Physics 11 - Work, Power, Energy Worksheet

KEY

1. Calculate the work done by a 47 N force pushing a pencil 0.26 m.

   $W = F \cdot \Delta x$ $W = 47(.26) = $ **12.2 J**

2. Calculate the work done by a 47 N force pushing a 0.025 kg pencil 0.25 m against a force of 23 N.

   $F_{net} = 47 - 23 = 24 N$ $W = F\Delta x = 24(.25) = $ **6 J**

3. Calculate the work done by a 2.4 N force pushing a 400 g sandwich across a table 0.75 m wide.

   $W = F \cdot \Delta x$ $W = (2.4)(.75) = $ **1.8 J**

4. How far can a mother push a 20.0 kg baby carriage, using a force of 62 N, if she can only do 2920 J of work?

   $W = F\Delta x$
   $2920 = 62(\Delta x)$ **$\Delta x = 47 m$**

5. How much work is it to lift a 20 kg sack of potatoes vertically 6.5 m?

   $F_A = 196 N$
   $F_g = 20(9.8) = 196 N$
   $W = 196(6.5)$
   $=$ **1274 J**

6. If a small motor does 520 J of work to move a toy car 260 m, what force does it exert?

   $W = F \cdot \Delta x$
   $520 = F \cdot 260$ **$F = 2N$**

7. A girl pushes her little brother on his sled with a force of 300 N for 750 m. How much work is this if the force of friction acting on the sled is (a) 200 N, (b) 300 N?

   $W_{net} = F_{net} \cdot \Delta x$
   a) $W_{net} = (300 - 200)(750)$
   $=$ **75000**
   b) $W_{net} = (300 - 300)(750) = 0$ ← sled doesn't move

8. A 75.0 kg man pushes on a 500,000 t wall for 250 s but it does not move. How much work does he do on the wall?

   0 J

9. A boy on a bicycle drags a wagon full of newspapers at 0.80 m/s for 30 min using a force of 40 N. How much work has the boy done?

   $\bar{v} = \frac{\Delta x}{t}$ $\frac{30 min}{1} \cdot \frac{60 s}{1 min} = 1800 s$
   $.8 m/s = \frac{\Delta x}{1800 s}$ $\Delta x = 1440 m$
   $W = F \cdot \Delta x$
   $= 40(1440)$
   $=$ **57600 J**

10. What is the gravitational potential energy of a 61.2 kg person standing on the roof of a 10-storey building relative to (a) the tenth floor, (b) the sixth floor, (c) the first floor. (Each storey is 2.50 m high.)

    a) $E_p = mgh$
    $= 61.2(9.8)(2.5) = $ **1500 J**
    b) $E_p = 61.2(9.8)(5 \cdot 2.5) = $ **7,500 J**
    c) $E_p = 61.2(9.8)(10 \cdot 2.5) = $ **15000 J**

11. A 10 000 kg airplane lands, descending a vertical distance of 10 km while travelling 100 km measured along the ground. What is the plane's loss of potential energy?

    $\Delta PE = PE_f - PE_i$
    $\Delta PE = 0 - PE_i$
    $E_{p_{loss}} = mgh = 10000(9.8)(10000)$
    $=$ **980,000,000 J** lost

12. A coconut falls out of a tree 12.0 m above the ground and hits a bystander 3.00 m tall on the top of the head. It bounces back up 1.50 m before falling to the ground. If the mass of the coconut is 2.00 kg, calculate the potential energy of the coconut relative to the ground at each of the following sites:

(a) while it is still in the tree,
(b) when it hits the bystander on the head,
(c) when it bounces up to its maximum height,
(d) when it lands on the ground,
(e) when it rolls into a groundhog hole, and falls 2.50 m to the bottom of the hole.

a) $PE = mgy = 2(9.8)(12) = 235\ J$
b) $PE = 2(9.8)(3) = 59\ J$
c) $PE = 2(9.8)(3+1.5) = 88\ J$
d) $0\ J$
e) $PE = mgy = 2(9.8)(-2.5) = -49\ J$

13. Calculate the kinetic energy of a 45 g golf ball travelling at: (a) 20 m/s, (b) 40 m/s, (c) 60 m/s.

$KE = \frac{1}{2}mv^2$ (g → kg)
a) $KE = \frac{1}{2}(.045)(20)^2 = 9\ J$
b) $= 36\ J$
c) $81\ J$

