Promoting Social Interactions in (Remote) Education

NSF-Harvard Virtual Workshop: Building a Network to Support and Improve High-School Physics Education
July 15, 2020
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@eric__mazur
WHO OWNS THE LEARNING?

Preparing Students for Success in the Digital Age

ALAN NOVEMBER
Ownership of learning physics?
team & project-based approach
an illusion...
Archimedes Principle
An object submerged either fully or partially in a fluid experiences an upward buoyant force the magnitude of which is equal to the magnitude of the force of gravity exerted on the fluid displaced by the object.
An object submerged either fully or partially in a fluid experiences an upward buoyant force the magnitude of which is equal to the magnitude of the force of gravity exerted on the fluid displaced by the object.

The volume of displaced fluid is equal to the volume of the submerged portion of the object.
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The volume of displaced fluid is equal to the volume of the submerged portion of the object.

2. Enter info

3. Join Session ID: 40796710
A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.
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After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than
2. the same as
3. lower than

it was when the boulder was in the boat.
A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.

After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than
2. the same as
3. lower than

it was when the boulder was in the boat.
Before I tell you the answer, let’s analyze what happened.

You...
Before I tell you the answer, let’s analyze what happened.

You...

1. made a commitment
Before I tell you the answer, let’s analyze what happened.

You...

1. made a commitment
2. externalized your answer
Before I tell you the answer, let’s analyze what happened.

You...

1. made a commitment
2. externalized your answer
3. moved from the answer/fact to reasoning
Before I tell you the answer, let’s analyze what happened.

You...

1. made a commitment
2. externalized your answer
3. moved from the answer/fact to reasoning
4. became emotionally invested in the learning process
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After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than
2. the same as
3. lower than

it was when the boulder was in the boat.
remember: amount of displaced water
remember: amount of displaced water
remember: amount of displaced water
remember: amount of displaced water

displaced water
remember: amount of displaced water

\[ \text{displaced water} = \text{weight of rock} \]
remember: amount of displaced water

displaced water = weight of rock

volume of rock
remember: amount of displaced water

\[\text{displaced water} = \text{weight of rock} = \text{volume of rock}\]
points worth noting

• my “clear” lecture wasn’t very good

• discussion promoted “aha” moments
information transfer

sense-making
in class

information transfer

sense-making
in class

information transfer

out of class

sense-making
in class

information transfer

out of class

sense-making

Should focus on THIS!
out of class

information transfer

in class

sense-making
out of class

information transfer

in class

sense-making

Peer Instruction
question
question

think

poll
question
→
think
→
poll
→
discuss
question

think

poll

discuss

repoll

explain
question

think

poll

discuss

repoll

explain
Peer instruction gains
Higher learning gains

<table>
<thead>
<tr>
<th>Normalized Gain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

Lecturing
Higher learning gains

- Lecturing
- PI

Normalized gain (%)

0 20 40 60 80 100

Institution
Peer instruction leads to:

- Higher learning gains
- Better retention
You are a triage nurse in a pediatric urgent care clinic and the following patients are waiting:
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1. 3-yr old F with a FUO and T = 40 °C who is riding a tricycle in the waiting room
2. 6-wk old term M, cc: fussy breast, T = 38.6 °C
3. 14-yr old M with hx of epilepsy who had a seizure at home lasting 5 minutes about half hour ago
You are a triage nurse in a pediatric urgent care clinic and the following patients are waiting:

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2. 6-wk old term M, cc: fussy breast, T = 38.6 °C
3. 14-yr old M with hx of epilepsy who had a seizure at home lasting 5 minutes about half hour ago

Whom would you triage first?
how to effectively transfer information outside classroom?
Solution

turn out-of-class component also into a social interaction!
CHAPTER 4  MOMENTUM

In the preceding two chapters, we developed a mathematical framework for describing motion along a straight line. In this chapter, we continue our study of motion by investigating inertia, a property of objects that affects their motion. The experiments we carry out in studying inertia lead us to discover one of the most fundamental laws in physics—conservation of momentum.

4.1 Friction

Picture a block of wood sitting motionless on a smooth wooden surface. If you give the block a shove, it slides some distance but eventually comes to rest. Depending on the smoothness of the block and the smoothness of the wooden surface, this stopping may happen sooner or it may happen later. If the two surfaces in contact are very smooth and slippery, the block will not travel far before it stops. The surfaces are so smooth you have probably seen this in your everyday experience. A hockey puck slides easily on ice but not on a rough road.

