UNIT 3 Review

Knowledge/Understanding

True/False

In your notebook, indicate whether each statement is true or false. Correct each false statement.

1. Doing work on an object does not change the object's energy.
2. Mechanical kinetic energy is stored energy due to gravity.
3. Work done is proportional to the applied force and the square of the displacement in the same direction.
4. Work is done on an object by a force acting perpendicularly to the displacement.
5. It is possible to do negative work.
6. Gravitational energy is always measured from the same reference point.
7. Conservation of mechanical energy requires that a non-conservative force does the work.
8. The force of friction is a non-conservative force.
9. Efficiency is a ratio of useful work input compared to the amount of work output.

Multiple Choice

In your notebook, write the letter of the best answer for each of the following questions.

10. Work is not energy itself, but rather
    - **(a)** it is a form of kinetic energy.
    - **(b)** it is a form of gravitational potential energy.
    - **(c)** it is a force.
    - **(d)** it is a transfer of mechanical energy.
    - **(e)** it is a result of parallel forces.
11. Which of the following are equivalent to a joule (J)?
    - **(a)** $N \cdot m^2$
    - **(b)** $kg\frac{m^2}{s^2}$
    - **(c)** $N \cdot m$
    - **(d)** $N\frac{m}{s}$
    - **(e)** both (b) and (c)
12. Work done is zero when
    - **(a)** an applied force does not result in any motion.
    - **(b)** uniform motion exists in the absence of a force.
    - **(c)** the applied force is perpendicular to the displacement.
    - **(d)** both (a) and (c).
    - **(e)** all of the above.
13. A weight lifter lowers a barbell at constant speed. Down is assigned as positive. In doing so, the weight lifter
    - **(a)** does positive work on the barbell.
    - **(b)** allows gravity to do negative work on the barbell.
    - **(c)** does not do any work on the barbell.
    - **(d)** does negative work on the barbell.
    - **(e)** allows the kinetic energy of the barbell to increase.
14. You throw a rock straight up into the air. While it rises and falls, its kinetic energy
    - **(a)** remains constant
    - **(b)** increases steadily
    - **(c)** changes direction only
    - **(d)** decreases then increases
    - **(e)** increases then decreases
15. Starting from rest at the top of a hill, a bicyclist pedals furiously on the way down. The kinetic energy of the bicycle and rider at the bottom will be equal to
    - **(a)** lost potential energy
    - **(b)** work done
    - **(c)** work done plus lost potential energy
    - **(d)** work done plus kinetic energy plus potential energy
    - **(e)** zero

Short Answer

16. Explain how work and a transformation of energy are related.
17. What type of energy does a wind-up toy contain after being wound just before release?
18. Does your arm do any work on your textbook as you carry it down the hall if the book's vertical position does not change?
19. Describe the work done by a nail on a hammer as the nail is driven into a wall. What evidence is there that the work done is negative?
20. What is the factor by which a javelin's kinetic energy is changed, if its velocity is increased to five times its initial velocity?

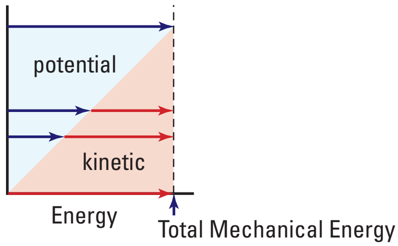
21. Draw a graphical representation showing total mechanical energy, gravitational energy, and mechanical kinetic energy versus time for the following processes.
   (a) A block of ice, initially at rest, slides down a frictionless slope.
   (b) A moving block of ice slides up a frictionless slope and instantaneously comes to rest.
22. Distinguish between an open system, a closed system, and an isolated system.
23. Explain why a water hose recoils when the water is turned on.
24. Explain why the first hill of a roller-coaster ride must be the highest hill.
25. (a) Under what conditions will a marble of mass m_1 and a rock of mass $3m_1$ have the same gravitational potential energy?
   (b) Under what conditions will a moving marble of mass m_1 and a moving rock of mass $3m_1$ have the same kinetic energy?
26. Write a general equation for the amount of mechanical energy in a system and include expressions for as many different forms of potential energy as you can locate.
27. Consider two bodies, A and B, moving in the same direction with the same kinetic energy. A has a mass twice that of B. If the same retarding force is applied to each, how will the stopping distances of the bodies compare?
28. (a) Under what circumstances does the work done on a system equal its change in kinetic energy only?
   (b) Under what circumstances does the work done on a system equal the change in gravitational potential energy only?
   (c) Under what circumstances does the change in kinetic energy of a system equal the change in gravitational potential energy?

