Q1W5-Ph.-Qs.Bank-Work and Energy

Multiple Choice
Identify the choice that best completes the statement or answers the question.

____ 1. In which of the following sentences is *work* used in the scientific sense of the word?
a. Holding a heavy box requires a lot of work.
b. A scientist works on an experiment in the laboratory.
c. Sam and Rachel pushed hard, but they could do no work on the car.
d. John learned that shoveling snow is hard work.

____ 2. In which of the following sentences is *work* used in the everyday sense of the word?
a. Lifting a heavy bucket involves doing work on the bucket.
b. The force of friction usually does negative work.
c. Sam and Rachel worked hard pushing the car.
d. Work is a physical quantity.

____ 3. A force does work on an object if a component of the force
a. is perpendicular to the displacement of the object.
b. is parallel to the displacement of the object.
c. perpendicular to the displacement of the object moves the object along a path that returns the object to its starting position.
d. parallel to the displacement of the object moves the object along a path that returns the object to its starting position.

____ 4. Work is done when
a. the displacement is not zero.
b. the displacement is zero.
c. the force is zero.
d. the force and displacement are perpendicular.

____ 5. What is the common formula for work? Assume that *W* is the work, *F* is a constant force, Δv is the change in velocity, and *d* is the displacement.
a. $W = F\Delta v$
b. $W = Fd$
c. $W = Fd^2$
d. $W = F^2 d$

____ 6. In which of the following scenarios is work done?
a. A weightlifter holds a barbell overhead for 2.5 s.
b. A construction worker carries a heavy beam while walking at constant speed along a flat surface.
c. A car decelerates while traveling on a flat stretch of road.
d. A student holds a spring in a compressed position.

____ 7. In which of the following scenarios is no net work done?
a. A car accelerates down a hill.
b. A car travels at constant speed on a flat road.
c. A car decelerates on a flat road.
d. A car decelerates as it travels up a hill.

____ 8. A child moving at constant velocity carries a 2 N ice-cream cone 1 m across a level surface. What is the net work done on the ice-cream cone?
a. 0 J
b. 0.5 J
c. 2 J
d. 20 J

____ 9. A worker does 25 J of work lifting a bucket, then sets the bucket back down in the same place. What is the total net work done on the bucket?

a. –25 J
b. 0 J
c. 25 J
d. 50 J

____ 10. A construction worker pushes a wheelbarrow 5.0 m with a horizontal force of 50.0 N. How much work is done by the worker on the wheelbarrow?
a. 10 J
b. 55 J
c. 250 J
d. 1250 J

____ 11. A horizontal force of 200 N is applied to move a 55 kg television set across a 10 m level surface. What is the work done by the 200 N force on the television set?
a. 550 J
b. 2000 J
c. 6000 J
d. 11000 J

____ 12. A child pulls a balloon for 12 m with a force of 1.0 N at an angle 60° below horizontal. How much work does the child do on the balloon?
a. –10 J
b. –6.0 J
c. 6.0 J
d. 12 J

____ 13. Which of the following energy forms is associated with an object in motion?
a. potential energy
b. elastic potential energy
c. nonmechanical energy
d. kinetic energy

____ 14. Which of the following energy forms is associated with an object due to its position?
a. potential energy
b. positional energy
c. total energy
d. kinetic energy

____ 15. Which of the following energy forms is *not* involved in hitting a tennis ball?
a. kinetic energy
b. chemical potential energy
c. gravitational potential energy
d. elastic potential energy

____ 16. Ball A has triple the mass and speed of ball B. What is the ratio of the kinetic energy of ball A to ball B.
a. 3
b. 6
c. 9
d. 27

____ 17. What is the kinetic energy of a 0.135 kg baseball thrown at 40.0 m/s?
a. 54.0 J
b. 87.0 J
c. 108 J
d. 216 J

____ 18. Which of the following equations expresses the work-kinetic energy theorem?
a. $ME_i = ME_f$
b. $W_{net} = \Delta PE$
c. $\Delta W = \Delta KE$
d. $W_{net} = \Delta KE$

____ 19. If friction is the only force acting on an object during a given physical process, which of the following assumptions can be made in regard to the object’s kinetic energy?
a. The kinetic energy decreases.
b. The kinetic energy increases.
c. The kinetic energy remains constant.
d. The kinetic energy decreases and then increases.

____ 20. The main difference between kinetic energy and potential energy is that
a. kinetic energy involves position, and potential energy involves motion.
b. kinetic energy involves motion, and potential energy involves position.
c. although both energies involve motion, only kinetic energy involves position.
d. although both energies involve position, only potential energy involves motion.

____ 21. Which form of energy is involved in weighing fruit on a spring scale?
a. kinetic energy
b. nonmechanical energy
c. gravitational potential energy
d. elastic potential energy

____ 22. Gravitational potential energy is always measured in relation to
a. kinetic energy.
c. total potential energy.

b. mechanical energy.
d. a zero level.

____ 23. The equation for determining gravitational potential energy is $PE_g = mgh$. Which factor(s) in this equation is (are) *not* intrinsic to an object?
a. *m*
c. *h*
b. *g*
d. both *g* and *h*

____ 24. Which of the following parameters does *not* depend on how resistant a spring is to being compressed or stretched?
a. compression distance
c. spring constant
b. relaxed length
d. stretching distance

____ 25. What are the units for a spring constant?
a. N
c. N•m
b. m
d. N/m

____ 26. If the displacement of a horizontal mass-spring system was doubled, the elastic potential energy in the system would change by a factor of
a. 1/4.
c. 2.
b. 1/2.
d. 4.

____ 27. If the mass in a horizontal mass-spring system was doubled, the elastic potential energy in the system would change by a factor of
a. 0 (no change).
c. 2.
b. 1/2.
d. 4.