Figure 4.1 shows how the velocity of a wooden block decreases on three different surfaces. The slowing down is due to friction—the resistance to motion that one surface or object encounters when moving over another. Notice that, during the interval covered by the velocity-versus-time graph, the velocity decreases as the block slides over ice is hardly observable. The block slides easily over ice because there is very little friction between the two surfaces. The effect of friction is to bring two objects to rest with respect to each other—in this case the wooden block and the surface it is sliding on. The less friction there is, the longer it takes for the block to come to rest.

Figure 4.1  Velocity-versus-time graph for a wooden block sliding on three different surfaces. The rougher the surface, the more quickly the velocity decreases.

You may wonder whether it is possible to make surfaces that have no friction at all, such that an object, once given a shove, continues to glide forever. There is no totally frictionless surface over which objects slide forever, but there are ways to minimize friction. You can, for instance, float an object on a cushion of air. This is not easily accomplished on land, but some aquatic objects, such as a puck in ice hockey, or a submarine in water, are cushioned from the surface on which they are sliding. The air serves as a cushion on which a conveniently shaped object can float, with friction between the object and the track all but eliminated. Alternatively, one can use wheeled carts with low-friction bearings on an ordinary track. Figure 4.2 shows low-friction carts you may have encountered in your lab or class. Although there is still some friction both for low-friction tracks and for the track shown in Figure 4.2, this friction is so small that it can be ignored during an experiment. For example, if the track in Figure 4.2 is horizontal, carts move along its length without slowing down appreciably. In other words:

In the absence of friction, objects moving along a horizontal track keep moving without slowing down.

Another advantage of using such carts is that the track constrains the motion to being along a straight line. We can then use a high-speed camera to record the cart’s position at various instants, and from that information determine its speed and acceleration.

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Figure 4.1 shows how the velocity of a wooden block decreases on three different surfaces. The slowing down is due to friction—the resistance to motion that one surface offers another when moving over another. Notice how covered by the velocity vs. time graph, the velocity decreases as the block slides. The block slides easily over low-friction between the two surfaces to bring two objects to rest. In this case, the wooden block and the puck slide on the rough surface. The less friction there is, the easier it is for the object to come to rest.

Figure 4.1 Velocity-versus-time graph for a wooden block sliding on three different surfaces. The rougher the surface, the more quickly the velocity decreases.

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**Figure 4.2** Low-friction track and carts used in the experiment described in this chapter.

You may wonder whether it is possible to make surfaces that have no friction at all, such that an object, once given a shove, continues to glide forever. There is no totally frictionless surface over which objects slide forever, but there are ways to minimize friction. You can, for instance, float an object on a cushion of air. This is most easily accomplished with a low-friction track—a track whose surface is dotted with little holes through which pressurized air blows. The air serves as a cushion on which a conveniently shaped object can float, with friction between the object and the track almost eliminated. Alternatively, one can use wheeled carts with low-friction bearings on an ordinary track.

Figure 4.2

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Figure 4.1 shows how the final velocity of a block decreases on three different surfaces due to friction—the constant velocity reached by the surface object encounters when moving over another. Notice that, during the interval covered by the velocity-versus-time graph, the velocity decrease as the block slides on ice is hardly observable. The block slides easily over ice because there is very little friction between the two surfaces. The effect of friction is to bring two objects together with respect to each other—in this case the wooden block and the surface it is sliding on. The less friction there is, the longer it takes for the block to come to rest.

Another advantage of using such carts is that the track constrains the motion to being along a straight line. We can then use a high-speed camera to record the cart's position at various instants, and from this information determine its speed and acceleration.

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The lever arm distances must now be determined relative to the left end of the rod. The lever arm distance of force \( F_1 \) to this point is zero, and so the torque caused by that force about the left end of the rod is zero. If \( F \) is chosen counterclockwise as the positive direction of rotation, \( F_1 \) causes a negative torque about the left end of the rod; the force \( F_2 \) exerted by the pivot causes a positive torque about the left end of the rod. The lever arm distance of \( F_2 \) about the left end of the rod is \( r_1 + r_2 \); that of \( F_3 \) is \( r_1 \). Because the rod is at rest, the magnitude of the force exerted by the pivot is equal to the sum of the forces \( F_1 \) and \( F_2 \). Taking into account the signs of the torques, we find that the sum of the torques about the left end of the rod is \( r_1(F_1 + F_3) - (r_1 + r_2)F_2 = r_1F_1 - r_1F_3 \). This is the same result we obtained for the torques about the pivot, and so the sum of the torques about the left end is zero.

