ACTIVATING UNIVERSITY PHYSICS: MAKING PHYSICS LECTURES COME ALIVE

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10 MAY 2023

PLEASE FEEL FREE TO ASK QUESTIONS DURING THE WEBINAR!
I understand the concepts...
I understand the concepts... I just can’t do the problems!
Today's Lesson: \( W_0 \) or "Witten's Dog"

\[ e^- + p \rightarrow \Omega + \gamma \]

\[ \Omega \gamma = \sum_{i=1}^{\infty} \left( \frac{m_i}{93\text{ eV}} \right)^2 \left( \frac{\Omega_0 W_0}{(Z+1)^4} \right)^2 \]

"SuperDuperSymmetric String Theory"

"Neutron Encrusted Steaming Hot Dark Matter"

(FUTURAMA)
LECTURE 1375

(University of Bologna -- Painting by Laurentius de Voltolina)
(UNIVERSITY OF BOLOGNA -- PAINTING BY LAURENTIUS DE VOLTOLINA)
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STUDENT LEARNING GAINS IN PHYSICS

CLASS LEARNING GAIN: \[ g = \frac{\langle \text{post-test\%} \rangle - \langle \text{pre-test\%} \rangle}{100 - \langle \text{pre-test\%} \rangle} \]
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**STUDENT LEARNING GAINS IN PHYSICS**

**CLASS LEARNING GAIN:**

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WHAT IS ACTIVE LEARNING?
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STUDENTS ARE ACTIVELY ENGAGED DURING THE CLASS PERIOD
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• ANSWERING CONCEPTUAL QUESTIONS
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• ANSWERING CONCEPTUAL QUESTIONS
• PREDICTING THE RESULTS OF EXPERIMENTS
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• SOLVING PROBLEMS
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• ANSWERING CONCEPTUAL QUESTIONS
• PREDICTING THE RESULTS OF EXPERIMENTS
• SOLVING PROBLEMS
I understand the concepts...

...I just can't do the problems!
I understand the concepts… I just can’t do the problems!
I can do the problems that are just like those in the book...
I can do the problems that are just like those in the book... but I don't understand the concepts well enough to do anything else!
AN IN-CLASS TOOL TO HELP STUDENTS WITH CONCEPTUAL UNDERSTANDING: CLICKER QUESTIONS

I CAN DO THE PROBLEMS THAT ARE JUST LIKE THOSE IN THE BOOK...

... BUT I DON'T UNDERSTAND THE CONCEPTS WELL ENOUGH TO DO ANYTHING ELSE!
A wave on a string is moving to the right. This graph of $y(x, t)$ versus coordinate $x$ for a specific time $t$ shows the shape of part of the string at that time.

At this time, what is the velocity of a particle of the string at $x = a$?

A. The velocity is upward.
B. The velocity is downward.
C. The velocity is zero.
D. Either A. or B. is possible.
E. Any of A., B., or C. is possible.
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At this time, what is the **velocity** of a particle of the string at $x = b$?

A. The velocity is upward.

B. The velocity is downward.

C. The velocity is zero.

D. Either A. or B. is possible.

E. Any of A., B., or C. is possible.
A wave on a string is moving to the right. This graph of $y(x, t)$ versus coordinate $x$ for a specific time $t$ shows the shape of part of the string at that time.

At this time, what is the velocity of a particle of the string at $x = b$?

A. The velocity is upward.
B. The velocity is downward.
C. The velocity is zero.
D. Either A. or B. is possible.
E. Any of A., B., or C. is possible.
The figure shows three orbits of a spacecraft around the Earth:

A. circular orbit, radius
   \( r_1 = 7000 \text{ km} \)

B. circular orbit, radius
   \( r_2 = 14,000 \text{ km} \)

C. an elliptical transfer orbit between the orbits A and B

Rank these three orbits from \textit{highest} to \textit{lowest} angular momentum.
A RANKING TASK

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C. an elliptical transfer orbit between the orbits A and B

Rank these three orbits from highest to lowest angular momentum.

B, C, A
WHAT ACTIVE LEARNING PROVIDES
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STUDENT-TO-STUDENT FEEDBACK
WHAT ACTIVE LEARNING PROVIDES

STUDENT-TO-STUDENT FEEDBACK
STUDENT-TO-INSTRUCTOR FEEDBACK
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INSTRUCTOR-TO-STUDENT FEEDBACK
WHERE CAN CLICKER QUESTIONS (AND ANSWERS!) BE FOUND?
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Resources by Chapter

Chapter 2: Motion Along a Straight Line

Download instructor resources from the links below.