____ 28. What is the potential energy of a 1.0 kg mass 1.0 m above the ground?
a. 1.0 J
c. 10 J
b. 9.8 J
d. 96 J

____ 29. How much elastic potential energy is stored in a bungee cord with a spring constant of 10.0 N/m when the cord is stretched 2.00 m?
a. 10.0 J
c. 40.0 J
b. 20.0 J
d. 200 J

____ 30. Which of the following is a true statement about the conservation of energy?
a. Potential energy is always conserved.
b. Kinetic energy is always conserved.
c. Mechanical energy is always conserved.
d. Total energy is always conserved.

____ 31. In the presence of frictional force,
a. nonmechanical energy is negligible and mechanical energy is no longer conserved.
b. nonmechanical energy is negligible and mechanical energy is conserved.
c. nonmechanical energy is no longer negligible and mechanical energy is conserved.
d. nonmechanical energy is no longer negligible and mechanical energy is no longer conserved.

____ 32. Why doesn’t the principle of mechanical energy conservation hold in situations when frictional forces are present?
a. Kinetic energy is not completely converted to a form of potential energy.
b. Potential energy is completely converted to a form of gravitational energy.
c. Chemical energy is not completely converted to electrical energy.
d. Kinetic energy is completely converted to a form of gravitational energy.

____ 33. For which of the following situations is the conservation of mechanical energy most likely to be a valid assumption?
a. A skateboard rolls across a sewer grate.
b. A parachutist falls from a plane.

c. You rub your hands together to keep warm.
d. A soccer ball flies through the air.

_____ 34. Which of the following refers to the sum of kinetic energy and all forms of potential energy?
a. total energy
b. Σ energy
c. nonmechanical energy
d. mechanical energy

_____ 35. Which of the following are examples of conservable quantities?
a. potential energy and length
b. mechanical energy and length
c. mechanical energy and mass
d. kinetic energy and mass

_____ 36. Which of the following is a form of mechanical energy?
a. internal energy
b. chemical potential energy
c. gravitational potential energy
d. electrical energy

_____ 37. Friction converts kinetic energy to
a. mechanical energy.
b. potential energy.
c. nonmechanical energy.
d. total energy.

_____ 38. A 3.00 kg toy falls from a height of 1.00 m. What will the kinetic energy of the toy be just before the toy hits the ground? (Assume no air resistance and that g = 9.81 m/s^2.)
a. 0.98 J
b. 9.8 J
c. 29.4 J
d. 294 J

_____ 39. Which of the following is the rate at which energy is transferred?
a. potential energy
b. kinetic energy
c. mechanical energy
d. power

_____ 40. Which of the following is the rate at which work is done?
a. potential energy
b. kinetic energy
c. mechanical energy
d. power

_____ 41. Which of the following equations is *not* an equation for power, *P*, in terms of work, *W*, displacement, *d*, time interval, Δt, force, *F*, and/or velocity, *v*?
a. $P = F\frac{d}{\Delta t}$
b. $P = \frac{W}{\Delta t}$
c. $P = Fv$
d. $P = \frac{Fv}{\Delta t}$

_____ 42. How much power is required to lift a 2.0 kg mass at a speed of 2.0 m/s?
a. 2.0 J
b. 4.0 J
c. 9.8 J
d. 39 J

_____ 43. What is the average power supplied by a 60.0 kg person running up a flight of stairs a vertical distance of 4.0 m in 4.2 s?
a. 57 W
b. 240 W
c. 560 W
d. 670 W

_____ 44. Which of the following has the greatest power output?
a. a weightlifter who lifts a 250 N weight 2.1 m in 3.0 s
b. a mechanic's lift that raises a 1.2×10^4 N car 2.1 m in 12 s
c. a car engine that does 1.2×10^3 J of work in 5.0 s
d. a crane that lifts a 2.5×10^4 N beam at a speed of 1.2 m/s

_____ 45. A more powerful motor can do
a. more work in a longer time interval.
b. the same work in a shorter time interval.
c. less work in a longer time interval.
d. the same work in a longer time interval.

Short Answer

1. Explain the scientific meaning of *work.*
2. In the following sentence, is the everyday meaning or the scientific meaning of work intended?
   A student works on a term paper.
3. In the following sentence, is the everyday meaning or the scientific meaning of work intended?
   A coach does work on the bleachers by moving them into place before the basketball game.
4. In the following sentence, is the everyday meaning or the scientific meaning of work intended?
   A bulldozer does work lifting a load.
5. In the following sentence, is the everyday meaning or the scientific meaning of work intended?
   A clerk works overtime on Saturdays.
6. How is work related to force and displacement?
7. What formula can be used to calculate work if the force acts at an angle to the displacement?
8. Name the two SI units for work.
9. Is work a vector quantity or a scalar quantity?
10. A child pulls a toy across the floor. Is the work done on the toy positive, negative, or zero?
11. Air exerts a force on a leaf as it falls from a tree to Earth. Is the work done on the leaf positive, negative, or zero?

    A car travels at a speed of 25 m/s on a flat stretch of road. The driver must maintain pressure on the accelerator to keep the car moving at this speed.

12. Are any forces doing work on the car? Explain your answer.
13. What is the net work done on the car over a distance of 250 m?
14. The car’s engine is doing work on the car, yet the kinetic energy of the car is not changing. What is happening to the energy supplied by the engine?
15. What form of energy is associated with the position of an object in Earth’s gravitational field?
16. What form of energy is stored in any stretched or compressed object?
17. Is kinetic energy a vector quantity or a scalar quantity?
18. State, in words, the work-kinetic energy theorem.
19. Negative work is done on a moving object. How does the kinetic energy of the object change?
20. Describe the relationship between kinetic energy and gravitational potential energy during the free fall of a pencil from a desk.
21. A pocket watch contains a long, spiral piece of metal which is coiled tightly as the watch is wound. What form of potential energy is involved in winding a pocket watch?
22. An object is lowered into a deep hole in the ground. How does the potential energy of the object change?
23. You are analyzing the flight of a projectile through the air. What assumption do you have to make in order to use conservation of mechanical energy in your analysis?

