CHAPTER 7 Review

REFLECTING ON CHAPTER 7

- Applied forces are conservative if the work that they do on an object as it moves between two points is independent of the path taken by the object while moving between those points.
- Applied forces are non-conservative if the amount of work that they do on an object as it moves between two points is dependent on the path of the object between those points.
- Work done by an object on its environment is negative work and decreases the total energy of that object. Work done on an object by its environment is positive work and increases the total energy of the object.
- Mechanical energy of a system is conserved when work is done by conservative forces.
- Total energy is conserved even when work is done by non-conservative forces. The work done by non-conservative forces decreases the mechanical energy of the system.

  $$W_{\text{nc}} = E_{\text{final}} - E_{\text{initial}}$$
- An isolated system is one that neither gains energy from its environment nor loses energy to its environment.
- The law of conservation of energy states that, in an isolated system, the total energy is conserved, but can be transformed from one form to another.
- The concept of impulse plays a significant role in the design of safety systems. By extending the time, Δt, of a collision, you can reduce the amount of force, $\vec{F}$, exerted.
- By applying Newton's third law, you can show that momentum is conserved in a collision.
- The momentum of an isolated system is conserved.
- Recoil is the interaction of two objects that are in contact with each other and exert a force on each other. Momentum is conserved during recoil.
- Kinetic energy is conserved in elastic collisions.
- Kinetic energy is *not* conserved in inelastic collisions.

Knowledge/Understanding

1. Explain what happens to the total mechanical energy over a period of time for open systems, closed systems, and isolated systems.

2. Explain what it means when you say that work done on an object is independent of the path taken by the object?

3. **(a)** Describe a situation in which kinetic energy is converted into elastic potential energy.
   (b) Describe a situation in which gravitational energy is converted first into elastic potential energy and then into kinetic energy.

4. In the derivation that showed that the kinetic energy of an object after falling a distance Δh, is equal to the gravitational potential energy of the object before it fell, neglecting any frictional forces, how did you use the kinematic equation that relates final velocity, initial velocity, acceleration and displacement?

5. Explain the difference between a closed system and an isolated system.

6. Explain, in words, how Newton's third law is used to show that momentum is conserved in a collision.

7. How can the principles used in problems involving conservation of momentum in one dimension apply to problems involving two or three dimensions?

8. You wind up the spring of a toy car and then release it so that it travels up a ramp. Describe all of the energy transformations that take place.

9. When two objects recoil, they start at rest and then push against each other and begin to move. Initially, since their velocities are zero, they have no momentum. When they begin to move, they have momentum. Explain how momentum can be conserved during recoil, when the objects start with no momentum and then acquire momentum.

Inquiry

10. Design a small wooden cart, with several raw eggs as passengers. Incorporate elements into your design to ensure that the passengers would suffer no injury if the cart was involved in a collision while travelling at 5.0 m/s. If possible, test your design.

11. Design and carry out an experiment in which an object initially has gravitational potential energy that is soon converted into kinetic energy. The object then collides with another object that is stationary. Include in your design a method for testing whether mechanical energy is conserved in the first part of the experiment. If possible, test your design.

Communication

12. A child descends a slide in the playground. Write expressions to show the total mechanical energy of the child at the top, halfway down, and at the bottom of the slide. Write a mathematical expression that relates the energy total at the three positions.

13. It is a calm day on a lake and you and a friend are on a sailboat. Your friend suggests attaching a fan to the sailboat and blowing air into the sails to propel the sailboat ahead. Explain whether this would work.

14. Imagine you are standing, at rest, in the middle of a pond on *perfectly frictionless* ice. Explain what will happen when you try to walk back to shore. Describe a possible method that you could use to start moving. Would this method allow you to reach shore? Explain.

15. You and a friend arrive at the scene of a car crash. The cars were both severely mangled. Your friend is appalled at the damage to the cars and says that cars ought to be made to be sturdier. Explain to your friend why this reaction to the crash is unwarranted.

16. Start with expressions that apply the impulse-momentum theorem to two objects and use Newton's third law to derive the conservation of momentum for a collision between the two objects. Explain and justify every substitution and mathematical step in detail.

Making Connections

17. Car bumper systems are designed to absorb the impact of slow-speed collisions in such a way that the vehicles involved sustain no permanent damage. Prepare a presentation on how a bumper system works, including an explanation of the energy transformations involved.

