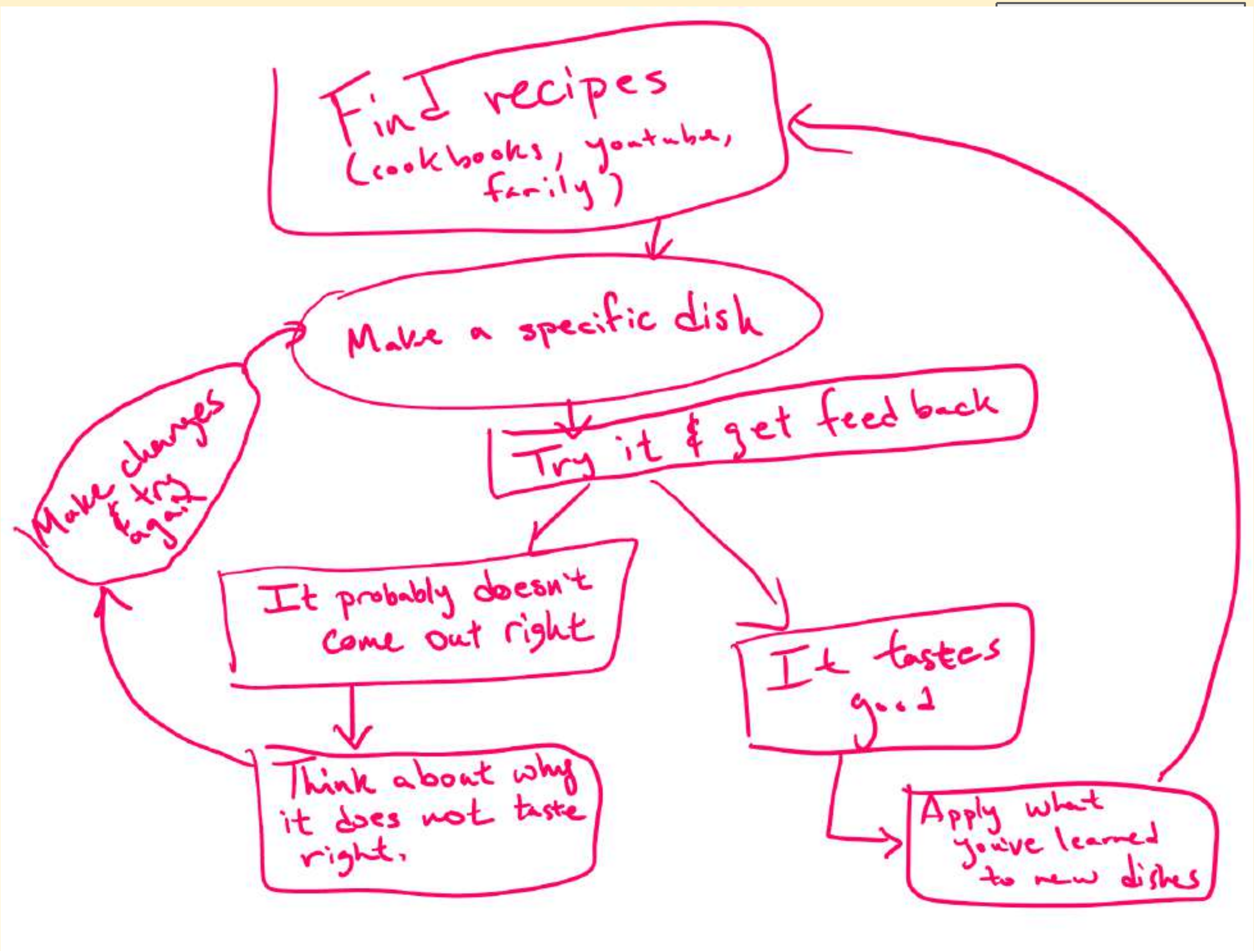
Feel proud of your new skills.