24. A ski jumper has 1.2×10^4 J of potential energy at the top of the ski jump. The friction on the jump slope is small, but not negligible. What can you conclude about the ski jumper's kinetic energy at the bottom of the jump? Explain your answer.

25. List three different forms of mechanical energy.

26. Write a symbolic expression of the conservation of mechanical energy.

27. Write an equation that expresses the conservation of mechanical energy in a system where the only forms of mechanical energy are kinetic energy and gravitational potential energy.

28. Write an equation that expresses the conservation of mechanical energy in a system where the only forms of mechanical energy are kinetic energy and elastic potential energy.

29. Write an equation that expresses the conservation of mechanical energy in a system that involves kinetic energy, gravitational potential energy, and elastic potential energy.

30. A pendulum is raised 1.5 cm and allowed to fall. If air resistance is negligible, how high will the pendulum rise on the other side?

31. A child does 5.0 J of work on a spring while loading a ball into a spring-loaded toy gun. If mechanical energy is conserved, what will be the kinetic energy of the ball when it leaves the gun?

32. Explain how energy, time, and power are related.

33. How are work and power related?

34. Is power a vector quantity or a scalar quantity?

35. Show how the alternative definition of *power* can be derived by substituting the definitions of *work* and *speed* into the standard definition of *power*, $P = \frac{W}{\Delta t}$.

36. What does the wattage of a light bulb indicate?

37. How is a machine's power rating related to its rate of doing work on an object?

38. In terms of energy, what occurs when a machine does work on an object?

39. Which motor performs more work in the same amount of time—a 10 kW motor or a 20 kW motor? How much more work can it do?

40. What is the kinetic energy of a 1.5×10^3 kg car traveling at 25 m/s?

Problem

1. How much work is done on a bookshelf being pulled 4.00 m at an angle of 35.0° from the horizontal? The magnitude of the component of the force that does the work is 87.0 N.

2. A worker pushes a box with a horizontal force of 40.0 N over a level distance of 4.0 m. If a frictional force of 27 N acts on the box in a direction opposite to that of the worker, what net work is done on the box?

3. A flight attendant pulls a 60.0 N flight bag a distance of 239.0 m along a level airport floor at a constant speed. A 21.0 N force is exerted on the bag at an angle of 66.0° above the horizontal. How much work is done on the flight bag?

4. A hill is 132 m long and makes an angle of 12.0° with the horizontal. As a 54 kg jogger runs up the hill, how much work does the jogger do against gravity?
5. A professional skier starts from rest and reaches a speed of 48 m/s on a ski slope angled 22.0° above the horizontal. Using the work-kinetic energy theorem and disregarding friction, find the minimum distance along the slope the skier would have to travel in order to reach this speed.
6. A 31.0 kg crate, initially at rest, slides down a ramp 2.6 m long and inclined at an angle of 14.0° with the horizontal. Using the work-kinetic energy theorem and disregarding friction, find the velocity of the crate at the bottom of the ramp. (g = 9.81 m/s^2)
7. A child riding a bicycle has a total mass of 49.0 kg. The child approaches the top of a hill that is 15.0 m high and 106.0 m long at 14.0 m/s. If the force of friction between the bicycle and the hill is 22.0 N, what is the child's velocity at the bottom of the hill? (Assume no air resistance and that g = 9.81 m/s^2.)
8. A skier with a mass of 84 kg hits a ramp of snow at 32 m/s and becomes airborne. At the highest point of flight, the skier is 4.7 m above the ground. What is the skier's gravitational potential energy at this point?
9. A 2.74 g coin, which has zero potential energy at the surface, is dropped into a 12.2 m well. After the coin comes to a stop in the mud, what is its potential energy with respect to the surface?
10. A 3.62×10^2 N crate is pushed to the top of a 2.53 m ramp, which is inclined at 15.0° with the horizontal. What is the potential energy of the crate?
11. A 53.0 N crate is pulled up a 5.6 m inclined plane at a constant velocity. If the plane is inclined at an angle of 34.0° to the horizontal and there is a constant force of friction of 15.0 N between the crate and the surface, what is the net gain in potential energy by the crate?
12. A 37 kg child on roller skates, initially at rest, rolls 2.0 m down an incline at an angle of 17.0° with the horizontal. If there is no friction between incline and skates, what is the kinetic energy of the child at the bottom of the incline? (g = 9.81 m/s^2)
13. On a given occasion, Old Faithful geyser in Yellowstone National Park shoots water to a height of 47.1 m. With what velocity does the water leave the ground during this eruption? (Assume no air resistance and that g = 9.81 m/s^2.)
14. A pole vaulter clears 6.41 m. With what velocity does the vaulter strike the mat in the landing area? (Assume no air resistance and that g = 9.81 m/s^2.)
15. A bobsled zips down an ice track, starting from rest at the top of a hill with a vertical height of 170 m. Disregarding friction, what is the velocity of the bobsled at the bottom of the hill? (g = 9.81 m/s^2)
16. A pendulum with a mass of 4.0 kg is released from a height of 2.9 cm above the height of its resting position. How fast will the pendulum be moving when it passes through the lowest point of its swing?
17. What is the average power output of a weightlifter who can lift 260 kg to a height of 1.9 m in 1.8 s?
18. A jet engine develops 1.1×10^5 N of thrust to move an airplane forward at a speed of 9.3×10^2 km/h. What is the power output of the engine?
19. A 1.71×10^3 kg sports car accelerates from rest to 25.8 m/s in 7.41 s. What is the average power output of the automobile engine?
20. Water flows over a section of Niagara Falls at a rate of 1.30×10^6 kg/s and falls 49.5 m. What is the power of the waterfall?