Exercise 12.1 shows that the sum of the torques about the left end of the rod is zero, just like the sum of the torques about the pivot. You can repeat the calculation for the torques about the right end of the rod or any other point, and each time you will find that the sum of the torques is zero. The reason is that the rod is not rotating about any point, and so the sum of the torques must be zero about any point. In general we can say:

For a stationary object, the sum of the torques is zero.

For a stationary object we can choose any reference point we like to calculate torques. It pays to choose a reference point that simplifies the calculation. As you have seen, we do not need to consider any force that is exerted at a reference point. So, by putting the reference point at the point of application of a force, we can eliminate that force from the calculation.

Exercise 12.1 Reference point

Consider again the rod in Figure 12.4. Calculate the sum of the torques about the left end of the rod.

SOLUTION Begin by making a sketch of the rod and the three forces exerted on it, showing their points of application on the rod (Figure 12.6).

Example 12.2 Torques on lever

Three forces are exerted on the lever of Figure 12.7. Forces \( F_1 \) and \( F_2 \) are equal in magnitude, and the magnitude of \( F_3 \) is half as great. Force \( F_1 \) is horizontal, \( F_2 \) and \( F_3 \) are vertical, and the lever makes an angle of 45° with the horizontal. Do these forces cause the lever to rotate about the pivot? If so, in which direction?
The lever arm distances must now be determined relative to the left end of the rod. The lever arm distance of force $F_1$ to this point is zero, and so the torque caused by that force about the left end of the rod is zero. If I choose counterclockwise as the positive direction of rotation, $F_1$ causes a negative torque about the left end of the rod; the force $F_2$ exerted by the pivot causes a positive torque about the left end of the rod. The lever arm distance of $F_2$ about the left end of the rod is $r_1 + r_2$; that of $F_3$ is $r_1$. Because the rod is at rest, the magnitude of the force exerted by the pivot is equal to the sum of the forces $F_1$ and $F_2$. Taking into account the signs of the torques, we find that the sum of the torques about the left end of the rod is $r_1(F_1 + F_2) - (r_1 + r_2)F_3 = r_1F_1 - r_1F_2$. This is the same result we obtained for the torques about the pivot, and so the sum of the torques about the left end is zero.

Exercise 12.1 shows that the sum of the torques about the left end of the rod is zero, just like the sum of the torques about the pivot. You can repeat the calculation for the torques about the right end of the rod or any other point, and each time you will find that the sum of the torques is zero. The reason is that the rod is not rotating about any point, and so the sum of the torques must be zero about any point. In general we can say:

For a stationary object, the sum of the torques is zero.

For a stationary object we can choose any reference point we like to calculate torques. It pays to choose a reference point that simplifies the calculation. As you have seen, we do not need to consider any force that is exerted at the reference point. So, by putting the reference point at the point of application of a force, we can eliminate that force from the calculation.

12.2 In the situation depicted in Figure 12.2a, you must continue to exert a force on the seesaw to keep the child off the ground. The force you exert causes a torque on the seesaw, and yet the seesaw's rotational acceleration is zero. How can this be if torques cause objects to accelerate rotationally?

**Example 12.2 Torques on lever**

Three forces are exerted on the lever of Figure 12.7. Forces $F_1$ and $F_2$ are equal in magnitude, and the magnitude of $F_3$ is half as great. Force $F_1$ is horizontal, $F_2$ and $F_3$ are vertical, and the lever makes an angle of 45° with the horizontal. Do these forces cause the lever to rotate about the pivot? If so, in which direction?
I don't understand how this combination of factors tells you anything about direction? Aren't magnitude and lever arm distance both scalar quantities? It seems like we would need to know some sort of direction to calculate torque.

I think you may be able to think about the direction separately. So, after multiplying this magnitude and distance, you can attach a sign to the torque based on the defined parameters of the system. In the following paragraph, they start to explain how to choose this direction.

