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Essential Physics™

Tom Hsu, Ph.D.
Manos Chaniotakis, Ph.D.
Michael Pahre, Ph.D.

Second Edition

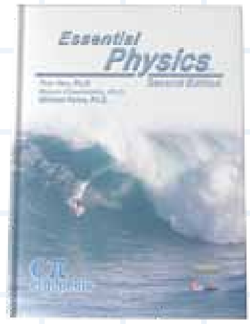
- ☑ Stand-alone e-Book
- ☑ Online e-Book
- ☑ Hardcover textbook
- ☑ Full digital T.E.
- ☑ Exceptional equipment

Second Edition

Essential Physics™

Essential Physics is a high school STEM physics program that includes an extraordinary e-Book, a matching print textbook, and a coordinated set of powerful, wirelessly-connected lab equipment. Suitable for introductory levels through AP physics, *Essential Physics'* interactivity makes rigorous physics concepts accessible to all levels. The digital Teacher's Edition includes 139 slide presentations, lesson plans, student assignments, self-grading assessments, access to our infinite test bank, and more!

Textbook



e-Book

Equipment

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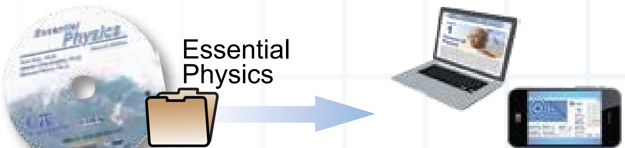
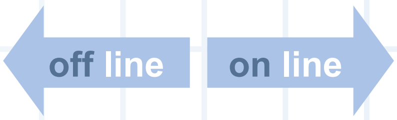
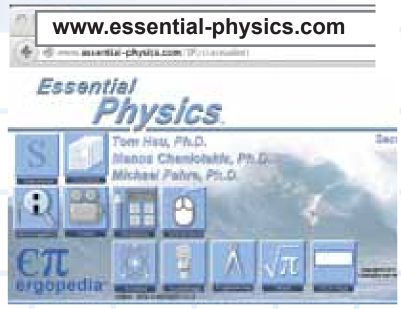
HTML5

... with the Internet and without,







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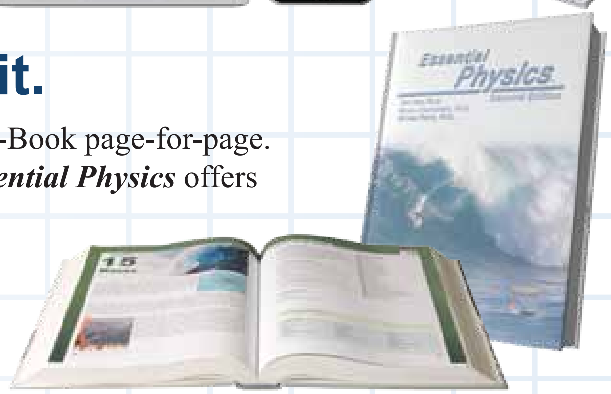

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A true STEM curriculum

Technology, engineering, and mathematics are intimately connected to physics. Students can see these connections within the current chapter by clicking the icon at the top of every page. The same icons from the front cover provide book-wide references for technology, engineering, and mathematics content.

Technology

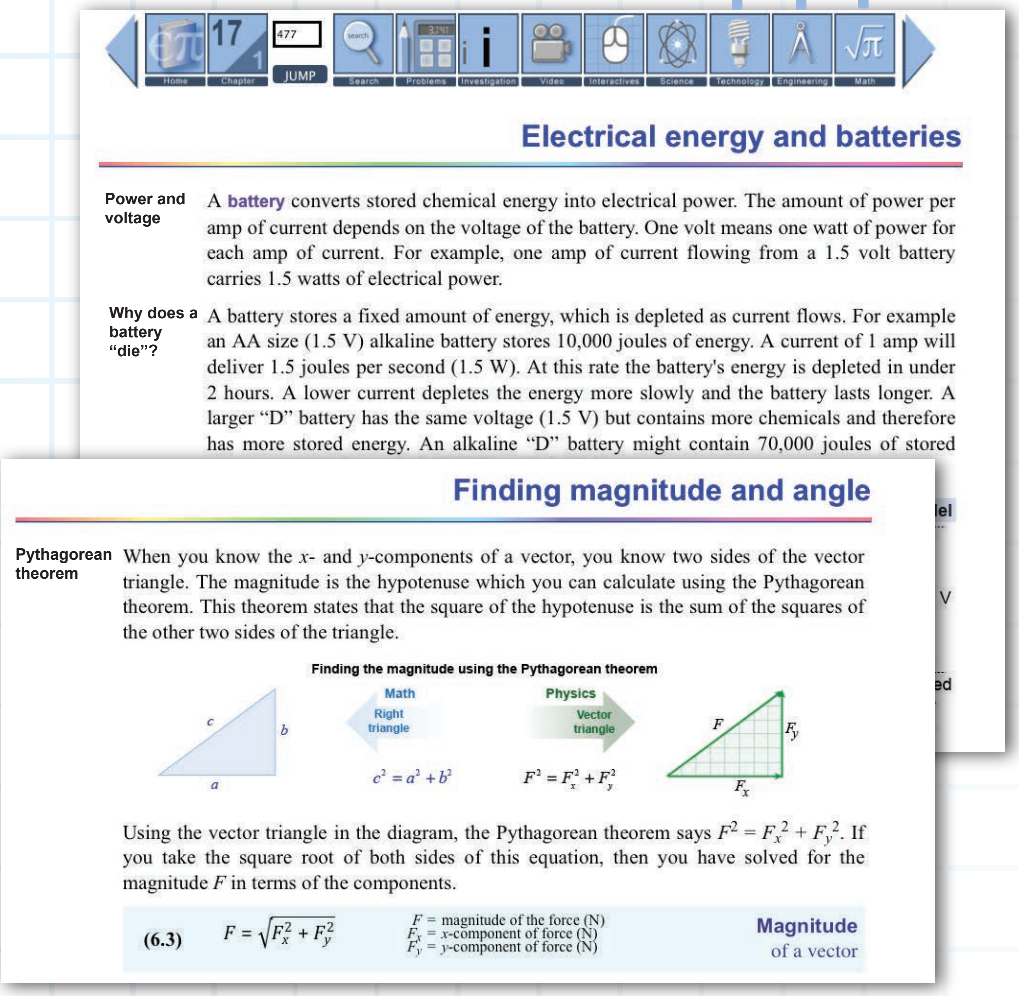
- Rechargeable batteries
- AC home wiring
- Circuit breakers and fuses
- Electric motors
- Semiconductors
- The digital multimeter

Engineering

- Designing a lemon battery
- Electrical power
- Photovoltaic power systems
- Regenerative braking
- Wire gauges and resistance
- Electrical conductors

Mathematics

- Solving two equations for two unknowns
- Inverse and direct relationships
- Square roots



Electrical energy and batteries

Power and voltage A **battery** converts stored chemical energy into electrical power. The amount of power per amp of current depends on the voltage of the battery. One volt means one watt of power for each amp of current. For example, one amp of current flowing from a 1.5 volt battery carries 1.5 watts of electrical power.

Why does a battery "die"? A battery stores a fixed amount of energy, which is depleted as current flows. For example an AA size (1.5 V) alkaline battery stores 10,000 joules of energy. A current of 1 amp will deliver 1.5 joules per second (1.5 W). At this rate the battery's energy is depleted in under 2 hours. A lower current depletes the energy more slowly and the battery lasts longer. A larger "D" battery has the same voltage (1.5 V) but contains more chemicals and therefore has more stored energy. An alkaline "D" battery might contain 70,000 joules of stored

Finding magnitude and angle

Pythagorean theorem When you know the x- and y-components of a vector, you know two sides of the vector triangle. The magnitude is the hypotenuse which you can calculate using the Pythagorean theorem. This theorem states that the square of the hypotenuse is the sum of the squares of the other two sides of the triangle.

Finding the magnitude using the Pythagorean theorem

Using the vector triangle in the diagram, the Pythagorean theorem says $F^2 = F_x^2 + F_y^2$. If you take the square root of both sides of this equation, then you have solved for the magnitude F in terms of the components.

(6.3) $F = \sqrt{F_x^2 + F_y^2}$ — F = magnitude of the force (N); F_x = x-component of force (N); F_y = y-component of force (N) — **Magnitude** of a vector

Science

Physics is the fundamental science underlying all of nature and human technology.

Technology

From the digital recording of sound to simple machines or hybrid cars, people experience physics through technology.

Engineering

Engineering is the creative process of applying science to create technology.

Mathematics

Essential Physics develops math skills by explicitly showing how important math concepts apply to physics.