14. When the speed of an object doubles, does its kinetic energy double? Explain your answer.

$KE = \frac{1}{2}mv^2$ (refer to 18)
No, KE quadruples $v^2 \rightarrow (2v)^2 = 4v^2$

15. How fast must a 1000 kg car be moving to have a kinetic energy of: (a) 2.0×10^3 J, (b) 2.0×10^5 J, (c) 1.0 kW·h?

$KE = \frac{1}{2}mv^2$
a) $2000 = \frac{1}{2}(1000)v^2$ $v = 2\ m/s$
b) $200000 = \frac{1}{2}(1000)v^2$ $v = 20\ m/s$

16. How high would you have to lift a 1000 kg car to give it a potential energy of: (a) 2.0×10^3 J, (b) 2.00×10^5 J, (c) 1.00 kW·h?

a) $PE = mgy$
$2000 = 1000(9.8)y$
$y = .2\ m$
b) $200000 = 1000 \cdot 9.8y$
$y = 20.4\ m$

17. A 50 kg bicyclist on a 10 kg bicycle speeds up from 5.0 m/s to 10 m/s.
(a) What was the total kinetic energy before accelerating?
(b) What was the total kinetic energy after accelerating?
(c) How much work was done to increase the kinetic energy of the bicyclist?
(d) Is it more work to speed up from 0 to 5.0 m/s than from 5.0 to 10.0 m/s?

a) $KE = \frac{1}{2}mv^2 = \frac{1}{2}(60)(5)^2 = 750\ J$
b) $KE = \frac{1}{2}(60)(10)^2 = 3000\ J$
c) $W = \Delta KE = 3000 - 750 = 2250\ J$
d) 0–5 m/s: $\Delta KE = \frac{1}{2}(60)(5)^2 - \frac{1}{2}(60)(0)$
$= 750\ J = W < 2250\ J$
More work to ↑ speed from 5–10 m/s

18. At the moment when a shotputter releases a 5.00 kg shot, the shot is 3.00 m above the ground and travelling at 15.0 m/s. It reaches a maximum height of 8.00 m above the ground and then falls to the ground. If air resistance is negligible,

(a) What was the potential energy of the shot as it left the hand relative to the ground?

(b) What was the kinetic energy of the shot as it left the hand?

(c) What was the total energy of the shot as it left the hand?

(d) What was the total energy of the shot as it reached its maximum height?

(e) What was the potential energy of the shot at its maximum height?

(f) What was the kinetic energy of the shot at its maximum height?

(g) What was the kinetic energy of the shot just as it struck the ground?

a) PE = mgy = 5(9.8)3 = 147 J

b) KE = ½mv² = (.5)(5)(15)² = 563 J

c) TE = KE + PE = 147 + 563 = 710 J

d) $TE_i = TE_f$ = 710 J

e) PE = mgy = 5(9.8)(8) = 392 J

f) KE = TE − PE = 710 − 392 = 318 J

g) PE = 0, so if PE + KE = TE, 710 J = KE = TE

19. A power mower does 9.00 x 10^5 J of work in 0.500 h. What power does it develop?

P = W/t .5h · 3600s/1h = 1800s P = 900000 J / 1800s = 500 W

20. How long would it take a 500 W electric motor to do 1.50 x 10^5 J of work?

P = W/t 500W = 150000/t t = 300s

21. How much work can a 22 kW car engine do in 60 s if it is 100% efficient?

P = W/t 22000W = W/60 W = 1,320,000 J

22. A force of 5.0 N moves a 6.0 kg object along a rough floor at a constant speed of 2.5 m/s.

(a) How much work is done in 25 s.?

(b) What power is being used?

(c) What force of friction is acting on the object?

a) v̄ = Δx/t 2.5 m/s = Δx/25

Δx = 62.5 m

W = FΔx = 5N(62.5m) = 312.5 J

b. P = W/t = 312.5 J / 25 s = 12.5 W

c. a = 0 F_{net} = 0

$F_A = F_{fr}$ = 5.0 N

23. How much electrical energy (in kilowatt hours) would a 60.0 W light bulb use in 60.0 days if left on steadily?

24. A 6.0 kg metal ball moving at 4.0 m/s hits a 6.0 kg ball of putty at rest and sticks to it. The two go on at 2.0 m/s.