Q1W5-Ph.-Qs.Bank-Work and Energy
Answer Section

MULTIPLE CHOICE

1. ANS: C	PTS: 1	DIF: I	OBJ: 5-1.1
2. ANS: C	PTS: 1	DIF: I	OBJ: 5-1.1
3. ANS: B	PTS: 1	DIF: I	OBJ: 5-1.2
4. ANS: A	PTS: 1	DIF: I	OBJ: 5-1.2
5. ANS: B	PTS: 1	DIF: I	OBJ: 5-1.2
6. ANS: C	PTS: 1	DIF: I	OBJ: 5-1.3
7. ANS: B	PTS: 1	DIF: I	OBJ: 5-1.3
8. ANS: A	PTS: 1	DIF: II	OBJ: 5-1.4
9. ANS: B	PTS: 1	DIF: II	OBJ: 5-1.3

10. ANS: C

2.5×10^2 J

Given

$F = 50.0$ N

$d = 5.0$ m

Solution

$W = Fd = (50.0\ \mathrm{N})(5.0\ \mathrm{m}) = 2.5 \times 10^2\ \mathrm{J}$

PTS: 1 DIF: IIIA OBJ: 5-1.4

11. ANS: B

Given

$F = 200$ N

$d = 10$ m

Solution

$W = Fd = (200\ \mathrm{N})(10\ \mathrm{m}) = 2 \times 10^3\ \mathrm{J}$

PTS: 1 DIF: IIIA OBJ: 5-1.4

12. ANS: C

Given

$F = 1.0$ N

$d = 12$ m

$\theta = -60°$

Solution

$W = Fd\cos\theta = (1.0\ \mathrm{N})(12\ \mathrm{m})\left[\cos(-60°)\right] = 6.0\ \mathrm{J}$

	PTS: 1	DIF: IIIA	OBJ: 5-1.4	
13.	ANS: D	PTS: 1	DIF: I	OBJ: 5-2.1
14.	ANS: A	PTS: 1	DIF: I	OBJ: 5-2.1
15.	ANS: B	PTS: 1	DIF: I	OBJ: 5-2.1
16.	ANS: D	PTS: 1	DIF: II	OBJ: 5-2.2
17.	ANS: C			

Given

$m = 0.135\ \mathrm{kg}$

$v = 40.0\ \mathrm{m/s}$

Solution

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(0.135kg)(40.0m/s)^2 = 108J$

	PTS: 1	DIF: IIIA	OBJ: 5-2.2	
18.	ANS: D	PTS: 1	DIF: I	OBJ: 5-2.3
19.	ANS: A	PTS: 1	DIF: II	OBJ: 5-2.3
20.	ANS: B	PTS: 1	DIF: I	OBJ: 5-2.4
21.	ANS: D	PTS: 1	DIF: I	OBJ: 5-2.5
22.	ANS: D	PTS: 1	DIF: I	OBJ: 5-2.5
23.	ANS: D	PTS: 1	DIF: II	OBJ: 5-2.5
24.	ANS: B	PTS: 1	DIF: II	OBJ: 5-2.5
25.	ANS: D	PTS: 1	DIF: I	OBJ: 5-2.6
26.	ANS: D	PTS: 1	DIF: II	OBJ: 5-2.6
27.	ANS: A	PTS: 1	DIF: II	OBJ: 5-2.6
28.	ANS: B			

Given

$m = 1.0\ \mathrm{kg}$

$h = 1.0\ \mathrm{m}$

$g = 9.81\ \mathrm{m/s^2}$

Solution

$PE = mgh = (1.0\ \mathrm{kg})(9.81\ \mathrm{m/s^2})(1.0\ \mathrm{m}) = 9.8\ \mathrm{J}$

	PTS: 1	DIF: IIIA	OBJ: 5-2.6
29.	ANS: B		

Given

$k = 10.0\ \mathrm{N/m}$

$x = 2.00\ \mathrm{m}$

Solution

$PE = \frac{1}{2}kx^2 = \frac{1}{2}(10.0\ \text{N/m})(2.00\ \text{m})^2 = 20.0\ \text{J}$

	PTS: 1	DIF: IIIA	OBJ: 5-2.6	
30.	ANS: D	PTS: 1	DIF: I	OBJ: 5-3.1
31.	ANS: D	PTS: 1	DIF: I	OBJ: 5-3.1
32.	ANS: A	PTS: 1	DIF: II	OBJ: 5-3.1
33.	ANS: D	PTS: 1	DIF: II	OBJ: 5-3.1
34.	ANS: D	PTS: 1	DIF: I	OBJ: 5-3.2
35.	ANS: C	PTS: 1	DIF: I	OBJ: 5-3.2
36.	ANS: C	PTS: 1	DIF: I	OBJ: 5-3.2
37.	ANS: C	PTS: 1	DIF: I	OBJ: 5-3.2
38.	ANS: C			

Given

$m = 3.00\ \text{kg}$

$h = 1.00\ \text{m}$

$g = 9.81\ \text{m/s}^2$

Solution

$KE_f = PE_{g,i} = mgh = (3.00\ \text{kg})(9.81\ \text{m/s}^2)(1.00\ \text{m}) = 29.4\ \text{J}$

	PTS: 1	DIF: IIIA	OBJ: 5-3.3	
39.	ANS: D	PTS: 1	DIF: I	OBJ: 5-4.1
40.	ANS: D	PTS: 1	DIF: I	OBJ: 5-4.1
41.	ANS: D	PTS: 1	DIF: I	OBJ: 5-4.1
42.	ANS: D			