Inquiry

29. Investigate the energy transformations that take place when an athlete is pole-vaulting.
30. Design a pogo stick for a child. Designate the age range of the child you hope will enjoy the stick and calculate the required spring constant. Determine other parameters, such as the length of the stick, the size of the spring, and the range of distances that the child will be able to depress the spring. Include a sketch of your design.
31. Imagine that you found a very unusual spring that did not obey Hooke's law. In fact, you performed experiments on the spring and discovered that the restoring force was proportional to the square distance that the spring was stretched or compressed from its equilibrium or $F = -kx^2$.
   (a) Describe an experiment that you might have done to find the expression for the restoring force.
   (b) Describe a method for finding the elastic potential energy stored in the spring when it is stretched a distance x.

Communication

32. Can the gravitational potential energy of a golf ball ever be negative? Explain without using a formula.
33. Describe how the graph represents conservation of energy.



34. Explain whether it is possible to exert a force and yet not cause a change in kinetic energy.
35. You blow up a balloon and release the open end, causing the balloon to fly around the room as the air is rapidly exhausted. What exerts the force that causes the balloon to accelerate?

Making Connections

36. Do research to find the efficiency of motion in various animals. Compare the efficiencies of walking, running, and swimming for humans. For example, how much energy does a person

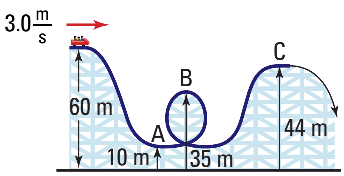
use to walk a kilometre, run a kilometre, and swim a kilometre? Compare these efficiencies for other animals. Include kangaroos, because a comparison of walking and hopping is quite interesting.

37. When gymnasts perform routines in the uneven bars or other events, they strive to land firmly and stop without allowing their feet to move to another position. Make some estimates about their motion just before landing to calculate their momentum. Since an impulse is required to change their momentum, find out how much force their bodies must endure in order to stop abruptly. How to they spread this force around to prevent injury?

Problems for Understanding

38. How fast will a 2.55 kg bowling ball be travelling if the 358 J of work done to the ball are transformed into kinetic energy?

39. A 250 kg roller coaster cart loaded with people has an initial velocity of 3.0 m/s. Find the velocity of the cart at A, B, and C. Assume that friction is negligible.



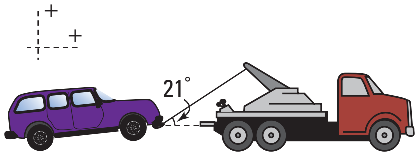
40. A 45 kg cyclist travelling 15 m/s on a 7.0 kg bike brakes suddenly and slides to a stop in 3.2 m.

(a) Calculate the work done by friction to stop the cyclist.

(b) Calculate the coefficient of friction between the skidding tires and the ground.

(c) Are you able to determine if the tires were digging into the ground from your answer in part (b)? Explain.

41. A tow truck pulls a car by a cable that makes an angle of 21° to the horizontal. The tension in the cable is 6.5×10^3 N.



(a) How large is the force that causes the car to move horizontally?

(b) How much work has the tow truck done on the car after pulling it 3.0 km?