Room 3



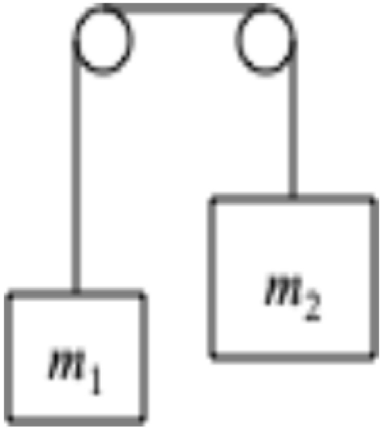
Upgrade tools
Someone gave us the game
Interest is key. we put through ourselves, spend time on it.
battle, complete the challenges, get pass the tutorial
Realize I sucked by playing against others
Seek out expertise, google online, watch actual experts play
Apply the experts techniques
Continue mastering that game
Try out similar games with new knowledge
Specific skill practice separate from the actual game/puzzle

4 Cooking/ baking/ being a mom



What abilities are being assessed?

Your friend Juan is presented with the following problem:
Two blocks, masses m_1 = 4 kg and m_2 = 5kg, hang over light frictionless pulleys from a string of negligible mass. Find the acceleration of the system. After some calculating, Juan comes up an acceleration of 19.2m/s^2 for the system.
WITHOUT solving the problem from scratch, is Juan's solution reasonable or not? Use your knowledge of physics to construct a clear argument why his solution is reasonable or not reasonable.



Summary of the expertise activity

When to use the expertise activity?
https://drive.google.com/file/d/18MaGMVgCg68QZS7zyg02M6dNbGKktuSs/view?usp=sharing

Useful TED-talk to share with students:

The first 20 hours -- how to learn anything | Josh Kaufman

https://youtu.be/5MgBikgcWnY

Developing a Growth Mindset with Carol Dweck
https://youtu.be/hiiEeMN7vbQ

New section

Backwards design - Brainstorm goals

Goals → Assessment → Activities

Process goals of the ISLE approach:

- Represent physical ideas in multiple ways
- Design an experiment to test multiple hypotheses
- Apply physics to the real world
- Evaluate reasonableness of an idea or result
- Analyze data and draw valid conclusions from that analysis.
- Communicate physics ideas effectively to others

*Wiggins, G. P., & McTighe, J. (2005). Understanding by design (2nd ed.). ASCD.

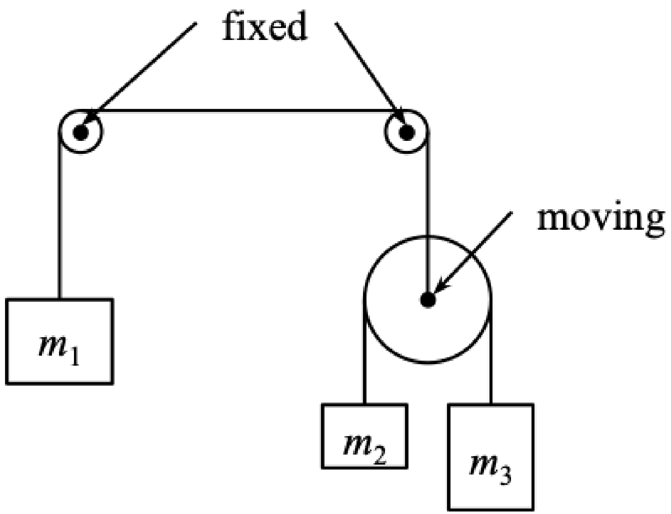
A traditional physics problem...

From “University Physics” by Young and Freedman, 14th edition
Problem 5.15** **Atwood’s Machine**. A 15.0 kg load of bricks hangs from one end of a rope that passes over a small, frictionless pulley. A 28.0 kg counterweight is suspended from the other end of the rope. The system is released from rest.

a) Draw two free-body diagrams, one for the load of bricks and one for the counterweight.
b) What is the magnitude of the upward acceleration of the load of bricks?
c) What is the tension in the rope while the load is moving? How does the tension compare to the weight of the load of bricks? To the weight of the counterweight?

What abilities are being assessed?

Three blocks, masses m_1, m_2, and m_3, hang over light (negligible mass) frictionless pulleys from a string of negligible mass. Two of the pulley wheels are fixed in place (they can still rotate freely) while the third is attached to the string and can accelerate up and down with the string as well as being able to rotate. Find the acceleration each of the three blocks.