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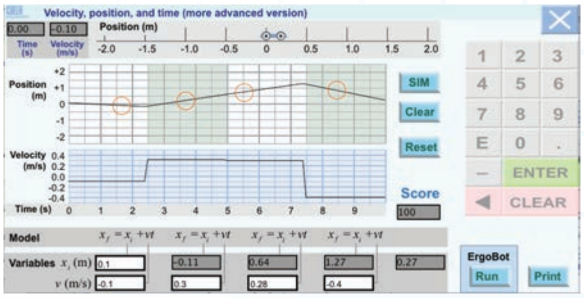
Interactivity makes powerful learning

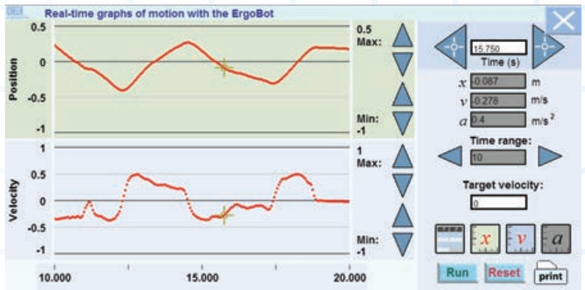
Second Edition

71 fully interactive simulations provide you with extraordinary tools to help students master physics concepts. Project them for class-wide discussions. Challenge students to explore physics ideas themselves. The instant feedback and self-grading features are exceptional at engaging students. ***There has never been an e-Book like this!***

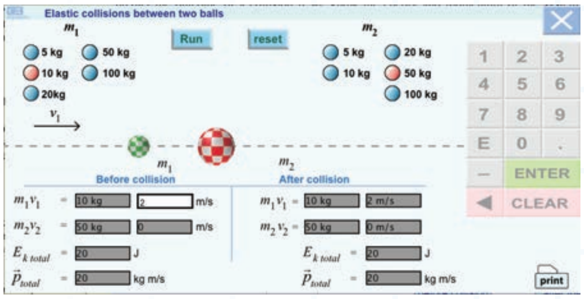
Just a few of the 71 interactive simulations included with *Essential Physics!*



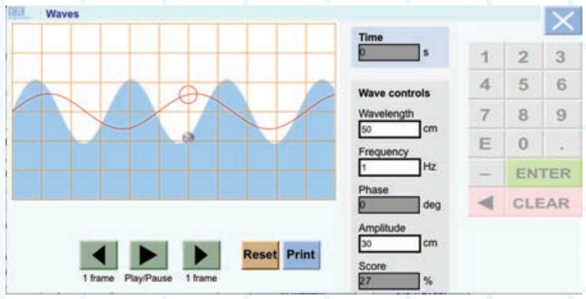
Interactive motion graphs with animation



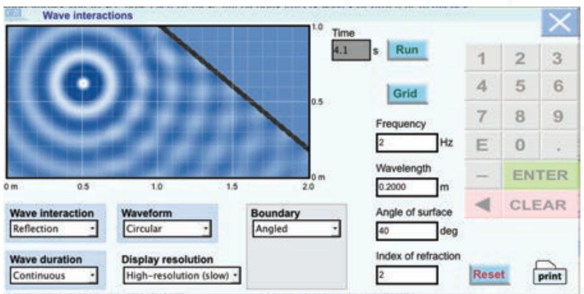
Real-time motion graphs show live data!



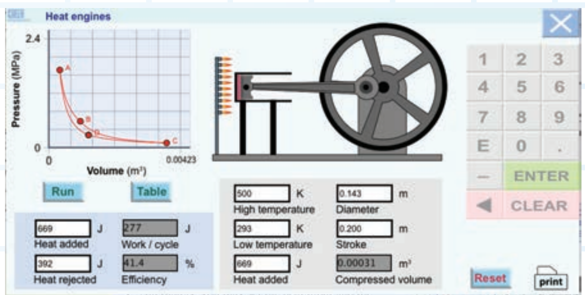
Collision simulations vary mass and velocities



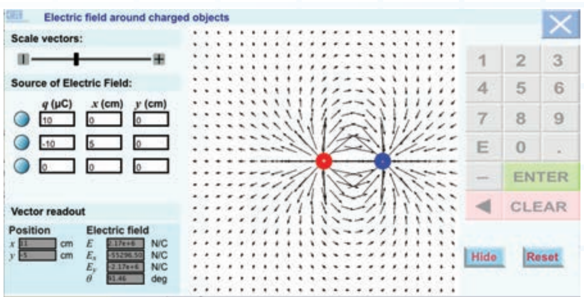
Amplitude, wavelength, and frequency of a wave



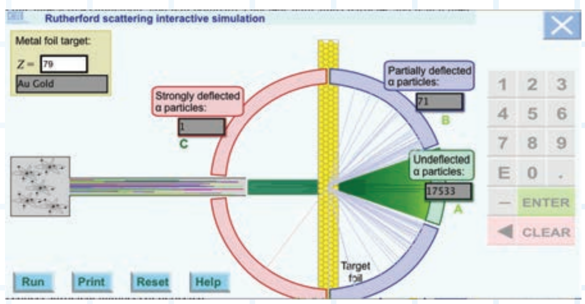
A "no-spill" ripple tank explores wave interactions.



Interactive heat engine explores thermodynamics



Electric and magnetic field viewer



Interactive Rutherford scattering experiment

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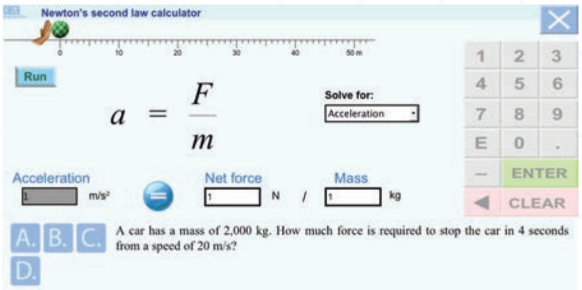
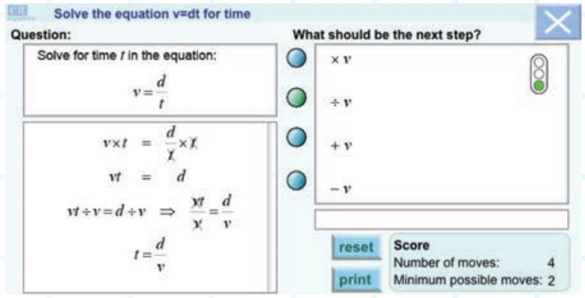
Learning math gets a turbo-boost

84 interactive equations provide a completely new way for students to understand equations and the mathematical language of physics. Project them and have your own animated lessons for each new formula! Example problems (included) help students learn to read and solve problems. ***There has never been an e-Book like this!***

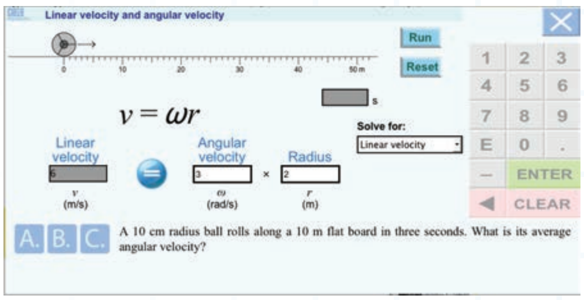
Just a few of the 84 interactive equations included with *Essential Physics!*



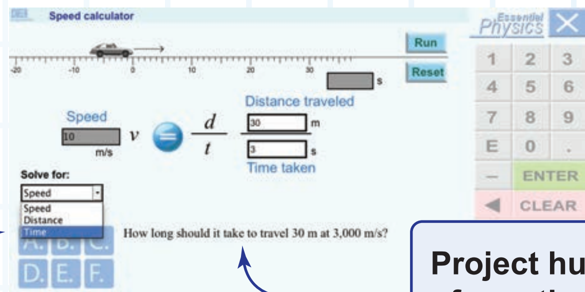
How does acceleration relate to force and mass?



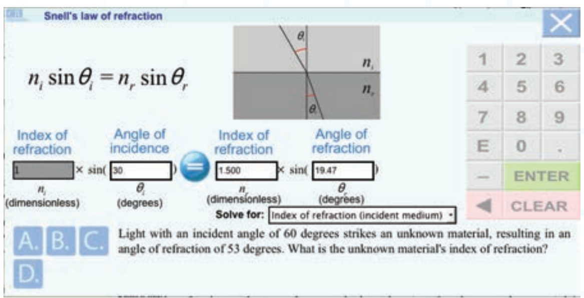
Equation solvers challenge students to apply algebra to manipulate equations.



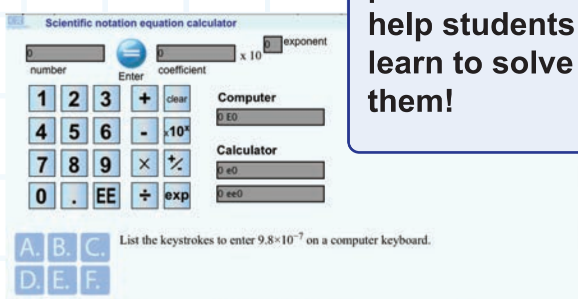
How are linear and angular velocity related?



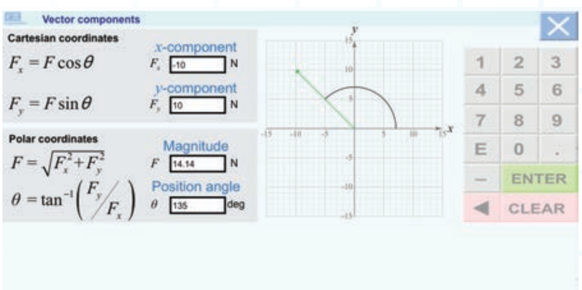
Project hundreds of practice problems and help students learn to solve them!