**Lecture Outline and Text Elements**

**Chapter 2 Lecture and Text Elements**

**Chapter 2 Clicker Questions**
Clicker questions in PowerPoint with alt text for accessibility.
Mastering Physics includes extensive video content.
MASTERING PHYSICS INCLUDES EXTENSIVE VIDEO CONTENT

-- VIDEO TUTOR SOLUTIONS
-- VIDEO TUTOR DEMONSTRATIONS
-- CONCEPTUAL VIDEOS
-- VIDEO LECTURES BY PROF. MATT ANDERSON, SAN DIEGO STATE UNIVERSITY
IDEA: USE THESE TO REPLACE PART OR ALL OF YOUR OWN LECTURES -- FREEING UP CLASS TIME FOR ACTIVE LEARNING!

-- VIDEO LECTURES BY PROF. MATT ANDERSON, SAN DIEGO STATE UNIVERSITY
Textbook features designed to help with student learning.
VISUAL AIDS TO LEARNING
VISUAL AIDS TO LEARNING

THE AMAZING SPIDER-MAN #2, APRIL 1963 ©MARVEL
VISUAL AIDS TO LEARNING

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VISUAL AIDS TO LEARNING

A KEY EQUATION AS PRESENTED IN MOST TEXTBOOKS

\[ \vec{F}_{A \text{ on } B} = -\vec{F}_{B \text{ on } A} \] (4.10)
A key equation as presented in most textbooks

\[ \vec{F}_{A \text{ on } B} = -\vec{F}_{B \text{ on } A} \quad (4.10) \]

The same equation as presented in Young & Freedman

**Newton's third law:**
When two objects A and B exert forces on each other ...

\[ \vec{F}_{A \text{ on } B} = -\vec{F}_{B \text{ on } A} \]

Note: The two forces act on different objects.

... the two forces have the same magnitude but opposite directions.
Figure 4.17  Our sketch for this problem.

The vertical components of the external forces on the box sum to zero, and the box has no vertical acceleration.

The horizontal components of the external forces on the box do not add to zero, so the box has a horizontal acceleration.
PROBLEM-SOLVING GUIDANCE
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**ISEE:** IDENTIFY, SET UP, EXECUTE, EVALUATE
PROBLEM-SOLVING GUIDANCE

ISEE: IDENTIFY, SET UP, EXECUTE, EVALUATE
-- USED IN PROBLEM-SOLVING STRATEGIES
IN EVERY CHAPTER

PROBLEM-SOLVING STRATEGY 16.1 Sound Intensity

IDENTIFY the relevant concepts: The relationships between the intensity and amplitude of a sound wave are straightforward. Other quantities are involved in these relationships, however, so it’s particularly important to decide which is your target variable.

SET UP the problem using the following steps:
1. Sort the physical quantities into categories. Wave properties include the displacement and pressure amplitudes $A$ and $p_{\text{max}}$. The frequency $f$ can be determined from the angular frequency $\omega$, the wave number $k$, or the wavelength $\lambda$. These quantities are related through the wave speed $v$, which is determined by properties of the medium ($B$ and $\rho$ for a liquid, and $\gamma$, $T$, and $M$ for a gas).

2. List the given quantities and identify the target variables. Find relationships that take you where you want to go.

EXECUTE the solution: Use your selected equations to solve for the target variables. Express the temperature in kelvins (Celsius temperature plus 273.15) to calculate the speed of sound in a gas.

EVALUATE your answer: If possible, use an alternative relationship to check your results.
Problem-solving guidance

ISEE: Identify, Set Up, Execute, Evaluate
-- Used in Problem-solving Strategies in every chapter
-- Used in all worked examples

Example 16.5 Intensity of a sound wave in air

Find the intensity of the sound wave in Example 16.1, with $p_{\text{max}} = 3.0 \times 10^{-2}$ Pa. Assume the temperature is 20°C so that the density of air is $\rho = 1.20 \text{ kg/m}^3$ and the speed of sound is $v = 344 \text{ m/s}$.

Identify and Set Up Our target variable is the intensity $I$ of the sound wave. We are given the pressure amplitude $p_{\text{max}}$ of the wave as well as the density $\rho$ and wave speed $v$ for the medium. We can determine $I$ from $p_{\text{max}}$, $\rho$, and $v$ from Eq. (16.14).

Execute From Eq. (16.14),

$$I = \frac{p_{\text{max}}^2}{2\rho v} = \frac{(3.0 \times 10^{-2} \text{ Pa})^2}{2(1.20 \text{ kg/m}^3)(344 \text{ m/s})}$$

$$= 1.1 \times 10^{-6} \text{ J/(s \cdot m}^2) = 1.1 \times 10^{-6} \text{ W/m}^2$$

Evaluate This seems like a very low intensity, but it is well within the range of sound intensities encountered on a daily basis. A very loud sound wave at the threshold of pain has a pressure amplitude of about 30 Pa and an intensity of about 1 W/m². The pressure amplitude of the faintest sound wave that can be heard is about $3 \times 10^{-5}$ Pa, and the corresponding intensity is about $10^{-12}$ W/m². (Try these values of $p_{\text{max}}$ in Eq. (16.14) to check that the corresponding intensities are as we have stated.)