This is a great question. To further elaborate on this, we can think of this in terms of the Torque equation. The equation for torque is $\tau = r \times F$, with $r$ being the level arm distance and $F$ being force. We know that force is a vector vector from previous chapters, and in regards to "$r" it can also be thought of as the radial vector. What this means is that this distance from the pivot points from the axis of rotation to the point where the force acts. In as previously mentioned, there is a general convention (the right-hand rule) that is used to determine the direction which happens to be perpendicular to both the radius from the axis and to the force.
connect pre-class and in-class activities
Confusion report for Chapter 24

right hand rule (11 questions)

- JB  Can someone in simpler terms explain the right-hand rule?
- WJ  Is there another way, besides the right hand rule, to find the direction of the magnetic field with a current?
- SB  Using the right hand rule, I believe the answer is D. Is that correct?

direction magnetic field (8 questions)

- CP  Why is it that the magnet field points away from the north pole and towards the south pole? When on the previous page it stated that the direction of the magnetic field is the direction that the north pole of a compass needle points.
- AB  How can you determine which direction the magnetic field will point towards?
- KH  So whichever way the north pole faces is the direction of the magnetic field but that doesn’t always mean its pointing true north?

earth magnetic field (6 questions)

- CP  Does that mean that the compass will be distracted from the Earth’s magnetic field and use the magnetic field that the current of the wire gives off?
- AK  Can someone explain why this type of bacteria knows what direction the earth’s magnetic fields are facing?
- J  Does the circular loop of current have any similarities with the look of the earth’s magnetic field? They kind of look similar to me.
out of class

information transfer

Perusall

in class

sense-making

Peer Instruction
Perusall

Peer Instruction

works online!
suppose instead...
information transfer
instructor-paced synchronous lecture

sense-making
self-paced asynchronous home work/study

campus

home
Information transfer

Instructor-paced synchronous lecture

Sense-making

Self-paced asynchronous home work/study
In the diagram, the following activities are highlighted:

- **Campus**: instructor-paced synchronous lecture
- **Home**: instructor-paced synchronous **online** lecture
- **Home**: self-paced asynchronous home work/study

These activities suggest a comparison between learning environments and methodologies.
instructor-paced asynchronous recorded lecture

instructor-paced synchronous lecture

sense-making

home work/study

information transfer
instructor-paced asynchronous recorded lecture

ALONE!

self-paced asynchronous home work/study
online

information transfer

self-paced asynchronous

sense-making

instructor-led synchronous
interactive

self-paced
asynchronous

self-paced
asynchronous

instructor-led
synchronous

instructor-led
synchronous

online

information transfer

sense-making
interactive

two evidence-based approaches
blend of 6 scaffolded “best practices”
let’s try an RAA (2-stage exam)

• back to Learning Catalytics!

• join session ID 14666856

• enter the number of your team
team-round instructions

- **hands off keyboard** (until in BO rooms)
- **designate a “responder”**
- **have responder share screen**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>LC: Learning Catalytics</td>
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<tr>
<td>Tutorial</td>
<td>60 min</td>
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<tr>
<td>EA: Estimation Activity</td>
<td>30 min</td>
</tr>
<tr>
<td>EDA: Experimental Design Activity</td>
<td>90 min</td>
</tr>
<tr>
<td>Problem Set &amp; Reflection</td>
<td>90 min</td>
</tr>
<tr>
<td>RAA: Readiness Assurance Activity</td>
<td>90 min</td>
</tr>
<tr>
<td>Part 1: solve problems alone</td>
<td></td>
</tr>
<tr>
<td>Part 2: solve with team</td>
<td></td>
</tr>
</tbody>
</table>
You have completed all of the questions.

5/5 questions attempted, 18.0/20 possible points in team round

You have been scored on the following questions:

<table>
<thead>
<tr>
<th>Question</th>
<th>Individual Result</th>
<th>Points</th>
<th>Team Result</th>
<th>Points</th>
<th>Total Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>2.0</td>
<td>1.0</td>
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<tr>
<td>2</td>
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<tr>
<td>3</td>
<td>Correct</td>
<td>4.0</td>
<td>Correct (on attempt 1)</td>
<td>4.0</td>
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<tr>
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<td>Incorrect</td>
<td>0.0</td>
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<td>Correct (on attempt 1)</td>
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<td>2.0</td>
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<tr>
<td>Total</td>
<td></td>
<td>4.0</td>
<td></td>
<td></td>
<td>18.0</td>
</tr>
</tbody>
</table>

Total possible points: 20

Points earned: 18.0

Final score: 11.0

Scoring summary
Education is not just about:

• transferring information

• getting students to do what we do
Education is not just about:

• transferring information

• getting students to do what we do

active engagement/social interaction a must!
mazur.harvard.edu

Follow me! @eric_mazur