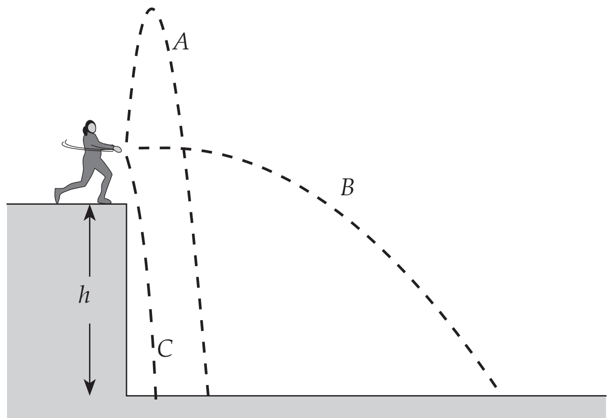
TWO-MINUTE PROBLEMS

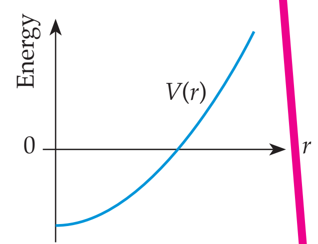
C8T.2 A person throws three rocks off a cliff of height h at exactly the same speed $|\vec{v}_i|$ each time, but throwing rock A almost vertically upward, rock B horizontally, and rock C almost vertically downward (see the diagram below)



Which rock hits the ground with the greatest *speed*? (Ignore air friction.)
A. Rock A.
B. Rock B.
C. Rock C.
D. Rocks A and C hit with the same speed, faster than B.
E. All three rocks hit with the same speed.

C8T.6 We cannot experimentally determine the actual value of a system's total energy, T or F?

C8T.7 Suppose that the following graph shows the potential energy function for a certain hypothetical interaction.



This interaction is
A. attractive for all r.
B. repulsive for all r.
C. attractive for small r, repulsive for large r.
D. repulsive for small r, attractive for large r.
E. impossible to characterize without more information.

Two-minute problems are multiple-choice conceptual problems one can use in peer-instruction classroom activities, though one can also use them as pre-class assignments that help ensure that students read the text before class.

HOMEWORK PROBLEMS

Basic Skills

C8B.1 Consider an object interacting gravitationally with the earth. If we move the object from position A to position B, we find that the system's gravitational potential energy increases by 10 J. If we move it from position B to position C, we find that the system's gravitational potential energy decreases by 5 J. If we take the system's reference separation to be when the object is at position B, what is the system's gravitational potential energy when the object is at points A, B, and C?

C8B.3 The driver of a car initially traveling at 55 mi/h increases the car's speed to 77 mi/h, which is 40% greater. By what percentage has the car's kinetic energy increased? (Note that the severity of a crash is roughly proportional to the kinetic energy that the colliding objects bring to it.)

C8B.4 Jump vertically as high as you can and measure how far you have raised your center of mass at the top of your trajectory. Then use conservation of energy to estimate your initial speed as you left the ground.

Basic Skills Problems help students develop skills through straightforward and well-defined tasks involving simple formulas or concepts.

Modeling

C8M.5 On June 10, 1974, a baseball hit by Phillies player Mike Schmidt hit a speaker suspended below the roof of the Houston Astrodome. The speaker was 117 ft (36 m) above the field and 329 ft (100 m) horizontally from home plate. (The ball dropped into center field and was ruled a single, even though it would almost certainly have been a home run if it missed the speaker.) If the ball left Schmidt's bat traveling at 47 m/s, what was the ball's speed when it hit the speaker (ignoring air friction)?

C8M.6 You are trying to design a "rail gun" to launch canisters with mass m at a high speed $|\vec{v}_i|$ on an initially almost horizontal trajectory along the surface of the moon (whose mass is M and radius is R). If $|\vec{v}_i|$ is large enough, the canisters will fly tangentially away from the moon into deep space. You want the canisters to have a certain speed $|\vec{v}_f|$ once they are very far from the moon.
(a) What should $|\vec{v}_i|$ be in terms of the symbols defined above?
(b) Calculate the numerical value of $|\vec{v}_i|$ given that the moon's radius is 1740 km and mass is 7.36×10^{22} kg.

Modeling Problems require students to think about realistic situations, build models (involving approximations and assumptions) and/or link several ideas together to answer the posed question.

Derivations

C8D.1 Consider an isolated system of two objects of mass m_1 and m_2. The second object is initially at rest, but the first has some arbitrary initial momentum $\vec{p}_0$. After the two objects interact, the first ends up with a final momentum of $\vec{p}_1$, and the second with a final momentum $\vec{p}_2$. Show that the second object's final kinetic energy K_2 is related to the first object's initial and final kinetic energies K_0 and K_1 by

$$K_2 = \frac{m_1}{m_2}(K_0 + K_1 - 2\sqrt{K_0 K_1}\cos\theta) \tag{C8.20}$$

where θ is the angle between $\vec{p}_0$ and $\vec{p}_1$. This means that if $m_2 >> m_1$, K_2 will still be negligible compared to K_0 and K_1, even though the first object was not initially at rest. [*Hints:* Show that conservation of momentum implies that the vectors $\vec{p}_0$, $\vec{p}_1$, and $\vec{p}_2$ must form a triangle. Use the law of cosines relate the magnitudes of these vectors.]

Derivation Problems ask students to derive mathematical results (often results associated with arguments made in the chapter).

Advanced

N11A.1 Consider an isolated two-object system interacting gravitationally such that M is not necessarily much greater than m. Assume that the smaller object's orbit around the system's center of mass is circular and has radius r. Argue that both objects have the same orbital period T around the system's center of mass and that

$$T^2 = \frac{4\pi^2 D^3}{G(M+m)} \tag{N11.32}$$

where D is the separation of the two objects.

Rich-Context

C8R.1 You are prospecting for rare metals on a spherical asteroid composed mostly of iron (whose density $\rho \approx 7800\ \text{kg/m}^3$) and whose radius is $R = 4.5$ km. You have left your spaceship in a circular orbit a distance $h = 400$ m above the asteroid's surface and gone down to the surface using a jet pack. However, one of your exploratory explosions knocks you back against a rock, ruining the pack. (This is why you have a backup pack which is, of course, back up in your ship.) Can you to simply jump high enough to reach your spaceship? (*Hint*: Consider problem C8B.4, and back up any bold claims that you might make about how high you can jump on earth with solid experimental evidence.)

Rich-Context Problems are like M problems but generally require more sophisticated modeling skills, finding missing information and/or ignoring given information, and/or deciding how to answer qualitative questions. Research identifies such problems as being the best for collaborative projects, because they provide non-trivial grist for discussion.

Rare **Advanced Problems** explore calculations or theoretical issues beyond the level of the text. They provide challenges for bright students and/or ideas for instructors.