Key Concept The intensity (power per unit area) of a sound wave is proportional to the square of the pressure amplitude of the wave. The proportionality constant depends on the density of the medium and the speed of sound in the medium.
PROBLEM-SOLVING GUIDANCE

ISEE: IDENTIFY, SET UP, EXECUTE, EVALUATE

-- USED IN PROBLEM-SOLVING STRATEGIES IN EVERY CHAPTER

-- USED IN ALL WORKED EXAMPLES

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PROBLEM-SOLVING GUIDANCE

-- KEY CONCEPT CALLED OUT EXPLICITLY IN ALL EXAMPLES

-- THREE EXAMPLES PER CHAPTER HAVE ASSOCIATED VARIATION PROBLEMS

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-- THREE EXAMPLES PER CHAPTER HAVE ASSOCIATED VARIATION PROBLEMS

(ANSWERS TO THE VARIATION PROBLEMS ARE PROVIDED AT THE END OF THE CHAPTER)
**Problem-Solving Guidance** -- Bridging Problem in Each Chapter Helps Transition to End-of-Chapter Problems (Answer Provided at End of Chapter)

**Bridging Problem**  Loudspeaker Interference

Loudspeakers A and B are 7.00 m apart and vibrate in phase at 172 Hz. They radiate sound uniformly in all directions. Their acoustic power outputs are $8.00 \times 10^{-4}$ W and $6.00 \times 10^{-3}$ W, respectively. The air temperature is 20°C. (a) Determine the difference in phase of the two signals at a point C along the line joining A and B, 3.00 m from B and 4.00 m from A (Fig. 16.39). (b) Determine the intensity and sound intensity level at C from speaker A alone (with B turned off) and from speaker B alone (with A turned off). (c) Determine the intensity and sound intensity level at C from both speakers together.

**SOLUTION GUIDE**

**IDENTIFY and SET UP**

1. Choose the equations that relate power, distance from the source, intensity, pressure amplitude, and sound intensity level.

**Figure 16.39** The situation for this problem.

2. Decide how you'll determine the phase difference in part (a). Once you have found the phase difference, how can you use it to find the amplitude of the combined wave at C due to both sources?

3. List the unknown quantities for each part of the problem and identify your target variables.

**EXECUTE**

4. Determine the phase difference at point C.

5. Find the intensity, sound intensity level, and pressure amplitude at C due to each speaker alone.

6. Use your results from steps 4 and 5 to find the pressure amplitude at C due to both loudspeakers together.

7. Use your result from step 6 to find the intensity and sound intensity level at C due to both loudspeakers together.

**EVALUATE**

8. How do your results from part (c) for intensity and sound intensity level at C compare to those from part (b)? Does this make sense?

9. What result would you have gotten in part (c) if you had (incorrectly) combined the *intensities* from A and B directly, rather than (correctly) combining the *pressure amplitudes* as you did in step 6?
CONFRONTING MISCONCEPTIONS
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-- CAUTION PARAGRAPHS IN EVERY CHAPTER
CONFRONTING MISCONCEPTIONS

-- CAUTION PARAGRAPHS IN EVERY CHAPTER
-- POINT OUT COMMON POINTS OF CONFUSION

CAUTION  Wave velocity vs. particle velocity  Remember that the velocity of the wave as a whole is *not* the same as the particle velocity. While the wave continues to move in the direction of propagation, individual particles in the wave medium merely slosh back and forth, as shown in Fig. 16.1. Furthermore, the maximum speed of a particle of the medium can be very different from the wave speed.
CONFRONTING MISCONCEPTIONS

-- CAUTION PARAGRAPHS IN EVERY CHAPTER
-- POINT OUT COMMON POINTS OF CONFUSION
-- POINT OUT COMMON PRECONCEPTIONS ABOUT PHYSICS

CAUTION  Any particle following a curved path is accelerating. When a particle is moving in a curved path, it always has nonzero acceleration, even when it moves with constant speed. This conclusion is contrary to the everyday use of the word “acceleration” to mean that speed is increasing. The more precise definition given in Eq. (3.9) shows that there is a nonzero acceleration whenever the velocity vector changes in any way, whether there is a change of speed, direction, or both.
CONFRONTING MISCONCEPTIONS

SCIENCE says you’re WRONG if you BELIEVE THAT

IN A VACUUM, A BULLET THAT IS DROPPED FROM A HAND WILL STRIKE THE GROUND SOONER THAN ONE FIRED FROM A RIFLE HELD PARALLEL TO THE GROUND AND FROM THE SAME HEIGHT...