(a) What is the kinetic energy of the metal ball before it hits?

(b) What is the kinetic energy of the metal ball after it hits?

(c) What is the kinetic energy of the putty ball after being hit?

(d) How much energy does the metal ball lose in the collision?

(e) How much kinetic energy does the putty ball gain in the collision?

(f) What happened to the rest of the energy?

a) KE = ½mv² = ½(6)(4)² = 48 J

b) KE = ½mv² = ½(6)(2)² = 12 J

c) KE = ½mv² = ½(6)(2)² = 12 J

d) 48 − 12 = 36 J

e) 12 J

f) lost to friction in collision

KEY

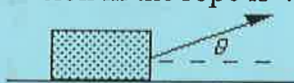
TYPICAL NUMERIC QUESTIONS FOR PHYSICS I REGULAR

QUESTIONS TAKEN FROM CUTNELL AND JOHNSON

WORK AND ENERGY

CONTENT STANDARD IV A

1. A concrete block is pulled 7.0 m across a frictionless surface by means of a rope. The tension in the rope is 40 N; and the net work done on the block is 247 J.



What angle does the rope make with the horizontal?
A) 28° B) 41° C) 47° D) 62° E) 88°

2. Mike is cutting the grass using a human-powered lawn mower. He pushes the mower with a force of 45 N directed at an angle of 41° below the horizontal direction. Calculate the work that Mike does on the mower in pushing it 9.1 m across the yard.
A) 510 J B) 460 J C) 410 J D) 360 J E) 310 J

3. A 5.00-kg block of ice is sliding across a frozen pond at 2.00 m/s. A 7.60-N force is applied in the direction of motion. After the ice block slides 15.0 m, the force is removed. The work done by the applied force is
A) −114 J B) +114 J C) −735 J D) +735 J E) +19.7 J

4. A force of magnitude 25 N directed at an angle of 37° above the horizontal moves a 10-kg crate along a horizontal surface at constant velocity. How much work is done by this force in moving the crate a distance of 15 m?
A) zero joules B) 1.7 J C) 40 J D) 98 J E) 300 J

skip X A 1.0-kg ball on the end of a string is whirled at a constant speed of 2.0 m/s in a horizontal circle of radius 1.5 m. What is the work done by the centripetal force during one revolution?
A) zero joules B) 2.7 J C) 6.0 J D) 25 J E) 33 J

6. Brenda carries an 8.0-kg suitcase as she walks 25 m along a horizontal walkway to her room at a constant speed of 1.5 m/s. How much work does Brenda do in carrying her suitcase?

A) zero joules B) 40 J C) 200 J D) 300 J E) 2000 J

$F \perp \Delta x$

7. A 1500-kg car travels at a constant speed of 22 m/s around a circular track that is 80 m across. What is the kinetic energy of the car?

A) zero joules B) 3.6×10^5 J C) 3.3×10^4 J D) 1.6×10^4 J E) 7.2×10^5 J

$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(1500)(22)^2$

8. The kinetic energy of a car is 8×10^6 J as it travels along a horizontal road. How much work is required to stop the car in 10 s?

A) zero joules B) 8×10^4 J C) 8×10^5 J D) 8×10^6 J E) 8×10^7 J

$W = \Delta KE$

9. How much energy is dissipated in braking a 1000-kg car to a stop from an initial speed of 20 m/s?

A) 20 000 J B) 200 000 J C) 400 000 J D) 800 000 J E) 10 000 J

$KE_{lost} = \frac{1}{2}mv^2 = \frac{1}{2}(1000)(20)^2 = 200\,000$ J

10. The kinetic energy of an 1100-kg truck is 4.6×10^5 J. What is the speed of the truck?

A) 21 m/s B) 29 m/s C) 33 m/s D) 17 m/s E) 25 m/s

$KE = \frac{1}{2}mv^2$ solve for v

11. A 40-kg block is lifted vertically 20 meters from the surface of the earth. To one significant figure, what is the change in the gravitational potential energy of the block?

A) +800 J B) −800 J C) +8000 J D) −8000 J E) zero joules

$PE = mgh$

12. A 1500-kg elevator moves upward with constant speed through a vertical distance of 25 m. How much work was done by the tension in the cable?