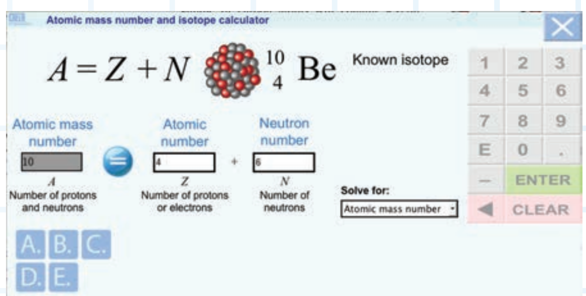
What are the angles in Snell's law?



How do you enter a scientific notation number on a calculator or spreadsheet?



Demonstrate the representations of vectors!



What are isotopes?

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Animation

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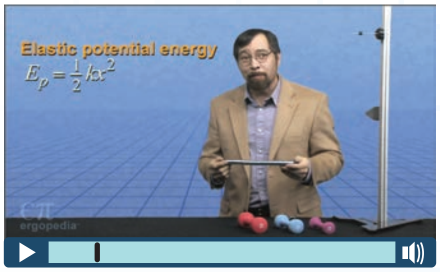
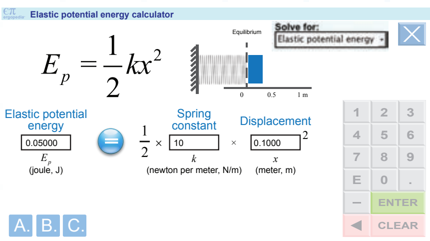
Embedded videos

Videos throughout the book cover a wide range of topics with clear, academically–rich content.



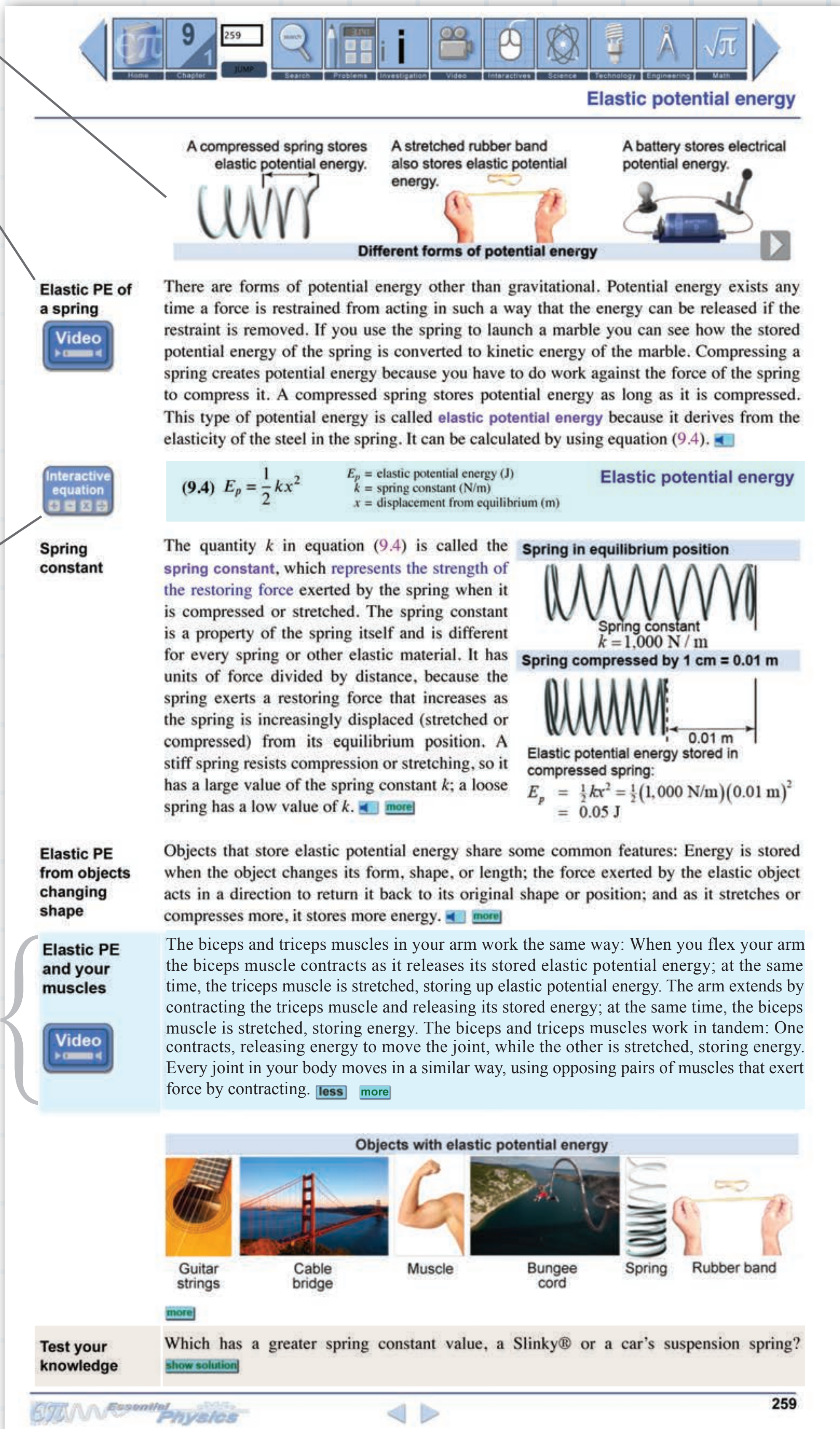
Interactive equations

Every new equation has an animated, interactive calculator allowing students to explore physical relationships quickly and quantitatively.



Extension paragraphs

Clicking the more button at the end of the paragraph opens additional descriptions, videos, or illustrations that provide interesting details precisely when and where you want them.



Elastic potential energy

A compressed spring stores elastic potential energy. A stretched rubber band also stores elastic potential energy. A battery stores electrical potential energy.

Different forms of potential energy

Elastic PE of a spring — Video

There are forms of potential energy other than gravitational. Potential energy exists any time a force is restrained from acting in such a way that the energy can be released if the restraint is removed. If you use the spring to launch a marble you can see how the stored potential energy of the spring is converted to kinetic energy of the marble. Compressing a spring creates potential energy because you have to do work against the force of the spring to compress it. A compressed spring stores potential energy as long as it is compressed. This type of potential energy is called **elastic potential energy** because it derives from the elasticity of the steel in the spring. It can be calculated by using equation (9.4).

Interactive equation

(9.4) $E_p = \frac{1}{2}kx^2$ — E_p = elastic potential energy (J); k = spring constant (N/m); x = displacement from equilibrium (m) — **Elastic potential energy**

Spring constant

The quantity k in equation (9.4) is called the **spring constant**, which represents the strength of the restoring force exerted by the spring when it is compressed or stretched. The spring constant is a property of the spring itself and is different for every spring or other elastic material. It has units of force divided by distance, because the spring exerts a restoring force that increases as the spring is increasingly displaced (stretched or compressed) from its equilibrium position. A stiff spring resists compression or stretching, so it has a large value of the spring constant k; a loose spring has a low value of k. more

Spring in equilibrium position — Spring constant $k = 1{,}000$ N / m

Spring compressed by 1 cm = 0.01 m — 0.01 m

Elastic potential energy stored in compressed spring:

$E_p = \frac{1}{2}kx^2 = \frac{1}{2}(1{,}000 \text{ N/m})(0.01 \text{ m})^2 = 0.05 \text{ J}$

Elastic PE from objects changing shape

Objects that store elastic potential energy share some common features: Energy is stored when the object changes its form, shape, or length; the force exerted by the elastic object acts in a direction to return it back to its original shape or position; and as it stretches or compresses more, it stores more energy. more

Elastic PE and your muscles — Video

The biceps and triceps muscles in your arm work the same way: When you flex your arm the biceps muscle contracts as it releases its stored elastic potential energy; at the same time, the triceps muscle is stretched, storing up elastic potential energy. The arm extends by contracting the triceps muscle and releasing its stored energy; at the same time, the biceps muscle is stretched, storing energy. The biceps and triceps muscles work in tandem: One contracts, releasing energy to move the joint, while the other is stretched, storing energy. Every joint in your body moves in a similar way, using opposing pairs of muscles that exert force by contracting. less more

Objects with elastic potential energy

Guitar strings — Cable bridge — Muscle — Bungee cord — Spring — Rubber band

more

Test your knowledge

Which has a greater spring constant value, a Slinky® or a car's suspension spring? show solution

259

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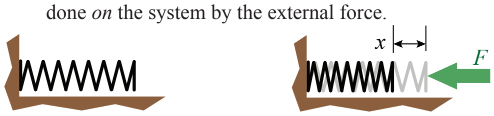
A readable textbook

10.2 - Work and energy transformations

So far, we have considered the energy in a system before and after a change. However, energy can also enter or leave a system. Mechanical energy enters or leaves a system through *work,* the action of forces. Work done *on* a system increases the system's total energy. Work done *by* a system decreases the system's total energy. This section broadens the scope of conservation of energy to include work done on or by a system.