As of 2021, Wolfram alpha has the following answer for the acceleration of m_3 posted on their website:

$$a_3 = \frac{-2m_1(m_2 - m_3)}{m_1(m_2 + m_3) + 4m_2 m_3} g$$

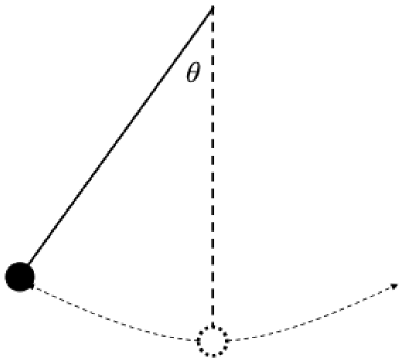
Is this answer correct or not? *Evaluate* the Wolfram alpha answer using two distinct special, limiting, or known cases.

What abilities are being assessed?

Draw a picture of a problem situation and describe a possible physical process that is represented by this equation. Note that physical quantities are Italicized and the units are not

$$\Delta x = (-20 \text{ m/s})(3 \text{ s}) + (1 \text{ m/s}^2)(3 \text{ s})^2$$

What abilities are being assessed?



Saalih wonders whether the period of a pendulum's oscillation depends on how big the oscillation is. In other words, does a pendulum's period depend on the amplitude of the oscillation? In order to find out, Saalih conducts an experiment where he increases the angle at which he releases the pendulum in 10° increments and times the period of the pendulum 5 times with a stopwatch for each angle. The data he acquires is presented in the table below:

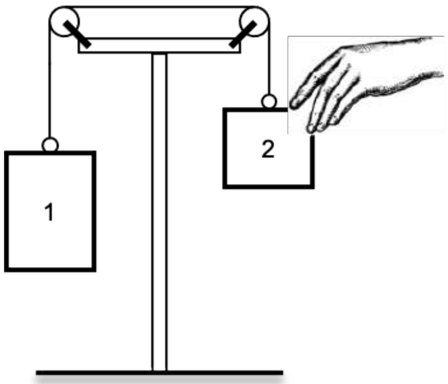
Angle	*T*, trial 1	*T*, trial 2	*T*, trial 3	*T*, trial 4	*T*, trial 5
10°	1.90s	1.88s	1.90s	1.89s	1.88s
20°	1.92s	1.91s	1.92s	1.87s	1.88s
30°	1.93s	1.92s	1.96s	1.90s	1.92s
40°	1.97s	1.93s	1.94s	1.98s	1.96s
50°	1.96s	1.97s	1.97s	2.00s	2.02s
60°	2.04s	2.03s	2.00s	2.01s	2.02s

Table 1: Table of periods versus release angle. I repeated the experiment 5 times for each angle

Analyze Saalih's data and write up a conclusion. Does the pendulum's period depend on the size/amplitude of the oscillation? Back up your reasoning using the analysis tools and techniques you've learned this semester.

What abilities are being assessed?

In the scenario in the figure, someone is holding block 2 so that the system is stationary. Saalih claims that the force exerted by Earth on block 1 and the force exerted by the string on block 1 are a Newton's third law pair. "Look," he says, "$F_{\text{Earth on 1}}$ and $F_{\text{string on 1}}$ *must* be equal in magnitude, and they point in opposite directions. They must be a pair of equal and opposite forces, just like Newton's third law says!"