Given

$m = 2.0\ \text{kg}$

$v = 2.0\ \text{m/s}$

$g = 9.81\ \text{m/s}^2$

Solution

$P = Fv = mgv = (2.0\ \text{kg})(9.81\ \text{m/s}^2)(2.0\ \text{m/s}) = 39\ \text{J/s}$

	PTS: 1	DIF: IIIA	OBJ: 5-4.2
43.	ANS: C		

Given

$m = 60.0\text{ kg}$

$d = 4.0\text{ m}$

$\Delta t = 4.2\text{ s}$

$g = 9.81\text{ m/s}^2$

Solution

$$P = \frac{W}{\Delta t} = \frac{Fd}{\Delta t} = \frac{mgd}{\Delta t} = \frac{(60.0\text{ kg})(9.81\text{ m/s}^2)(4.0\text{ m})}{4.2\text{ s}} = 5.6 \times 10^2\text{ W}$$

PTS: 1 DIF: IIIA OBJ: 5-4.2

44. ANS: D

Given

a: $F = 250\text{ N}$

$d = 2.1\text{ m}$

$\Delta t = 3.0\text{ s}$

b: $F = 1.2 \times 10^4\text{ N}$

$d = 2.1\text{ m}$

$\Delta t = 12\text{ s}$

c: $W = 1.2 \times 10^3\text{ J}$

$\Delta t = 3.0\text{ s}$

d: $F = 2.5 \times 10^4\text{ N}$

$v = 1.2\text{ m/s}$

Solution

$$P = \frac{W}{\Delta t} = \frac{Fd}{\Delta t} = Fv$$

$$P_a = \frac{Fd}{\Delta t} = \frac{(250\text{ N})(2.1\text{ m})}{2.0\text{ s}} = 2.6 \times 10^2\text{ J}$$

$$P_b = \frac{Fd}{\Delta t} = \frac{(1.2 \times 10^4\text{ N})(2.1\text{ m})}{12\text{ s}} = 2.1 \times 10^3\text{ J}$$

$$P_c = \frac{W}{\Delta t} = \frac{(1.2 \times 10^3\text{ J})}{5.0\text{ s}} = 2.4 \times 10^2\text{ J}$$

$$P_d = Fv = (2.5 \times 10^4\text{ N})(1.2\text{ m/s}) = 3.0 \times 10^4\text{ J}$$

$$P_d > P_b > P_a > P_c$$

PTS: 1 DIF: IIIA OBJ: 5-4.2

45. ANS: B PTS: 1 DIF: I OBJ: 5-4.3

SHORT ANSWER

1. ANS:
Work, in the scientific sense, is the product of the component of a force along the direction of displacement and the magnitude of the displacement. No work is done unless a force causes some displacement that is not perpendicular to the force.

PTS: 1 DIF: I OBJ: 5-1.1

2. ANS:
everyday meaning

PTS: 1 DIF: I OBJ: 5-1.1

3. ANS:
scientific meaning

PTS: 1 DIF: I OBJ: 5-1.1

4. ANS:
scientific meaning

PTS: 1 DIF: I OBJ: 5-1.1

5. ANS:
everyday meaning

PTS: 1 DIF: I OBJ: 5-1.1

6. ANS:
Work is equal to the magnitude of the component of a force parallel to the displacement of an object multiplied by the displacement of the object.

PTS: 1 DIF: I OBJ: 5-1.2

7. ANS:
$W = Fd\cos\theta$

PTS: 1 DIF: I OBJ: 5-1.2

8. ANS:
newton-meters (N•m) and joules (J)

PTS: 1 DIF: I OBJ: 5-1.2

9. ANS:
Work is a scalar quantity.

PTS: 1 DIF: I OBJ: 5-1.2

10. ANS:
positive

PTS: 1 DIF: II OBJ: 5-1.3

11. ANS:
negative

PTS: 1 DIF: II OBJ: 5-1.3

12. ANS:
Yes; both the force of the engine and the force of friction are doing work on the car.

PTS: 1 DIF: II OBJ: 5-1.3

13. ANS:
The net work is zero (because the net force on the car is zero).

PTS: 1 DIF: II OBJ: 5-1.4

14. ANS:
Energy equal in amount to the energy supplied by the engine is lost from the system due to friction.

PTS: 1 DIF: II OBJ: 5-3.2

15. ANS:
gravitational potential energy

PTS: 1 DIF: I OBJ: 5-2.1

16. ANS:
elastic potential energy

PTS: 1 DIF: I OBJ: 5-2.1

17. ANS:
Kinetic energy is a scalar quantity.

PTS: 1 DIF: I OBJ: 5-2.2

18. ANS:
The net work done by the net force acting on an object is equal to the change in the kinetic energy of the object.

PTS: 1 DIF: I OBJ: 5-2.3

19. ANS:
The kinetic energy will decrease.

PTS: 1 DIF: II OBJ: 5-2.3

20. ANS:
At the top of the fall, all the energy is gravitational potential energy. During the fall, gravitational potential energy decreases as it is transformed into kinetic energy. When the pencil reaches the ground, all the energy is kinetic energy.

PTS: 1 DIF: II OBJ: 5-2.4

21. ANS:
elastic potential energy

PTS: 1 DIF: II OBJ: 5-2.5

22. ANS:
The potential energy decreases.

PTS: 1 DIF: II OBJ: 5-2.6

23. ANS:
You have to assume that air resistance is negligible.

PTS: 1 DIF: II OBJ: 5-3.1

24. ANS:

It will be less than 1.2×10^4 J. Because friction is not negligible, mechanical energy is not conserved, and some mechanical energy will be lost.