Work and energy

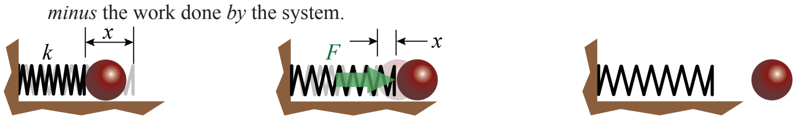
How do forces change the energy of a system? Recall that work is a form of energy. The work done by a force is the force multiplied by the distance moved in the direction of the force. Consider a system containing an uncompressed spring at its free length. A force acts from *outside the system* to compress the spring a distance, x. The final energy of the system is the initial energy it started with plus the work done *on* the system by the external force.



Initial energy		Work done		Final energy
$mgh_0 + \frac{1}{2}mv_0^2 + \frac{1}{2}kx_0^2$	+	W	=	$mgh_0 + \frac{1}{2}mv_0^2 + \frac{1}{2}kx^2$
		W	=	$\frac{1}{2}kx^2$

The final energy of a system is the initial energy plus work done on the system.

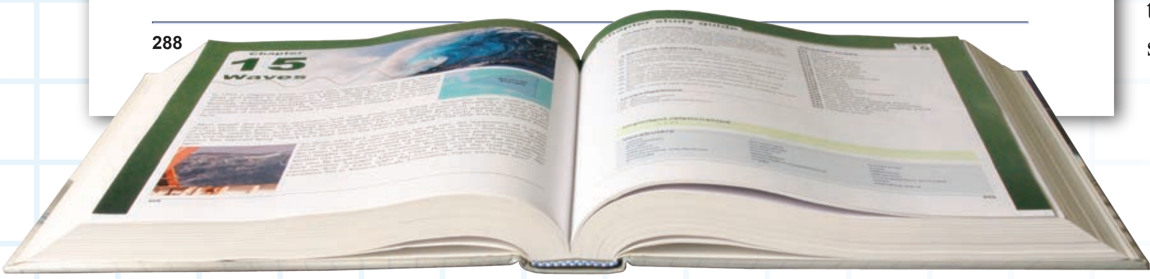
What if the system does work? Again, consider the system to consist only of the spring. If the spring is now used to launch a ball, the system does work on something outside the system: the ball. When a system exerts a force that does work outside the system, then the final energy is the initial energy *minus* the work done *by* the system.



Initial energy		Work done		Final energy
$mgh_0 + \frac{1}{2}mv_0^2 + \frac{1}{2}kx^2$	−	W	=	$mgh_0 + \frac{1}{2}mv_0^2 + \frac{1}{2}kx_0^2$
$\frac{1}{2}kx^2$	−	W	=	0

The final energy of a system is the initial energy minus work done by the system.

Work and conservation of energy If all forces act *inside* the system, then the total energy of the system remains constant because all the energy lost by one part of the system is gained by another part. If forces act *outside* the system, then the energy of the system either increases when work is done on the system or decreases when the system does work on the outside environment.



One idea per page

The main idea of every page is right at the top. Students know why they are reading each page.

Paragraph outlining

The main idea in each paragraph is set in the left margin. This helps students focus on important content.

Clear illustrations

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Even in the digital age, printed textbooks are a reliable part of your curriculum. Our clean and readable hardcover textbook is a page-for-page mirror of the e-Book, offering you the best of both worlds. We recommend a classroom set of textbooks even for those fortunate enough to have technology accessible to all students.

Teacher's Edition

Essential Physics™ Second Edition

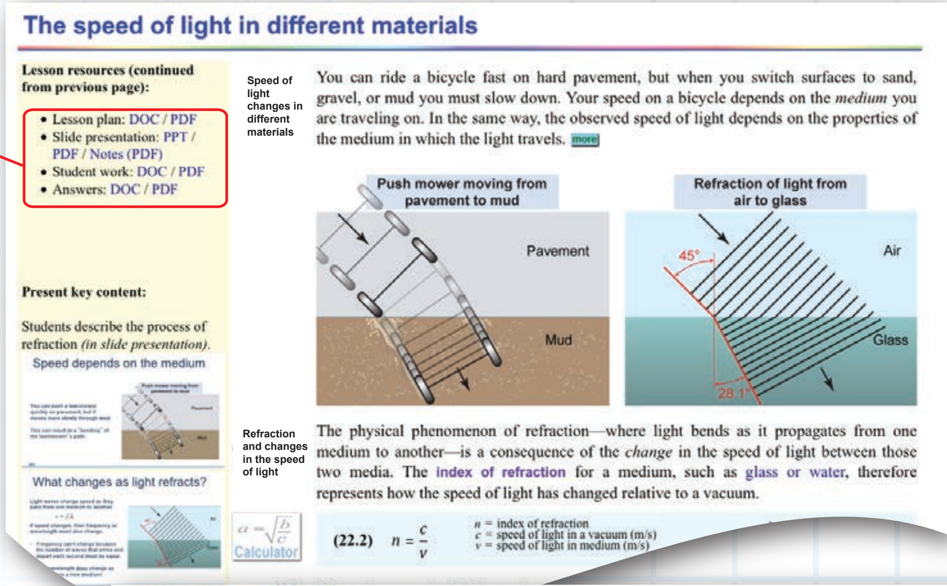
The electronic wrap-around Teacher's Edition organizes the content into 139 core lessons and additional extension lessons. Each lesson includes between 30 and 60 illustrated slides. Detailed lesson plans make prep work easier. Student assignments provide classroom-ready printable student work. Links at the top of each page make it easy for you to find everything you need to prepare a lesson quickly and efficiently.

Find what you need fast!

These links take you right to the slides, lesson plans, and student assignments with one click!

Easily review lesson concepts

A few key slides are shown right in the TE. You can click them to expand or open the link at the top of the page to review the entire lesson.



The speed of light in different materials

Lesson resources (continued from previous page):

- Lesson plan: DOC / PDF
- Slide presentation: PPT / PDF / Notes (PDF)
- Student work: DOC / PDF
- Answers: DOC / PDF

Present key content:

Students describe the process of refraction (in slide presentation).

Speed of light changes in different materials

You can ride a bicycle fast on hard pavement, but when you switch surfaces to sand, gravel, or mud you must slow down. Your speed on a bicycle depends on the *medium* you are traveling on. In the same way, the observed speed of light depends on the properties of the medium in which the light travels. more

Refraction and changes in the speed of light

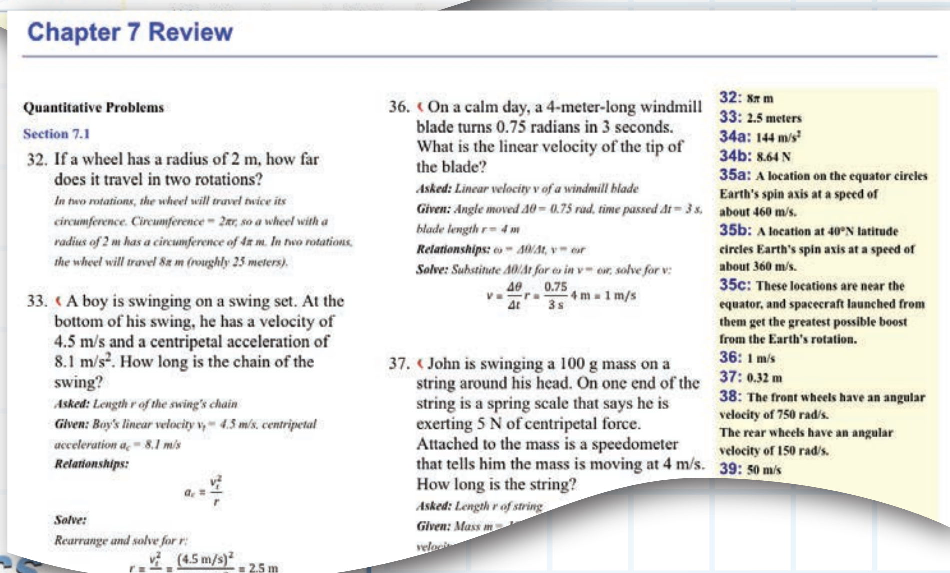
The physical phenomenon of refraction—where light bends as it propagates from one medium to another—is a consequence of the *change* in the speed of light between those two media. The index of refraction for a medium, such as glass or water, therefore represents how the speed of light has changed relative to a vacuum.

$$(22.2) \quad n = \frac{c}{v}$$

n = index of refraction
c = speed of light in a vacuum (m/s)
v = speed of light in medium (m/s)

Detailed solutions to chapter problems

Every problem has answers in the TE, and many problems have detailed solutions that follow a consistent, four-step problem-solving strategy.



Chapter 7 Review

Quantitative Problems

Section 7.1

32. If a wheel has a radius of 2 m, how far does it travel in two rotations?

In two rotations, the wheel will travel twice its circumference. Circumference = 2πr, so a wheel with a radius of 2 m has a circumference of 4π m. In two rotations, the wheel will travel 8π m (roughly 25 meters).