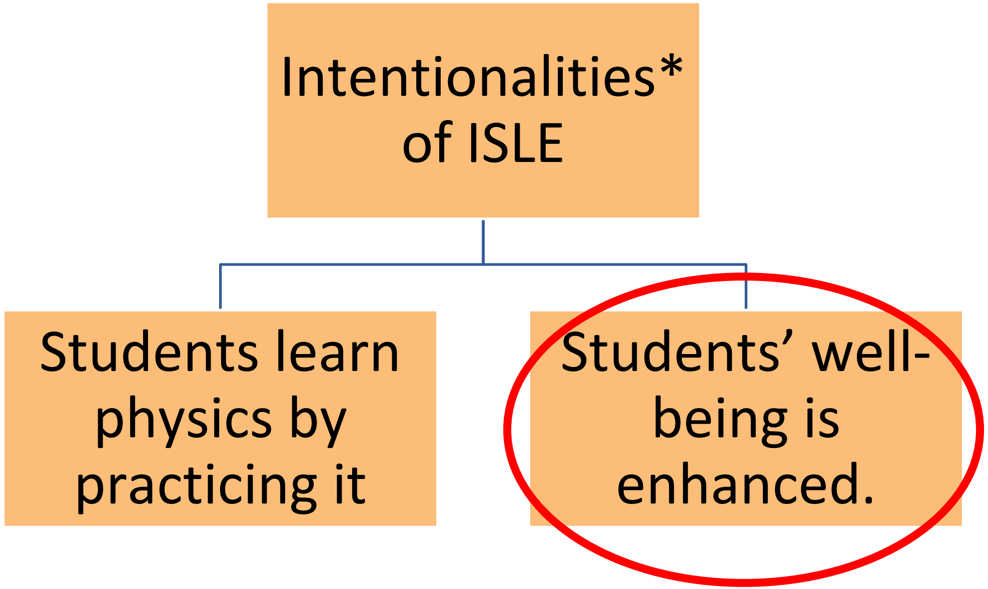


a. Explain (in terms of physics you understand) why, although the two forces are equal and point in opposite directions, they are NOT a Newton's third law pair. Explain which of Newton's laws justifies why the two forces (Earth on 1 and string on 1) are equal and why.

b. Explain to Saalih what the Newton's third law pairs of those forces really are. In other words, identify the equal and opposite force of $F_{\text{Earth on 1}}$ and the equal and opposite force of $F_{\text{string on 1}}$ that follow from the fundamental idea that "when two objects interact with each other they exert equal and opposite forces on each other."

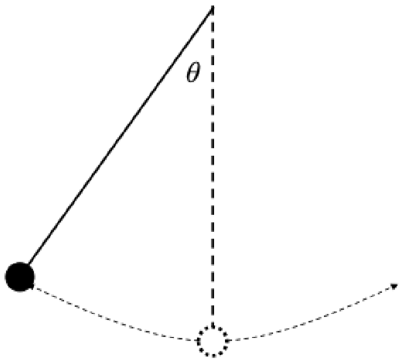
c. Draw appropriate force diagrams to backup your argument.

The intentionalities of the ISLE approach



What abilities are being assessed?

Saalih wonders whether the period of a pendulum's oscillation depends on how big the oscillation is. In other words, does a pendulum's period depend on the amplitude of the oscillation? In order to find out, Saalih conducts an experiment where he increases the angle at which he releases the pendulum in 10° increments and times the period of the pendulum 5 times with a stopwatch for each angle. The data he acquires is presented in the table below:



Angle	*T*, trial 1	*T*, trial 2	*T*, trial 3	*T*, trial 4	*T*, trial 5
10°	1.90s	1.88s	1.90s	1.89s	1.88s
20°	1.92s	1.91s	1.92s	1.87s	1.88s
30°	1.93s	1.92s	1.96s	1.90s	1.92s
40°	1.97s	1.93s	1.94s	1.98s	1.96s
50°	1.96s	1.97s	1.97s	2.00s	2.02s
60°	2.04s	2.03s	2.00s	2.01s	2.02s

Table 1: Table of periods versus release angle. I repeated the experiment 5 times for each angle

Analyze Saalih's data and write up a conclusion. Does the pendulum's period depend on the size/amplitude of the oscillation? Back up your reasoning using the analysis tools and techniques you've learned this semester.

How to evaluate student performance?

Rubric Item	Criteria for adequate performance	Score
Is able to clearly explain their reasoning in words (F3)	Student explains what they is doing and why. Explanation is clear, sufficiently detailed, easy to follow, and shows understanding.	
Is able to evaluate specifically how identified experimental uncertainties affect the data (G2)	The experimental uncertainties of the results are correctly evaluated.	
Is able to analyze data appropriately (G5)	The analysis of the data is appropriate, complete, and correct.	
Is able to make a judgment about the	An acceptable judgment is made about the experimental results, with clear reasoning. The	

https://sites.google.com/site/scientificabilities/rubrics or
https://docs.google.com/document/d/1Vyin51NIZuUGe9ZFDtBBPQvAbQhRlREpXYH9i-hbL1k/edit?usp=sharing

Our approach

- Specifications grading*
- If you're close I'll write "talk to me" on your exam paper
- You get three tries at every ability cluster.
- No curve, no average; students accumulate points to "level up" like a computer game.

* Nilson, L. B. (2015). Specifications Grading. Stylus Publishing, LLC.