PTS: 1 DIF: II OBJ: 5-3.1

25. ANS:

kinetic energy, gravitational potential energy, elastic potential energy

PTS: 1 DIF: I OBJ: 5-3.2

26. ANS:

$ME_i = ME_f$

PTS: 1 DIF: I OBJ: 5-3.2

27. ANS:

$\frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}mv_f^2 + mgh_f$

PTS: 1 DIF: I OBJ: 5-3.2

28. ANS:

$\frac{1}{2}mv_i^2 + \frac{1}{2}kx_i^2 = \frac{1}{2}mv_f^2 + \frac{1}{2}kx_f^2$

PTS: 1 DIF: I OBJ: 5-3.2

29. ANS:

$\frac{1}{2}mv_i^2 + mgh_i + \frac{1}{2}kx_i^2 = \frac{1}{2}mv_f^2 + mgh_f + \frac{1}{2}kx_f^2$

PTS: 1 DIF: I OBJ: 5-3.2

30. ANS:

1.5 cm

PTS: 1 DIF: II OBJ: 5-3.3

31. ANS:

5.0 J

PTS: 1 DIF: II OBJ: 5-3.3

32. ANS:

Power is the rate at which energy is transferred. In other words, power is the energy transferred in a given time interval.

PTS: 1 DIF: I OBJ: 5-4.1

33. ANS:

Power measures how much work is done in a given time interval. In other words, power is the rate of work.

PTS: 1 DIF: I OBJ: 5-4.1

34. ANS:

Power is a scalar quantity.

PTS: 1 DIF: I OBJ: 5-4.1

35. ANS:

Definition of *power*: $P = \frac{W}{\Delta t}$

Definition of *work*: $W = Fd$

Definition of *speed*: $v = \frac{d}{\Delta t}$

$$P = \frac{W}{\Delta t} = F\frac{d}{\Delta t} = Fv$$

Alternative definition of *power*: $P = Fv$

PTS: 1 DIF: II OBJ: 5-4.1

36. ANS:

The wattage tells the rate at which energy is converted by the bulb.

PTS: 1 DIF: II OBJ: 5-4.1

37. ANS:

The power rating of a machine indicates the rate at which it does work on an object.

PTS: 1 DIF: I OBJ: 5-4.3

38. ANS:

When a machine does work on an object, energy is transferred to that object.

PTS: 1 DIF: II OBJ: 5-4.3

39. ANS:

The 20 kW motor does twice as much work in the same amount of time.

PTS: 1 DIF: II OBJ: 5-4.3

40. ANS:

4.7×10^{3} J

Given

$m = 1.5 \times 10^3$ kg

$v = 25$ m/s

Solution

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}\left(1.5 \times 10^3 \text{ kg}\right)(25 \text{ m/s})^2 = 4.7 \times 10^5 \text{ J}$$

PTS: 1 DIF: IIIA OBJ: 5-2.2

PROBLEM

1. ANS:

348 J

Given
$F = 87.0\ \text{N}$

$d = 4.00\ \text{m}$

Solution
$W = Fd = (87.0\ \text{N})(4.00\ \text{m}) = 348\ \text{J}$

PTS: 1 DIF: IIIA OBJ: 5-1.4

2. ANS:
52 J

Given
$F_w = 40.0\ \text{N}$

$F_k = 27\ \text{N}$

$d = 4.0\ \text{m}$

Solution
$W_{net} = F_{net}d = \left(F_w - F_k\right)d = [40.0\ \text{N} - 27\ \text{N}](4.0\ \text{m})$

$W_{net} = (13\ \text{N})(4.0\ \text{m}) = 52\ \text{J}$

PTS: 1 DIF: IIIB OBJ: 5-1.4

3. ANS:
2040 J

Given
$F = 21.0\ \text{N}$

$d = 239.0\ \text{m}$

$\theta = 66.0°$

Solution
$W = Fd\cos\theta = (21.0\ \text{N})(239.0\ \text{m})(\cos 66.0°)$

$W = (21.0\ \text{N})(239.0\ \text{m})(0.407)$

$W = 2.04 \times 10^3\ \text{J}$

PTS: 1 DIF: IIIB OBJ: 5-1.4

4. ANS:
1.5×10^4 J

Given

$m = 54\ \text{kg}$

$d = 132\ \text{m}$

$\theta = 12.0°$

$g = 9.81\ \text{m/s}^2$

Solution

$W = \Delta PE_g = mgh$

$h = d \sin \theta$

$W = mgd \sin \theta = (54\ \text{kg})(9.81\ \text{m/s}^2)(132\ \text{m})(\sin 12.0°)$