33. A boy is swinging on a swing set. At the bottom of his swing, he has a velocity of 4.5 m/s and a centripetal acceleration of 8.1 m/s². How long is the chain of the swing?

Asked: Length r of the swing's chain
Given: Boy's linear velocity v_t = 4.5 m/s, centripetal acceleration a_c = 8.1 m/s
Relationships:

$$a_c = \frac{v_t^2}{r}$$

Solve: Rearrange and solve for r:

$$r = \frac{v_t^2}{a_c} = \frac{(4.5\ \text{m/s})^2}{8.1\ \text{m/s}^2} = 2.5\ \text{m}$$

36. On a calm day, a 4-meter-long windmill blade turns 0.75 radians in 3 seconds. What is the linear velocity of the tip of the blade?

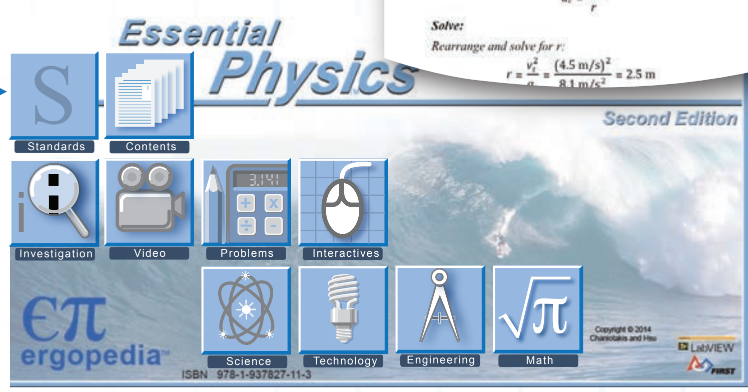
Asked: Linear velocity v of a windmill blade
Given: Angle moved Δθ = 0.75 rad, time passed Δt = 3 s, blade length r = 4 m
Relationships: ω = Δθ/Δt, v = ωr
Solve: Substitute Δθ/Δt for ω in v = ωr, solve for v:

$$v = \frac{\Delta\theta}{\Delta t} r = \frac{0.75}{3\ \text{s}} 4\ \text{m} = 1\ \text{m/s}$$

37. John is swinging a 100 g mass on a string around his head. On one end of the string is a spring scale that says he is exerting 5 N of centripetal force. Attached to the mass is a speedometer that tells him the mass is moving at 4 m/s. How long is the string?

Asked: Length r of string
Given: Mass m = ...

32: 8π m
33: 2.5 meters
34a: 144 m/s²
34b: 8.64 N
35a: A location on the equator circles Earth's spin axis at a speed of about 460 m/s.
35b: A location at 40°N latitude circles Earth's spin axis at a speed of about 360 m/s.
35c: These locations are near the equator, and spacecraft launched from them get the greatest possible boost from the Earth's rotation.
36: 1 m/s
37: 0.32 m
38: The front wheels have an angular velocity of 750 rad/s. The rear wheels have an angular velocity of 150 rad/s.
39: 50 m/s



See a full correlation to your standards with one click from both student and teacher editions.

(note - all states are not yet correlated as of Jan 2014)

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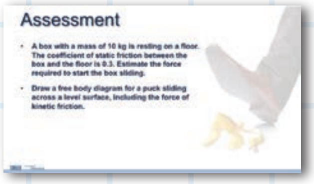
Superior tools support effective instruction

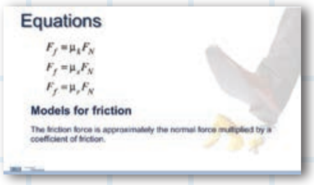
Teach as if you spent days prepping each lesson.

More than 6,000 illustrated slides are grouped into one or two period lessons. The slides for each lesson begin with assessment questions. Next comes the lesson content. Each lesson ends by revisiting the assessment questions with solutions.

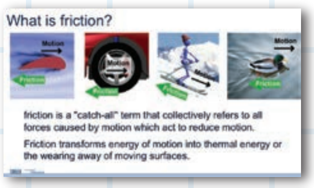
Slides from a typical lesson

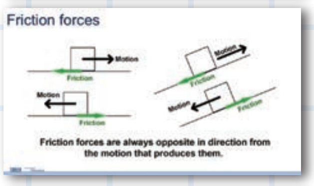


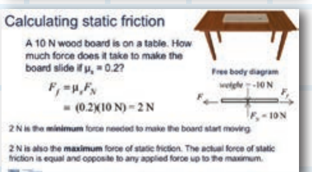
What should students learn from this lesson?



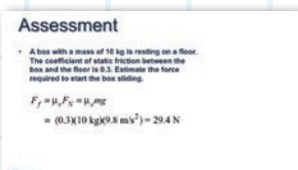
What equations and vocabulary are new?







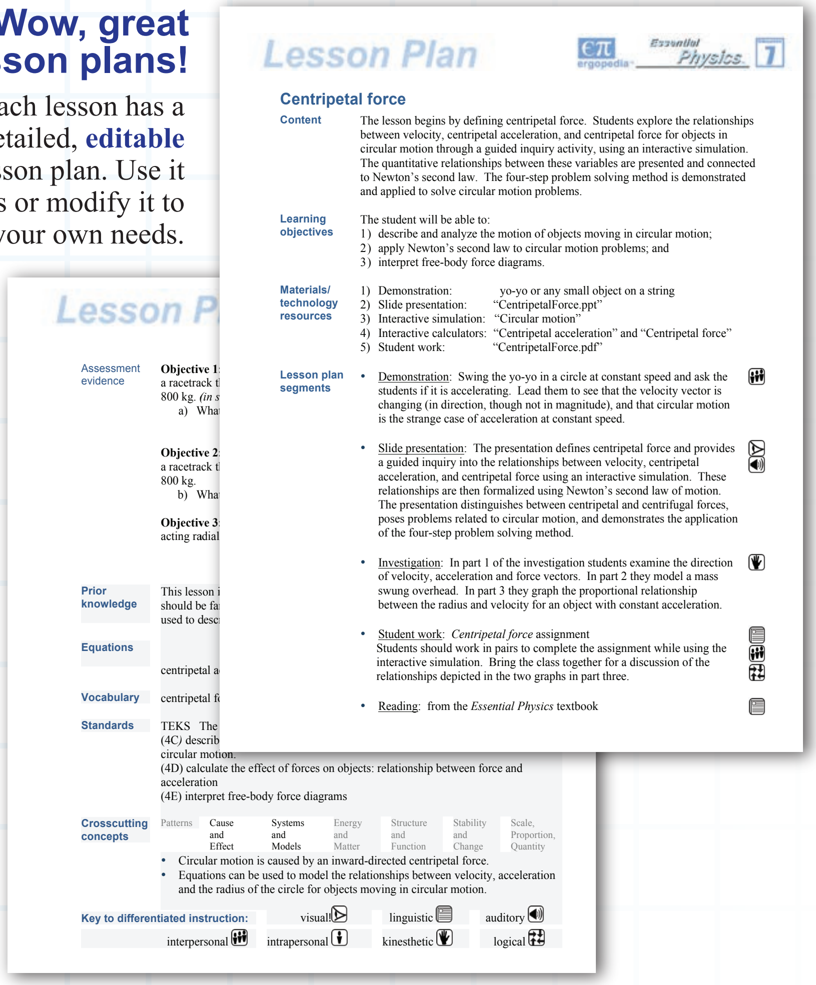
Each lesson includes between 30 and 60 well-illustrated content slides presenting each important concept with examples, key questions, illustrations, simulations, investigations, and more.



Concluding slides challenge students to answer the questions from the beginning of the lesson. *(Answers included!)*

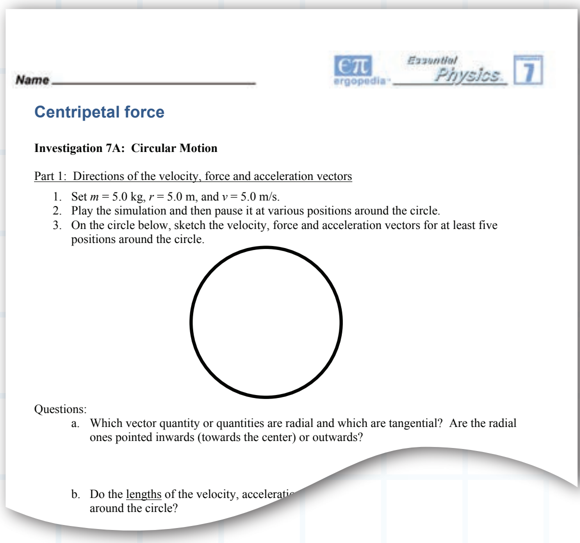
Wow, great lesson plans!

Each lesson has a detailed, **editable** lesson plan. Use it as-is or modify it to suit your own needs.



Student assignments for every lesson!

Printable and **editable** student assignments are included for every lesson.