Assessment examples

Here are a few examples of exam questions we use in our classes

https://docs.google.com/document/d/1UwhhVT487i7bgJRDQd2Hu5FXRG6yl-UCjdgxqXfPPAM/edit?usp=sharing

Textbook examples

Examine the following questions and problems in Chapter 20 pages 643-647 - how are they different from traditional?

1. Question 10
2. Problems 1 - 3
3. Problem 6
4. Problem 31
5. Problem 32
6. Problems 33- 35
7. Problem 36

Alternate Problem-Solving Rubric

https://docs.google.com/document/d/1HZXbQrUzR2RAdzmfxoJTKl91OSsu96FV/edit?usp=sharing&ouid=112314208470999647175&rtpof=true&sd=true

Break

What are the characteristics of your group members that you appreciate the most?

Active participation
Give others a chance as well
Everyone is involved one way or the other
They are talking or they are listening. Not both at the same time.
On task and progressing with work.
Balance listening and talking
Good listeners
They give me permission to share my ideas without any judgment. They listen carefully. They share they idea with respect to others. They see problems from different perspectives with different representations.
Responding to our ideas
Not giving us direct answer but asks questions to lead us to it
Willing to try something new
Don't always be satisfied with the first idea that sounds acceptable

Being OK with silence while others are thinking, i.e. not having to "jump in" when no-one is speaking.

- **Why do some student groups always function more effectively than others?**
- **How can we improve student group effectiveness?**

Example of less-equal discussion

Ronald: What does that tell you about force?

Robert: What do you mean?

Ronald: You have acceleration in the radial direction, but what about the force?

Robert: If you have acceleration in the radial direction you have force in the radial direction

Ronald: How would the force diagram be?

Robert: Pointing towards the center!

Ronald: Yeah?

Robert: Yeah, that's it!

Example of more-equal discussion

Edward: The first one, see how its moving flat?

Paul: Yeah

Edward: If it is moving at constant speed, there is no acceleration, right?

Paul: Yeah, since it's moving at constant speed, there's no acceleration.

Edward: The force diagram, do you agree with that?

Paul: Yeah

Edward: Since we determined the forces in the force diagram would be even, I said there is no net force.

Paul: Yip, zero

Hints for group success: A Google Study

https://www.nytimes.com/2016/02/28/magazine/what-google-learned-from-its-quest-to-build-the-perfect-team.html

- Social sensitivity/empathy:

- Equal participation:

- Psychological safety:

- Hedging/inviting words: e.g., I think...what do you think?...

https://journals.aps.org/prper/pdf/10.1103/PhysRevPhysEducRes.17.010103

Homework: Questions for students who learned physics through the ISLE approach

- Can you compare the traditional approach to learning physics with the ISLE approach?
- Do you have friends who went only through traditional approach of learning physics? Have you compared your experiences?
- Have you had a longer term interest and knowledge of physics?
- How does the workload and reading compare to other classes? Did the ISLE approach make sense right away or did you struggle to adapt to the new style the first few lessons?
- What was it like doing ISLE for physics while I assume your other science classes were more traditional? Was it confusing to move between the two environments and vocabulary?

What do students say?

Video of former students talking about the course

https://youtu.be/oqtEzCYzvAY

Current students on zoom.

What do teachers say?

Resources to implement the ISLE approach https://www.islephysics.net/

Read the textbook as if you never studied physics

Participant folder https://drive.google.com/drive/folders/1npi7He8rwz5gNwPI-xBdidP4oELHGuPr

Facebook discussion group

https://www.facebook.com/groups/320431092109343

What did you learn in this workshop?

INOT give up the equation at the beginning of the presentation. But build up HOW scientists developed our understanding.

I keep reseting my knowledge, I feel I need to learn everything again. I am reading the main book, also I am going to study more about uncertainties, I learned about light, I learn about acceleration, I learn how to relate centripetal acceleration without differential geometry, I heard how a student well being was enhanced. I have more papers to read, specially the one about groups and interactions because it is completely new to me, and like three books, about mindset, about grades and design. I need time to reflect and implement rubrics.

Allow opportunities for **iterations** to build knowledge by **DOING** physics

Distinction between prediction and hypothesis

Reinforce time for telling summary

If we make sure that students are successful than learning (physics) will be satisfying

I learned that observational and testing experiments are color-coded differently in the textbook!

Questions - post workshop limit time