Innovating education to educate innovators

2016 Transforming Undergraduate STEM Education
Association of American Colleges & Universities
Boston, MA, 3 November 2016
1. information transfer
2. assimilation of information
1. information transfer (easy)

2. assimilation of information (hard and left to student)
1. information transfer (easy)

2. assimilation of information (hard and left to student)
thermal expansion
all of them
Consider a rectangular metal plate with a circular hole in it.
Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole

1. increases.
2. stays the same.
3. decreases.
Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole:

1. increases.
2. stays the same.
3. decreases.
Before I tell you the answer, let’s analyze what happened.
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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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3. decreases.
consider atoms at rim of hole
consider atoms at rim of hole
consider atoms at rim of hole
consider atoms at rim of hole
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you won’t forget this
Higher learning gains
Higher learning gains

normalized gain (%)

lecture peer instruction
CLASS
1st exposure

ROOM
deeper understanding
1st exposure deeper understanding

1st exposure deeper understanding
how to effectively transfer information outside classroom?
but...
• transfer pace set by video
• viewer passive
• viewing/attention tanks as time passes
• isolated/individual experience
we’re simply moving this outside classroom!
• transfer pace set by reader

• viewer active
but...
isolated/individual experience & no real accountability
want:
every student prepared for every class
want:
every student prepared for every class
(without additional instructor effort)
Solution
turn out-of-class component also into a social interaction!
Perusall every student prepared for every class
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 sliding on a wooden surface. After traveling some distance, it 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 slides for a longer time interval than if the surfaces are rough or sticky. This you know from 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.

In the absence of friction, objects moving along a horizontal track keep moving without slowing down.
log in through social network
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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 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:

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Figure 4.2 shows low-friction track and carts used in the experiments described in this chapter.

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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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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.

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

4.1 (a) Are the accelerations of the motions shown in Figure 4.1 constant? (b) For which surface is the acceleration largest in magnitude?
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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 4.4 shows how the speed of the block decreases over time due to friction—the resistance to motion that one surface or object encounters when moving over another. Notice, during the interval covered by the velocity-versus-time graph, the velocity decreases as the block slides. Or, ice is hardly observable. The block slides easily because there is very little friction between the two surfaces. The effect of friction is to bring two objects into 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 smoother the surface, the more quickly the velocity decreases.

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![Figure 4.1](image) 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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action of the force and the axis of rotation. So, the torque caused by a force exerted on an object is the product of the magnitude of the force and its lever arm distance. It can be written equivalently as \( r \cdot F \), and as \( r \cdot F \).

Like other rotational quantities, torque carries a sign that depends on the choice of direction for increasing \( \theta \). In Figure 12.4, for example, the torque caused by \( F_1 \) about the pivot tends to rotate the rod in the direction of increasing \( \theta \) and so is positive; the torque caused by \( F_2 \) is negative. The sum of the two torques about the pivot is then \( r_1 F_1 - r_2 F_2 \). As we've seen, the two torques are equal in magnitude when the rod is balanced, and so the sum of the torques is zero. When the sum of the torques is not zero, the rod's rotational acceleration is nonzero, and so its rotational velocity and angular momentum change.

In the situations depicted in Figures 12.4 and 12.5 we used the pivot to calculate the lever arm distances. This is a natural choice because that is the point about which the object under consideration is free to rotate. However, torques also play a role for stationary objects that are suspended or supported at several different points and that are not free to rotate about any pivot. In such cases we can choose any reference point for the calculation. As we 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.

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.
Multiply magnitude of \( F \) by \( r \).

Action of the force and the axis of rotation. So, the torque caused by a force exerted on an object is the product of the magnitude of the force and its lever arm distance. It can be calculated as:

\[
\tau = r \times F
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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.
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.
how to get students to participate?
use combination of intrinsic and extrinsic motivation drivers
rubric-based assessment

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rubric-based assessment

must demonstrate thoughtful reading & interpretation
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must demonstrate thoughtful reading & interpretation

• **quantity (10–20)**

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Exercise 12.2 in the textbook contains a similar problem; you may want to try that one.
rubric-based assessment

must demonstrate thoughtful reading & interpretation

- quantity (10–20)

- timeliness (before class)
rubric-based assessment

must demonstrate thoughtful reading & interpretation

- quantity (10–20)
- timeliness (before class)
- distribution (not clustered)
rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)
- distribution (not clustered)

over 20,000 annotations!
rubric-based assessment

• quality (thoughtful reading & interpretation)
• quantity (minimum 10)
• timeliness (before class)
• distribution (not clustered)

how do you process all of that??
rubric-based assessment

- quality (thoughtful reading & interpretation)
- quantity (minimum 10)
- timeliness (before class)
- distribution (not clustered)

How do you process all of that??

fully automated assessment
fully automated assessment

• specialized machine learning algorithm

• assesses intellectual content

• exceeds intercoder reliability
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?
Intrinsic:

- social interaction

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

For a stationary object we can choose any reference point.

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Motivating factors:

- Intrinsic:
  - social interaction
motivating factors

Intrinsic:

• social interaction

• tie-in to in-class activity
motivating factors

**Intrinsic:**

- social interaction
- tie-in to in-class activity

**Extrinsic:**

- assessment (fully automated)
close to 95%!
every student prepared for every class
Benefits

• virtually 100% completion of assignments
• improved use of class time
Benefits

• virtually 100% completion of assignments
• improved use of class time

all at no cost & without additional instructor effort!
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 participation/social interaction a must!
for a copy of this presentation

ericmazur.com

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