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Assessment

Essential Physics™ Second Edition

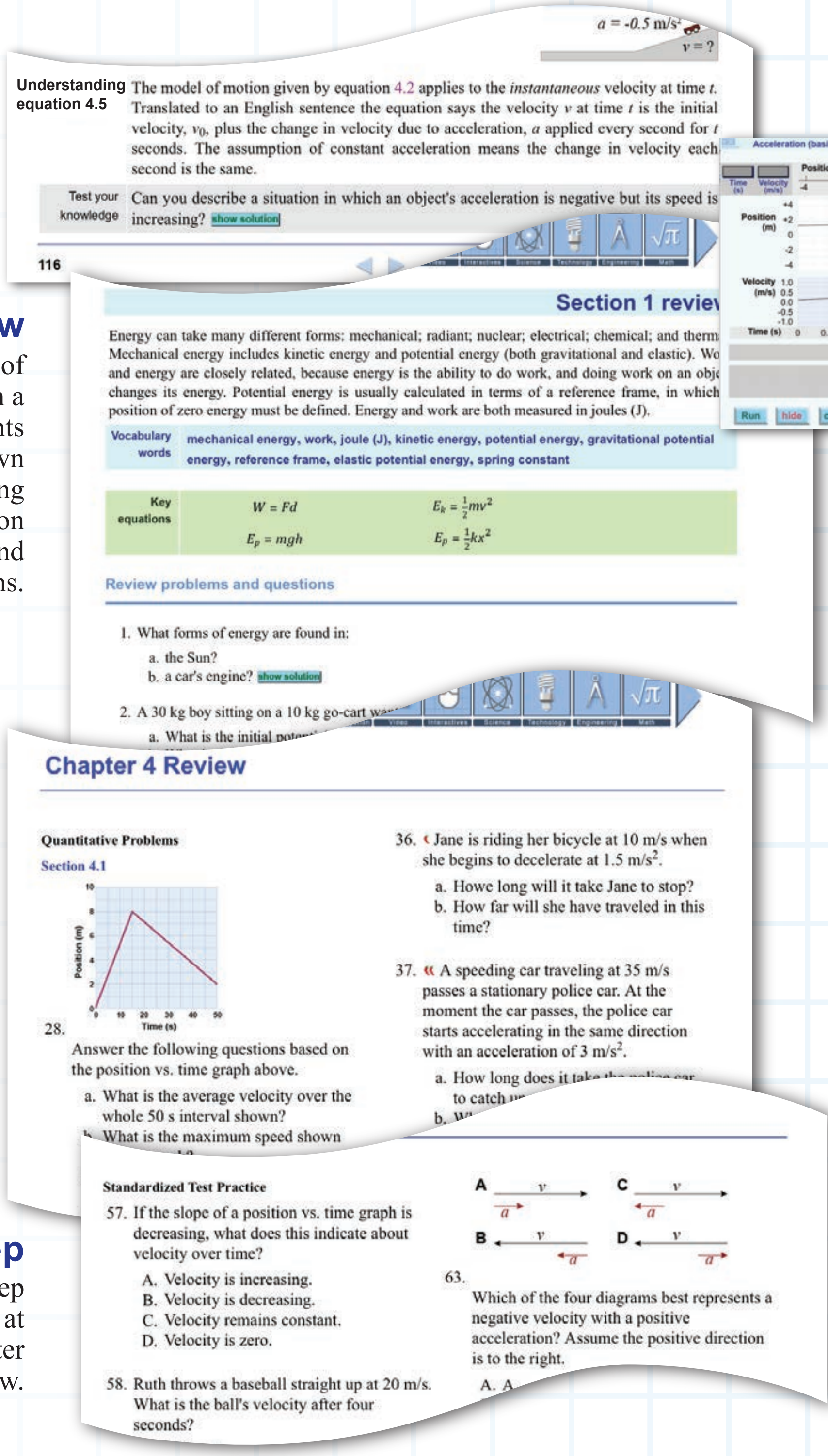
No curriculum is complete without a comprehensive suite of tools for assessing student learning. Both formative and summative assessments are part of the learning process and provide critical instructional feedback. *Essential Physics* includes a wide variety of assessment tools.

Page question

Each page of the e-Book has a "test your knowledge" question (with solution) at the bottom of the page.

Section review

Each 4-8 page section of the book ends with a section review. Students can check their own work by revealing solutions to section review questions and problems.


Understanding equation 4.5

The model of motion given by equation 4.2 applies to the *instantaneous* velocity at time *t*. Translated to an English sentence the equation says the velocity *v* at time *t* is the initial velocity, v_0, plus the change in velocity due to acceleration, *a* applied every second for *t* seconds. The assumption of constant acceleration means the change in velocity each second is the same.

Test your knowledge: Can you describe a situation in which an object's acceleration is negative but its speed is increasing? show solution

116

Section 1 review

Energy can take many different forms: mechanical; radiant; nuclear; electrical; chemical; and therm... Mechanical energy includes kinetic energy and potential energy (both gravitational and elastic). Wo... and energy are closely related, because energy is the ability to do work, and doing work on an obj... changes its energy. Potential energy is usually calculated in terms of a reference frame, in which... position of zero energy must be defined. Energy and work are both measured in joules (J).

Vocabulary words: mechanical energy, work, joule (J), kinetic energy, potential energy, gravitational potential energy, reference frame, elastic potential energy, spring constant

Key equations: $W = Fd$ $E_k = \frac{1}{2}mv^2$ $E_p = mgh$ $E_p = \frac{1}{2}kx^2$

Review problems and questions

1. What forms of energy are found in:
   a. the Sun?
   b. a car's engine? show solution
2. A 30 kg boy sitting on a 10 kg go-cart wa...

Chapter 4 Review

Quantitative Problems

Section 4.1

28. Answer the following questions based on the position vs. time graph above.
   a. What is the average velocity over the whole 50 s interval shown?
   b. What is the maximum speed shown

36. Jane is riding her bicycle at 10 m/s when she begins to decelerate at 1.5 m/s^2.
   a. Howe long will it take Jane to stop?
   b. How far will she have traveled in this time?

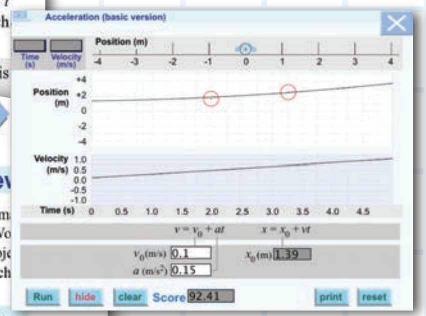
37. A speeding car traveling at 35 m/s passes a stationary police car. At the moment the car passes, the police car starts accelerating in the same direction with an acceleration of 3 m/s^2.
   a. How long does it take the police car to catch u...

Standardized Test Practice

57. If the slope of a position vs. time graph is decreasing, what does this indicate about velocity over time?
   A. Velocity is increasing.
   B. Velocity is decreasing.
   C. Velocity remains constant.
   D. Velocity is zero.

58. Ruth throws a baseball straight up at 20 m/s. What is the ball's velocity after four seconds?

63. Which of the four diagrams best represents a negative velocity with a positive acceleration? Assume the positive direction is to the right.



Simulations

Interactive simulations are scored and may be printed for homework or grading.

Chapter review

Essential Physics contains more than 1,600 questions and problems. Each chapter includes conceptual and vocabulary questions and quantitative problems. Complete solutions are in the Teacher's Edition.

Investigations

Every investigation includes formative assessments.

Test prep

Standardized test prep questions are included at the end of *every* chapter review.