A) 990 J B) 8100 J C) 140 000 J D) 370 000 J E) 430 000 J

$W = F \cdot \Delta x = m \cdot 9.8\,\Delta x$

13. A 12-kg crate is pushed up an incline from point A to point B as shown in the figure. What is the change in the gravitational potential energy of the crate?

5 m = Δy

A) +590 J B) −590 J C) +1200 J D) −1200 J E) +60 J

$PE = mgh$

$\Delta PE = mg(\Delta y)$
$= 12(9.8)(7.5 - 2.5)$
$12(9.8)(5)$
≈ 590 J

14. A helicopter (m = 1250 kg) is cruising at a speed of 25.0 m/s at an altitude of 185 m. What is the total mechanical energy of the helicopter?

A) 3.91×10^5 J
B) 2.66×10^6 J
C) 2.27×10^6 J
D) 6.18×10^5 J
E) 1.88×10^6 J

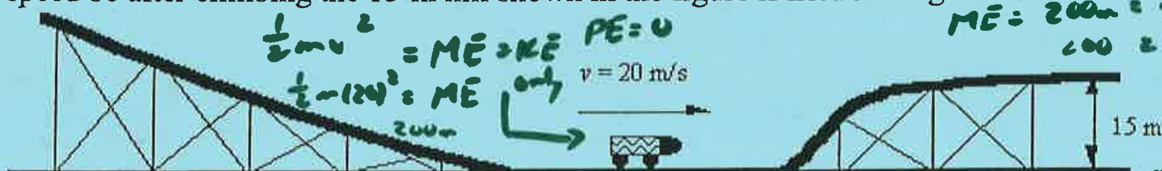
Use the following to answer question 15:

A 2.0-kg projectile is fired with initial velocity components v_{ox} = 30 m/s and v_{oy} = 40 m/s from a point on the earth's surface. Neglect any effects due to air resistance.

15. What is the kinetic energy of the projectile when it reaches the highest point in its trajectory?

A) zero joules B) 900 J C) 1600 J D) 2500 J E) 4900 J

16. A roller-coaster car is moving at 20 m/s along a straight horizontal track. What will its speed be after climbing the 15-m hill shown in the figure if friction is ignored?



A) 17 m/s B) 7 m/s C) 5 m/s D) 10 m/s E) 14 m/s

17. A 3.0-kg block falls from rest through a distance of 6.0 m in an evacuated tube near the surface of the earth. What is its speed after it has fallen the 6.0 m distance?

A) 8.0 m/s B) 11 m/s C) 13 m/s D) 26 m/s E) 120 m/s

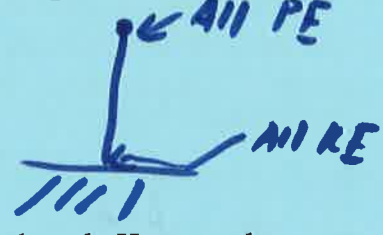
18. A roller coaster starts from rest at the top of an 18-m hill as shown. The car travels to the bottom of the hill and continues up the next hill that is 10.0 m high.

How fast is the car moving at the top of the 10.0-m hill if friction is ignored?

A) 6.4 m/s B) 8.1 m/s C) 13 m/s D) 18 m/s E) 27 m/s

19. A care package is dropped from rest from a helicopter hovering 25 m above the ground. What is the speed of the package just before it reaches the ground? Neglect air resistance
A) 22 m/s B) 16 m/s C) 12 m/s D) 8.0 m/s E) 5.0 m/s

$PE_i = KE_f$
$m(9.8)(25) = \frac{1}{2} m v^2$
$245 = \frac{1}{2} v^2$
$v = 22.1$ m/s



20. The kinetic energy of a car is 8×10^6 J as it travels along a horizontal road. How much power is required to stop the car in 10 s?
A) zero watts B) 8×10^4 W C) 8×10^5 W D) 8×10^6 W E) 8×10^7 W

$W = \Delta KE = 8 \times 10^6$ J
$P = \frac{W}{t} = \frac{8 \times 10^6}{10}$
$P = \frac{W}{t}$

21. What power is needed to lift a 49-kg person a vertical distance of 5.0 m in 20.0 s?
A) 12.5 W B) 25 W C) 60 W D) 120 W E) 210 W