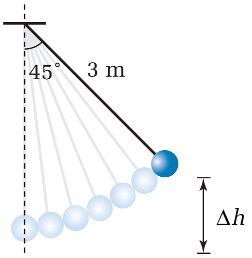
18. In many sports such as baseball and golf, "follow through" is considered to be very important. Based on your knowledge of elastic collisions, provide an explanation regarding the reason that "follow through" will improve the results of hitting a golf ball or baseball.

19. The floors of some gymnasiums are built so that they move a little when an athlete lands and then spring back in place. Explain, based on impulse and momentum, how this "spring" in the floor might reduce impact injuries to athletes' joints.

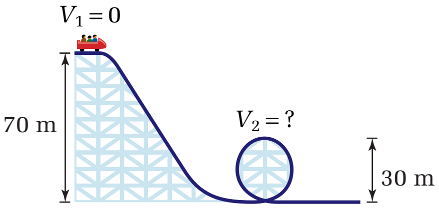
Problems for Understanding

20. A 0.500 kg mass resting on a frictionless surface is attached to a horizontal spring with a spring constant of 45 N/m. When you are not looking, your lab partner pulls the mass to one side and then releases it. When it passes the equilibrium position, its speed is 3.375 m/s. How far from the equilibrium position did your lab partner pull the mass before releasing it?

21. A 2.00 kg mass is attached to a 3.00 m string and is raised at an angle of 45° relative to the rest position, as shown. Calculate the gravitational potential energy of the pendulum relative to its rest position. If the mass is released, determine its velocity when it reaches its rest position.



22. A roller coaster at a popular amusement park has a portion of the track that is similar to the diagram provided. Assuming that the roller coaster is frictionless, find its velocity at the top of the loop.



23. A simple pendulum swings freely and rises at the end of its swing to a position 8.5 cm above its lowest point. What is its speed at its lowest point?

24. A 50.0 g pen has a retractable tip controlled by a button on the other end and an internal spring that has a constant of 1200 N/m. Suppose you hold the pen vertically on a table with the tip pointing up. Clicking the button into the table compresses the spring 0.50 cm. When the pen is released, how fast will it rise from the table? To what vertical height will it rise? (Assume for simplicity that the mass of the pen is concentrated in the button.)

25. A spring with a spring constant of 950 N/m is compressed 0.20 m. What speed can it give to a 1.5 kg ball when it is released?

26. A 48.0 kg in-line skater begins with a speed of 2.2 m/s. Friction also does –150 J of work on her. Assume that she did not push on the ground any more. If her final speed is 5.9 m/s,
- **(a)** determine the change (final – initial) in her gravitational potential energy.
- **(b)** By how much, and in which direction (up or down), has her height changed?

27. A 48.0 kg skateboarder kicks his 7.0 kg board ahead with a velocity of 2.6 m/s[E]. If he runs with a velocity of 3.2 m/s[E] and jumps onto the skateboard, what is the velocity of the skateboard and skateboarder immediately after he jumps on the board?

28. Astrid, who has a mass of 37.0 kg, steps off a stationary 8.0 kg toboggan onto the snow. If her forward velocity is 0.50 m/s, what is the recoil velocity of the toboggan? (Assume that the snow is level and the friction is negligible.)

29. A 60.0 t submarine, initially travelling forward at 1.5 m/s, fires a 5.0×10^2 kg torpedo straight ahead with a velocity of 21 m/s in relation to the submarine. What is the velocity of the submarine immediately after it fires the torpedo?

30. Suppose that a 75.0 kg goalkeeper catches a 0.40 kg ball that is moving at 32 m/s. With what forward velocity must the goalkeeper jump when she catches the ball so that the goalkeeper and the ball have a horizontal velocity of zero?

31. You and a colleague are on a spacewalk, repairing your spacecraft that has stalled in deep space. Your 60.0 kg colleague, initially at rest, asks you to throw her a hammer, which has a mass of 3.0 kg. You throw it to her with a velocity of 4.5 m/s[forward].
- **(a)** What is her velocity after catching the hammer?
- **(b)** What impulse does the hammer exert on her?
- **(c)** What percentage of kinetic energy is lost in the collision?