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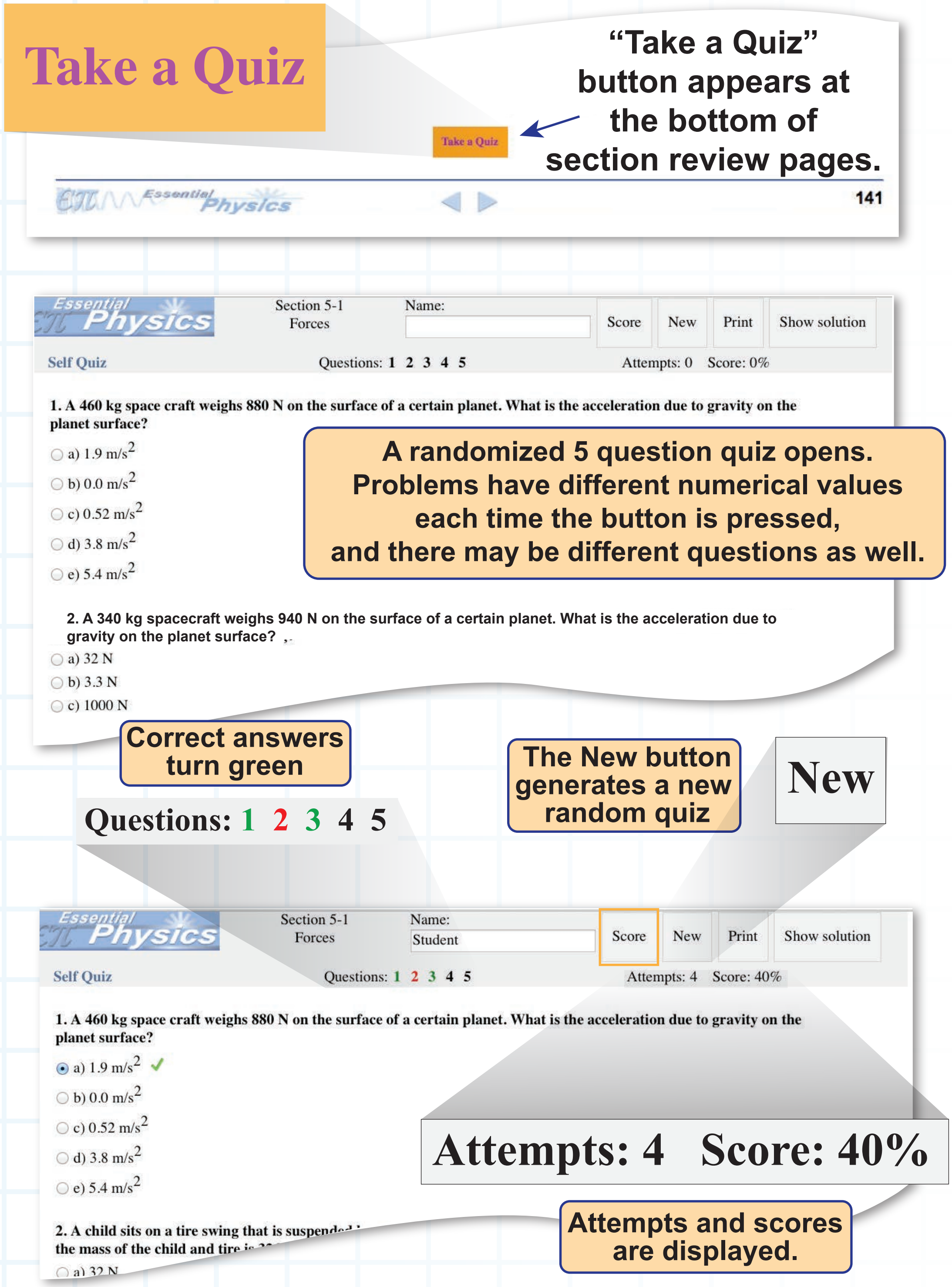
Essential Physics™ Second Edition

The innovative, powerful self grading quiz



The "Take a Quiz" button

Each section review page features a "Take a Quiz" button that randomly generates a 5 question self-quiz. Each time the button is pressed, both the questions and the values within questions randomly change so *the same quiz never repeats twice*.

Research shows

Students acquire and retain concepts better when they can test themselves frequently in a low-risk situation.

Immediate feedback

Students can score their quiz as many times as they want—and even see solutions. Items turn red or green for incorrect or correct answers.

Turn in for credit

The self-quiz counts how many attempts the student makes to score the test. Students can print their best score for credit or keep creating new quizzes until they can get all items correct with only one attempt at scoring.

Automatically graded quizzes can be printed or emailed to the teacher for credit.

A unique tool for student self-assessment

Students can check their comprehension and problem-solving abilities concept by concept and skill by skill. This is ideal for "flipped classrooms," as it motivates students to practice and allows them to keep trying problems on their own time until they can master the content. The "show solutions" feature allows students to learn from their errors and then create a new quiz to check if they can get the correct answers independently.

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- Choose the number of questions from each section.
- Build multiple versions of the same test!

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Assessment Builder

Instructor	Mr.Hsu
Course	Physics
Description	Sep, 2014

Question difficulty: 1 ☑ 2 ☐ 3 ☐

Questions: 6

Go To Review

Step 1 Design

Chapter 1 - Science of Physics

Chapter 2 - Physical Quantities and Measurement

Chapter 3 - Position and Velocity

Chapter 4 - Acceleration

- Section 1 - Acceleration — 12 questions available — 3
- Section 2 - Gravity and free fall — 6 questions available — 3

Chapter 5 - Forces and Newton's Laws

Mr.Hsu
Physics

Name: ________________

September 26, 2014
Period 1

1) A cart is rolling along at a steady 6.8 m/s when it meets a slope. The cart accelerates at 1.6 m/s^2 as it rolls down the hill. How far from the top of the hill will the cart move in 5.9 seconds?

a) 16.2 meters
b) 68.0 meters
c) 40.1 meters
d) 27.8 meters
e) 49.6 meters

6) Ruth throws a baseball straight up at 18 m/s. What is the ball's velocity after 2.6 seconds?

a) 18 m/s
b) -7.5 m/s
c) -47 m/s
d) 43 m/s
e) 6.9 m/s

Ergopedia Infinite Test Bank

Answer key | **Full solutions**

1) A cart is rolling along at a steady 6.8 m/s when it meets a slope. The cart accelerates at 1.6 m/s^2 as it rolls down the hill. How far from the top of the hill will the cart move in 5.9 seconds?

In this case, v_o for the cart is 6.8 m/s and a = 1.6 m/s^2. Plugging in this and t = 5.9 s into $x = x_o + v_o t + ½at^2$, we get that Δx = (6.8 m/s)(5.9 s) + ½(1.6 m/s^2)(5.9 s)^2 = 68.0 m.

2) Terra tosses a 0.2 kg volleyball straight up at 7 m/s. How high does it go?

Mr.Hsu
Physics

Name: ________________

September 26, 2014
Period 2

1) A cart is rolling along at a steady 3.7 m/s when it meets a slope. The cart accelerates at 1.6 m/s^2 as it rolls down the hill. How far from the top of the hill will the cart move in 9.7 seconds?

a) 51.4 meters
b) 111 meters
c) 35.9 meters
d) 19.2 meters
e) 75.3 meters

6) Ruth throws a baseball straight up at 21 m/s. What is the ...

Each version has the same questions but with different values.

Ergopedia Infinite Test Bank

Answer key | **Full solutions**

1) A cart is rolling along at a steady 3.7 m/s when it meets a slope. The cart accelerates at 1.6 m/s^2 as it rolls down the hill. How far from the top of the hill will the cart move in 9.7 seconds?

In this case, v_o for the cart is 3.7 m/s and a = 1.6 m/s^2. Plugging in this and t = 9.7 s into $x = x_o + v_o t + ½at^2$, we get that Δx = (3.7 m/s)(9.7 s) + ½(1.6 m/s^2)(9.7 s)^2 = 111 m.

2) Terra tosses a 0.2 kg volleyball straight up at 5 m/s. How high does it go?

Let straight up represent the positive direction. First, determine how much time the volleyball takes to reach its highest point.

Mr.Hsu
Physics

Name: ________________

September 29, 2014
Make up

1) A cart is rolling along at a steady 13 m/s when it meets a slope. The cart accelerates at 2.0 m/s^2 as it rolls down the hill. How far from the top of the hill will the cart move in 8.4 seconds?

a) 109 meters
b) 29.8 meters
c) 126 meters
d) 70.6 meters
e) 180 meters

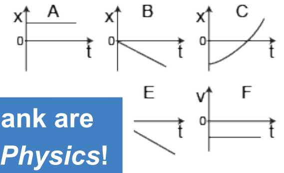
2) Terra tosses a 0.2 kg volleyball straight up at 7 m/s. How high does it go?

a) 1.4 m
b) 2.5 m
c) 0.71 m

6) Ruth throws a baseball straight up at 16 m/s. What is the ball's velocity after 2.5 seconds?

a) 16 m/s
b) 6.4 m/s
c) -40 m/s
d) -8.5 m/s
e) 41 m/s

7) From these position and velocity versus time graphs, which pair corresponds to a positive acceleration?



Ergopedia Infinite Test Bank

Answer key | **Full solutions**

1) A cart is rolling along at a steady 13 m/s when it meets a slope. The cart accelerates at 2.0 m/s^2 as it rolls down the hill. How far from the top of the hill will the cart move in 8.4 seconds?

In this case, v_o for the cart is 13 m/s and a = 2.0 m/s^2. Plugging in this and t = 8.4 s into $x = x_o + v_o t + ½at^2$, we get that Δx = (13 m/s)(8.4 s) + ½(2.0 m/s^2)(8.4 s)^2 = 180 m.

2) Terra tosses a 0.2 kg volleyball straight up at 7 m/s. How high does it go?

Let straight up represent the positive direction. First, determine how much time the volleyball takes to reach its highest point.

$$v = v_0 + at$$
$$t = \frac{v - v_0}{a} = \frac{0\ \text{m/s} - (7\ \text{m/s})}{-9.8\ \text{m/s}^2} = 0.714\ \text{s}$$

Then, substitute this value in to find the height of the volleyball at this time.

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2$$
$$x = 0\ \text{m} + (7\ \text{m/s})(0.714\ \text{s}) + \tfrac{1}{2}(-9.8\ \text{m/s}^2)(0.714\ \text{s}^2) = 2.50\ \text{m}$$

Full solutions show the correct values in each version.

Test generator and test bank are *INCLUDED* with *Essential Physics*! There are *NO* additional subscription fees to pay.

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Exceeding your standards

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Essential Physics meets your state standards in physics, including the Next Generation Science Standards* (NGSS). If you cannot find a correlation online, please contact us as we are constantly updating our standards information to reflect the most up-to-date requirements for your state.

Disciplinary Core Ideas

Definitions of Energy:
Energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
Energy Transfer:
Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.