$P = \frac{F \Delta x}{t}$
$P = \frac{mg \Delta x}{t}$

22. A warehouse worker uses a forklift to lift a crate of pickles on a platform to a height 2.75 m above the floor. The combined mass of the platform and the crate is 207 kg. If the power expended by the forklift is 1440 W, how long does it take to lift the crate?
A) 37.2 s B) 5.81 s C) 3.87 s D) 18.6 s E) 1.86 s

$P = \frac{W}{t}$
$W = \Delta E = mgy = 5579$ J
$P = \frac{W}{t} = $
$1440\ W = \frac{5579}{t}$

23. The amount on energy needed to power a 0.10-kW bulb for one minute would be just sufficient to lift a 1.0-kg object through a vertical distance of
A) 12 m B) 75 m C) 100 m D) 120 m E) 610 m

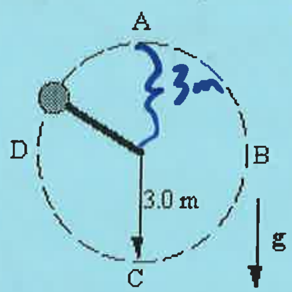
$P = \frac{W}{t} = \frac{\Delta E}{t}$
$100 = \frac{W}{60 s}$
$W = 6000$ J

$\frac{.10 kW}{1} \cdot \frac{1000 W}{1 kW} = 100 W$

$W = F \Delta x = mg \Delta x$
$6000 J = (1)(9.8) \Delta x$
$\Delta x = 612$ m

Use the following to answer question 24:

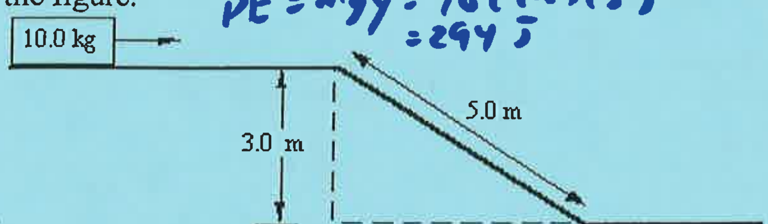
A 0.50-kg ball on the end of a rope is moving in a vertical circle of radius 3.0 m near the surface of the earth where the acceleration due to gravity, g, is 9.8 m/s^2.
Point **A** is at the top of the circle; **C** is at the bottom. Points **B** and **D** are exactly halfway between **A** and **C**.



24. The ball moves on the circle from A to C under the influence of gravity alone. If the kinetic energy of the ball is 35 J at A, what is its kinetic energy at **C**?
A) zero joules B) 29 J C) 35 J D) 44 J E) 64 J

Use the following to answer questions 25-28:

A 10.0-kg crate slides along a horizontal frictionless surface at a constant speed of 4.0 m/s. The crate then slides down a frictionless incline and across a second horizontal surface as shown in the figure.



25. What is the kinetic energy of the crate as it slides on the upper surface?
A) 30 J B) 80 J C) 140 J D) 290 J E) 490 J

26. While the crate slides along the upper surface, how much gravitational potential energy does it have compared to what it would have on the lower surface?
A) 30 J B) 80 J C) 140 J D) 290 J E) 490 J

$TE_{init} = PE + KE$
$294 + 80$
$= 374 J$

27. What is the speed of the crate when it arrives at the lower surface?
A) 7.7 m/s B) 8.6 m/s C) 59 m/s D) 75 m/s E) 98 m/s

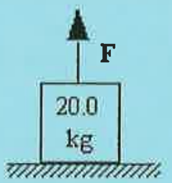
$TE_f = PE + KE$
$(374) = 0 + \frac{1}{2}mv^2$
$v = 8.6 m/s$

28. What is the kinetic energy of the crate as it slides on the lower surface?
A) 290 J B) 320 J C) 370 J D) 490 J E) 570 J

$KE = \frac{1}{2}mv^2$
$= \frac{1}{2}(10)(8.6)^2 = 374 J$

Use the following to answer question 29:

A rope exerts a force **F** on a 20.0-kg crate. The crate starts from rest and accelerates upward at 5.00 m/s^2 near the surface of the earth.



29. How much work was done by the force **F** in raising the crate 4.0 m above the floor?
A) 399 J B) 250 J C) 116 J D) 704 J E) 1180 J

$W_{net} = F_{net}\Delta x$
$= (ma)\Delta x$
$= (20)(5)(4)$
$= 400 J$