42. A 550 kg car travelling at 24.0 m/s[E] collides head-on with a 680 kg pickup truck. Both vehicles come to a complete stop on impact.

(a) What is the momentum of the car before the collision?

(b) What is the change in the car's momentum?

(c) What is the change in the truck's momentum?

(d) What is the velocity of the truck before the collision?

43. A rocket is travelling 160 m/s[forward] in outer space. It has a mass of 750 kg, which includes 130 kg of fuel. Burning all of the fuel produces an impulse of 41 600 N · s. What is the new velocity of the rocket?

44. An 8.0 kg stone falls off a 10.0 m cliff.

(a) How much work is done on it by the gravitational force?

(b) How much gravitational potential energy does it lose?

45. You are in a 1400 kg car, coasting down a 25° slope. When the car's speed is 15 m/s, you apply the brakes. If the car is to stop after travelling 75 m, what constant force (parallel to the road) must be applied?

46. An archery bow has a spring constant of 1.9×10^2 N/m. By how much does its elastic potential energy increase if it is stretched (a) 5.0 cm and (b) 71.0 cm?

47. You exert 72 N to compress a spring with a spring constant of 225 N/m a certain distance.
(a) What distance is the spring displaced?
(b) What is the elastic potential energy of the displaced spring?

48. A 2.50 kg mass is attached to one end of a spring on a horizontal, frictionless surface. The other end of the spring is attached to one end of a spring is attached to a solid wall. The spring has a spring constant of 75.0 N/m. The spring is stretched to 25.0 cm from its equilibrium point and released.
(a) What is the total energy of the mass-spring system?
(b) What is the velocity of the mass when it passes the equilibrium position?
(c) What is the elastic potential energy stored in the spring when the mass passes a point that is 15.0 cm from its equilibrium position?
(d) What is the velocity of the spring when it passes a point that is 15.0 cm from its equilibrium position?

49. A 275 g ball is resting on top of a spring that is mounted to the floor. You exert a force of 325 N on the ball and it compresses the spring 44.5 cm. If you release the ball from that position, how high, above the equilibrium position of the spring-ball system will the ball rise?

50. A 186 kg cart is released at the top of a hill.
(a) How much gravitational potential energy is lost after it descends through a vertical height of 8.0 m?
(b) If the amount of friction acting on the cart is negligible, determine the kinetic energy and the speed of the cart after it has descended through a vertical height of 8.0 m.

51. A small 95 g toy consists of a piece of plastic attached to a spring with a spring constant of 365 N/m. You compress the spring against the floor through a displacement of 5.5 cm, then release the toy. How fast is it travelling when it rises to a height of 10.0 cm?

52. Suppose a 1.5 kg block of wood is slid along a floor and it compresses a spring that is attached horizontally to a wall. The spring constant is 555 N/m and the block of wood is travelling 9.0 m/s when it hits the spring. Assume that the floor is frictionless and the spring is ideal.
(a) By how much does the block of wood compress the spring?

53. A spring with a spring constant of 120 N/m is stretched 5.0 cm from its rest position.
(a) Calculate the average force applied.
(b) Calculate the work done.
(c) If the spring is then stretched from its 5.0 cm position to 8.0 cm, calculate the work done.
(d) Sketch a graph of the applied force versus the spring displacement to show the extension of the spring. Explain how you can determine the amount of work done by analyzing the graph.

54. A 32.0 kg child descends a slide 4.00 m high. She reaches the bottom with a speed of 2.40 m/s. Was the mechanical energy conserved? Explain your reasoning and identify the energy transformations involved.

55. A 2.5 kg wooden block slides from rest down an inclined plane that makes an angle of 30° with the horizontal.
(a) If the plane is frictionless, what is the speed of the block after slipping a distance of 2.0 m?
(b) If the plane has a coefficient of kinetic friction of 0.20, what is the speed of the block after slipping a distance of 2.0 m?