Danger ahead — But our modern lifestyle may be living on borrowed time. After all, most of the power supplying our farms, cars, and factories comes from burning fossil fuels—and fossil fuels contain solar energy that took millions of years to store. Scientists disagree on how much coal, oil, and natural gas remains, but at some point—possibly during your lifetime—we will need to use more energy to obtain these resources than they give back.

Advantages of wind power

The vital yet controversial role that energy plays in our lives underlies the passion with which people pursue *renewable energy*—natural processes that can be harnessed to power our modern lifestyle without being destroyed, disrupted, or depleted. Renewable energy sources include sunlight, wind,

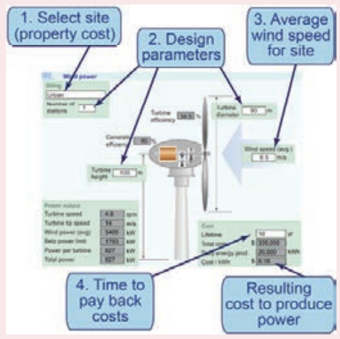
Student Expectations

Energy:
Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Design challenge — Design a wind turbine installation that:

- is located in your area (state or region);
- produces 200 megawatts (MW) average power;
- has a minimum 30 m clearance between the bottom of the blades and the ground (or water);
- pays back its cost in less than ten years by selling electricity to the grid at $0.07 per kilowatt-hour (kWh); and
- produces electricity at the minimum possible cost.

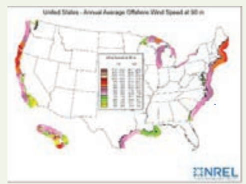
Which are the design *criteria*? Which are the design *constraints*? Write your answers in your report.



Crosscutting Concepts

Systems and system models:
When investigation or describing a system, the boundaries and initial conditions of the system need to be defined.

Design and prototype — The simulation assumes that you must purchase the land (urban, suburban, or rural sites) or lease it from the government (offshore, such as for the Cape Wind project off the Massachusetts coast); the costs will change depending on your siting choice. Use resources such as the maps at right to determine the typical wind speed for your potential sites.



Science and Engineering

Practices
Construction explanations and design solutions.
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Test — Investigate how the power produced and cost per kilowatt-hour vary with the design parameters (diameter, height, number of turbines, siting costs, average wind speed, and life expectancy). Identify the controlled variables in your investigation.

Evaluate — Evaluate your design to determine which solutions best meet the design criteria. Your design will pay back its cost over its lifetime when the cost per kilowatt-hour equals the average cost in your area. Research the average cost of electricity in your area (or state), which is usually provided in dollars per kilowatt-hour ($/kWh). A monthly home electricity bill is one way to determine the local cost of electricity.

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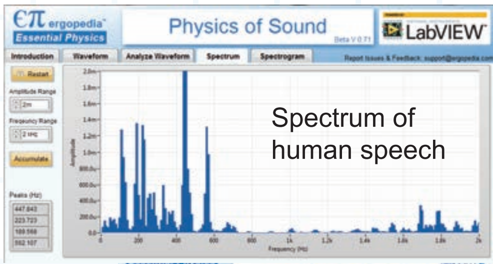

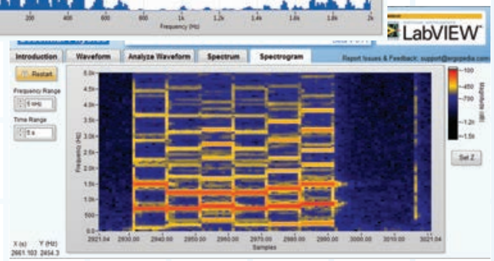

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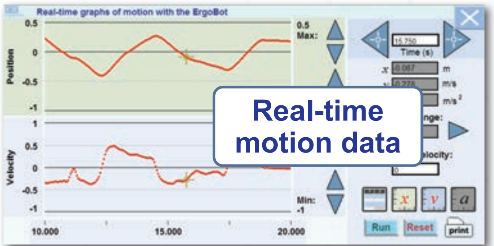
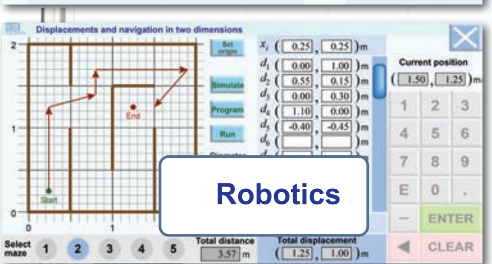
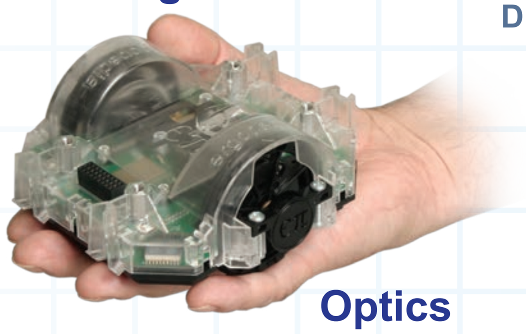




The ErgoBot



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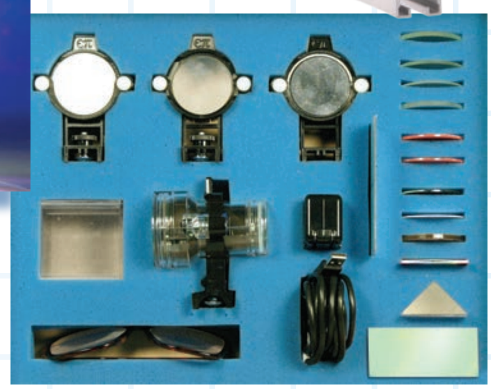

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Purchasing information and prices

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Technology requirements

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- **Operating systems:** OS X, Windows, Android, Chrome, iOS
- **Browsers:** Safari, Firefox, Chrome, Internet Explorer*
- **Hardware:** Mac, PC, iPad, Android tablet, Chromebook, most smart-phones
- **Internet:** Both online and stand-alone (offline) versions are *included*.
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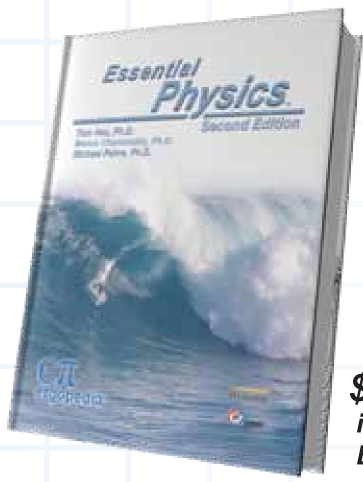

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130-01006	ErgoBot Dynamic Motion System		$ 595
130-01016	ErgoTrack (new double-pulley track)		$ 125
130-01012	Tripod Stand		$ 85
130-01009	Optics System (with Light Source)		$ 295
130-01013	Waves and Sound Kit		$ 85
130-01019	Forces and Machines Kit (expanded for 2015!)		$ 215
130-01018	Electricity and Magnetism Kit		$ 395
130-01020	Essential Physics 2015 Full Equipment Kit (includes all of the above equipment)		$ 1,495
	Equipment available individually or in custom kits to meet specific needs.		

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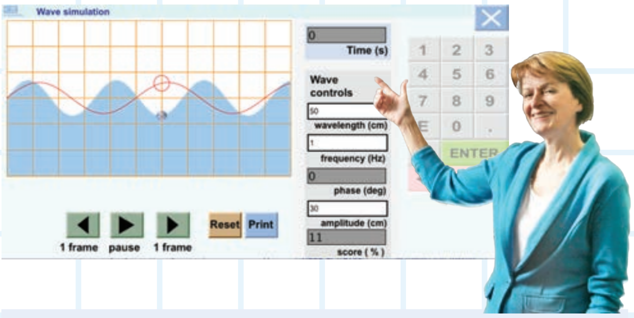

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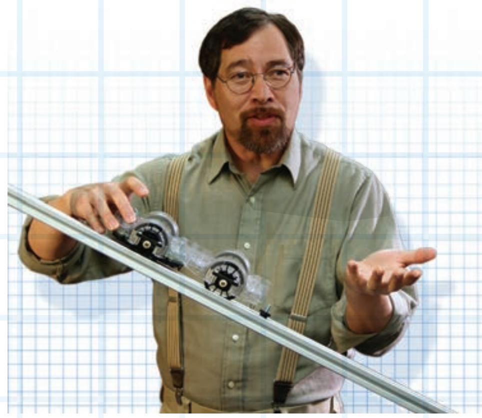
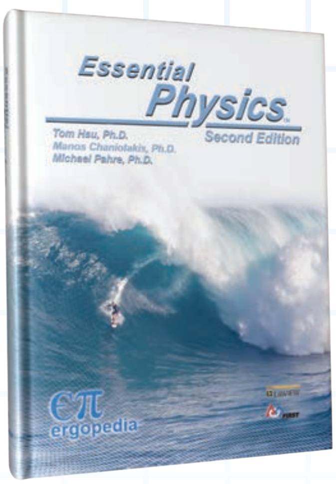


Dr. Tom Hsu
cofounder of Ergopedia



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