BOTH BULLETS WOULD FALL TO EARTH AT THE SAME INSTANT! IN AIR, THE DROPPED BULLET WOULD LAND A FRACTION OF A SECOND BEFORE THE FIRED BULLET!

THE MOON REVOLVES AROUND THE EARTH...

THE ORBITS OF THE EARTH AND MOON

IT IS ONLY PARTIALLY TRUE THAT THE MOON REVOLVES AROUND THE EARTH, FOR AT THE SAME TIME THE EARTH REVOLVES AROUND THE MOON! THE CENTER OF GRAVITY AROUND WHICH THE TWO BODIES MUTUALLY REVOLVE IS 1,000 MILES BELOW THE EARTH’S SURFACE!
CONFRONTING MISCONCEPTIONS

**Strange Adventures** #119
August 1960
©DC

**Mystery in Space** #70
September 1961
©DC
A NEW COMIC BOOK FOR PHYSICS
A NEW COMIC BOOK FOR PHYSICS

COLLABORATOR AND ARTIST: JUANELE
(DR. JUAN MANUEL RAMÍREZ DE ARELLANO)
A NEW COMIC BOOK FOR PHYSICS

ALONZO
A NEW COMIC BOOK FOR PHYSICS

ALONZO

ELENA
A NEW COMIC BOOK FOR PHYSICS

ALONZO

ELENA

KEPLER THE CAT
A NEW COMIC BOOK FOR PHYSICS

ALONZO

ELENA

KEPLER THE CAT

THE SQUIRREL
Alonzo has the same difficulties with physics as many typical students.
ELENA PROVIDES ALONZO WITH STUDENT-TO-STUDENT GUIDANCE (WITH COMIC RELIEF FROM KEPLER)
KEPLER checks for conceptual understanding
KEPLER CHECKS FOR CONCEPTUAL UNDERSTANDING … AND PROVIDES GUIDANCE WITH ASSISTANCE FROM THE SQUIRREL
THE ENTIRE CAST PROVIDES GUIDANCE WITH SOLVING PHYSICS PROBLEMS
The entire cast provides guidance with solving physics problems...including step-by-step help!

Now I just have to do a little algebra to solve for the maximum angle \( \theta \) to prevent sliding...

...and you can see that this angle is just the arctangent of \( \mu_s \), the coefficient of static friction!

Solve 1 for \( f_{\text{max}} \):

\[
f_{\text{max}} = mg \sin \theta
\]

Solve 2 for \( n \):

\[
n = mg \cos \theta
\]

Substitute \( f_{\text{max}} \) and \( n \) into 3:

\[
mg \sin \theta = \mu_s mg \cos \theta
\]

Cancel the \( mg \) factors:

\[
\sin \theta = \mu_s \cos \theta
\]

So

\[
\mu_s = \frac{\sin \theta}{\cos \theta} = \tan \theta
\]

Solve for \( \theta \):

\[
\theta = \arctan \mu_s
\]

Since

\[
\mu_s = 0.600,
\]

\[
\theta = \arctan 0.600 = 31.0^\circ
\]

And since \( \mu_s = 0.600 \), you can tilt the table up to \( 31.0^\circ \) without making us slide!
Elena and Kepler demonstrate that problem-solving doesn't end with finding a number or formula… you must also interpret the answer!
Resolución de problemas como los expertos:

Fricción cinética y estática

¡Ya tenemos todas las herramientas que necesitamos para resolver problemas con fricción!

¡Bien, Alonzo! Estamos otra vez en reposo en la mesa inclinada.

¿Puedes calcular el ángulo máximo desde la horizontal que puede tener la mesa, evitando que nos deslicemos?

Aquí hay información (potencialmente) útil:

Masa de Kepler: 4.00 kg
Masa de la ardilla: 0.60 kg
Masa del plató: 0.50 kg
Coeficientes de fricción:
\[ \mu_k = 0.400 \]
\[ \mu_s = 0.600 \]

¡Estoy listo! ¡Vamos!

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¡Estoy listo! ¡Vamos!

Each chapter of the comic book will also be available in Spanish
ROGER FREEDMAN
AIRBOY@UCSB.EDU

LINKS TO INFO ABOUT
ACTIVE LEARNING, A SAMPLE
CHAPTER OF THE COMIC BOOK,
CHATGPT, AND MUCH MORE!

bit.ly/42EozWY