$W = (54\ \text{kg})(9.81\ \text{m/s}^2)(132\ \text{m})(0.208)$

$W = 1.5 \times 10^4\ \text{J}$

PTS: 1 DIF: IIIB OBJ: 5-1.4

5. ANS:

310 m

Given

$v_i = 0\ \text{m/s}$

$v_f = 48\ \text{m/s}$

$\theta = 22.0°$

$g = 9.81\ \text{m/s}^2$

Solution

$W_{net} = \Delta KE$

$W_{net} = Fd = (mg \sin \theta)d$

$\Delta KE = KE_f - KE_i = \frac{1}{2} m{v_f}^2 - 0 = \frac{1}{2} m{v_f}^2$

$mgd \sin \theta = \frac{1}{2} m{v_f}^2$

$$d = \frac{{v_f}^2}{2g \sin \theta}$$

$$d = \frac{(48\ \text{m/s})^2}{(2)(9.81\ \text{m/s}^2)(\sin 22.0°)}$$

$$d = \frac{2300\ \text{m}^2/\text{s}^2}{(2)(9.81\ \text{m/s}^2)(0.375)}$$

$d = 310\ \text{m}$

PTS: 1 DIF: IIIC OBJ: 5-2.3

6. ANS:
3.5 m/s

Given
$v_i = 0 \text{ m/s}$

$m = 31.0 \text{ kg}$

$d = 2.6 \text{ m}$

$\theta = 14.0°$

$g = 9.81 \text{ m/s}^2$

Solution
$W_{net} = \Delta KE$

$W_{net} = F_{net}d = \left(F_g \sin\theta\right)d = mgd\sin\theta$

$\Delta KE = KE_f - KE_i = \frac{1}{2}mv_f^{\,2} - 0 = \frac{1}{2}mv_f^{\,2}$

$mgd\sin\theta = \frac{1}{2}mv_f^{\,2}$

$v_f = \sqrt{2gd\sin\theta}$

$v_f = \sqrt{(2)\left(9.81 \text{ m/s}^2\right)(2.6\text{m})(\sin 14.0°)}$

$v_f = \sqrt{(2)\left(9.81 \text{ m/s}^2\right)(2.6\text{m})(0.242)}$

$v_f = \sqrt{12 \text{ m}^2/\text{s}^2}$

$v_f = 3.5 \text{ m/s}$

PTS: 1 DIF: IIIC OBJ: 5-2.3

7. ANS:
19.9 m/s

Given
$v_i = 14.0 \text{ m/s}$

$m = 49.0 \text{ kg}$

$h = 15.0 \text{ m}$

$d = 106.0 \text{ m}$

$F_k = 22.0 \text{ N}$

$g = 9.81 \text{ m/s}^2$

Solution

$$W_{net} = \Delta KE$$

$$W_{net} = F_{net}d = \left(mg\sin\theta - F_k\right)d$$

$$\sin\theta = \frac{h}{d}$$

$$\Delta KE = KE_f - KE_i = \tfrac{1}{2}mv_f^{\,2} - \tfrac{1}{2}mv_i^{\,2}$$

$$\left(\frac{mgh}{d} - F_k\right)d = \tfrac{1}{2}mv_f^{\,2} - \tfrac{1}{2}mv_i^{\,2}$$

$$\tfrac{1}{2}mv_f^{\,2} = \tfrac{1}{2}mv_i^{\,2} + mgh - F_k d$$

$$v_f^{\,2} = v_i^{\,2} + 2gh - \frac{2dF_k}{m}$$

$$v_f = \sqrt{v_i^{\,2} + 2gh - \frac{2dF_k}{m}}$$

$$v_f = \sqrt{(14.0\ \text{m/s})^2 + (2)\left(9.81\ \text{m/s}^2\right)(15.0\ \text{m}) - \frac{(2)(106.0\ \text{m})(22.0\ \text{N})}{\left(49.0\ \text{kg}\right)}}$$

$$v_f = \sqrt{196\ \text{m}^2/\text{s}^2 + 294\ \text{m}^2/\text{s}^2 - 95.2\ \text{m}^2/\text{s}^2}$$

$$v_f = \sqrt{395\ \text{m}^2/\text{s}^2}$$

$$v_f = 19.9\ \text{m/s}$$

PTS: 1 DIF: IIIC OBJ: 5-2.3

8. ANS:
3.9×10^3 J

Given

$m = 84$ kg

$h = 32$ m

$g = 9.81\ \text{m/s}^2$

Solution

$$PE = mgh = \left(84\ \text{kg}\right)\left(9.81\ \text{m/s}^2\right)(4.7\ \text{m}) = 3.9 \times 10^3\ \text{J}$$

PTS: 1 DIF: IIIA OBJ: 5-2.6

9. ANS:
–0.328 J

Given

$m = 2.74\text{ g} = 2.74 \times 10^{-3}\text{ kg}$

$h = -12.2\text{ m}$

$g = 9.81\text{ m/s}^2$

Solution

$PE = mgh = \left(2.74 \times 10^{-3}\text{ kg}\right)\left(9.81\text{ m/s}^2\right)(-12.2\text{ m}) = -0.328\text{ J}$

PTS: 1 DIF: IIIB OBJ: 5-2.6

10. ANS:
237 J

Given

$F_g = mg = 3.62 \times 10^2\text{ N}$

$d = 2.53\text{ m}$

$\theta = 15.0°$

Solution

$h = d\sin\theta$

$PE = mgh = F_g d\sin\theta = \left(3.62 \times 10^2\text{ N}\right)(2.53\text{ m})(\sin 15.0°)$

$PE = \left(3.62 \times 10^2\text{ N}\right)(2.53\text{ m})(0.259)$

$PE = 237\text{ J}$

PTS: 1 DIF: IIIB OBJ: 5-2.6

11. ANS:
160 J

Given

$mg = 53.0\text{ N}$

$d = 5.6\text{ m}$

$\theta = 34.0°$

$h_i = 0.0\text{ m}$

Solution

$h_f = d\sin\theta = (5.6\text{ m})(\sin 34.0°) = (5.6\text{ m})(0.559) = 3.1\text{ m}$

$\Delta PE = PE_f - PE_i = mg\left(h_f - h_i\right) = (53.0\text{ N})(3.1\text{ m} - 0.0\text{ m}) = 160\text{ J}$

PTS: 1 DIF: IIIB OBJ: 5-2.6

12. ANS:
210 J

Given
$m = 37\ \text{kg}$

$d = 2.0\ \text{m}$

$\theta = 17.0°$

$g = 9.81\ \text{m/s}^2$

Solution
$h = d \sin\theta$

$KE_f = PE_{g,i} = mgh = mgd \sin\theta = (37\ \text{kg})(9.81\ \text{m/s}^2)(2.0\ \text{m})(\sin 17.0°)$

$KE_f = (37\ \text{kg})(9.81\ \text{m/s}^2)(2.0\ \text{m})(0.292)$

$KE_f = 210\ \text{J}$

PTS: 1 DIF: IIIB OBJ: 5-3.3

13. ANS:
30.4 m/s

Given
$h = 47.1\ \text{m}$

$g = 9.81\ \text{m/s}^2$

Solution
$KE_i = PE_{g,f}$

$\frac{1}{2} m{v_i}^2 = mgh$

$v_i = \sqrt{2gh} = \sqrt{(2)(9.81\ \text{m/s}^2)(47.1\text{m})}$

$v_i = \sqrt{924\ \text{m}^2/\text{s}^2}$

$v_i = 30.4\ \text{m/s}$

PTS: 1 DIF: IIIB OBJ: 5-3.3

14. ANS:
11.2 m/s

Given
$h = 6.41\ \text{m}$

$g = 9.81\ \text{m/s}^2$

Solution

$KE_f = PE_{g,i}$

$\frac{1}{2}mv_f^{\,2} = mgh$

$v_f = \sqrt{2gh} = \sqrt{(2)\left(9.81\ \text{m/s}^2\right)(6.41\ \text{m})}$

$v_f = \sqrt{126\ \text{m}^2/\text{s}^2}$

$v_f = 11.2\ \text{m/s}$

PTS: 1 DIF: IIIB OBJ: 5-3.3

15. ANS:
57 m/s

Given
$h = 170\ \text{m}$

$g = 9.81\ \text{m/s}^2$

Solution
$KE_f = PE_{g,i}$

$\frac{1}{2}mv_f^{\,2} = mgh$

$v_f = \sqrt{2gh} = \sqrt{(2)\left(9.81\ \text{m/s}^2\right)(170\ \text{m})}$

$v_f = \sqrt{3300\ \text{m}^2/\text{s}^2}$

$v_f = 57\ \text{m/s}$

PTS: 1 DIF: IIIB OBJ: 5-3.3

16. ANS:
0.75 m/s

Given
$h = 2.9\ \text{cm} = 2.9 \times 10^{-2}\ \text{m}$

$g = 9.81\ \text{m/s}^2$

Solution

$$ME_i = ME_f$$

$$mgh_i = \frac{1}{2}mv_f^{\,2}$$

$$v_f = \sqrt{2gh} = \sqrt{(2)\left(9.81\ \text{m/s}^2\right)\left(2.9 \times 10^{-2}\ \text{m}\right)}$$

$$v_f = \sqrt{2gh} = \sqrt{5.7 \times 10^{-1}\ \text{m}^2/\text{s}^2}$$

$$v_f = 0.75\ \text{m/s}$$

PTS: 1 DIF: IIIA OBJ: 5-3.3

17. ANS:
2.7 kW

Given
$m = 260\ \text{kg}$

$d = 1.9\ \text{m}$

$\Delta t = 1.8\ \text{s}$

$g = 9.81\ \text{m/s}^2$

Solution

$$P = \frac{W}{\Delta t} = \frac{Fd}{\Delta t} = \frac{mgd}{\Delta t} = \frac{(260\ \text{kg})\left(9.81\ \text{m/s}^2\right)(1.9\ \text{m})}{1.8\ \text{s}} = 2.7 \times 10^3\ \text{W} = 2.7\ \text{kW}$$

PTS: 1 DIF: IIIA OBJ: 5-4.2

18. ANS:
29 MW

Given
$F = 1.1 \times 10^5\ \text{N}$

$v = 9.3 \times 10^2\ \text{km/h}$

Solution
$P = Fv$

$$v = 9.3 \times 10^2\ \text{km/h} \times \left(\frac{1000\ \text{m}}{1\ \text{km}}\right) \times \left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = 2.6 \times 10^2\ \text{m/s}$$

$$P = \left(1.1 \times 10^5\ \text{N}\right)\left(2.6 \times 10^2\ \text{m/s}\right) = 2.9 \times 10^7\ \text{W} = 29\ \text{MW}$$

PTS: 1 DIF: IIIB OBJ: 5-4.2

19. ANS:
76.8 kW

Given

$m = 1.71 \times 10^3$ kg

$v_i = 0.0$ m/s

$v_f = 25.8$ m/s

$\Delta t = 7.41$ s

Solution

$$F = ma = m\left(\frac{v_f - v_i}{\Delta t}\right) = \left(1.71 \times 10^3 \text{ kg}\right)\left(\frac{25.8 \text{ m/s} - 0.0 \text{ m/s}}{7.41 \text{ s}}\right) = 5.95 \times 10^3 \text{ N}$$

$$\Delta x = \frac{1}{2}\left(v_i + v_f\right)\Delta t = \frac{1}{2}(0.0 \text{ m/s} + 25.8 \text{ m/s})(7.41 \text{ s}) = 95.6 \text{ m}$$

$$P = \frac{W}{\Delta t} = \frac{F\Delta x}{\Delta t} = \frac{\left(5.95 \times 10^3 \text{ N}\right)(95.6 \text{ m})}{7.41 \text{ s}} = 7.68 \times 10^4 \text{ W} = 76.8 \text{ kW}$$

PTS: 1 DIF: IIIC OBJ: 5-4.2

20. ANS:
631 MW

Given

$flow = 1.30 \times 10^6 \text{ kg/s} = \frac{m}{\Delta t}$

$d = 49.5$ m

$g = 9.81 \text{ m/s}^2$

Solution

$$\frac{m}{\Delta t} = 1.30 \times 10^6 \text{ kg/s}$$

$$P = \frac{W}{\Delta t} = \frac{Fd}{\Delta t} = \frac{mgd}{\Delta t} = \frac{m}{\Delta t} gd$$

$$P = \left(1.30 \times 10^6 \text{ kg/s}\right)\left(9.81 \text{ m/s}^2\right)(49.5 \text{ m}) = 6.31 \times 10^8 \text{ W} = 631 \text{ MW}$$

PTS: 1 DIF: IIIC OBJ: 5-4.2