 Name: ____________________

# Power

Read from **Lesson 1** of the **Work, Energy and Power** chapter at **The Physics Classroom:**

**http://www.physicsclassroom.com/Class/energy/u5l1e.html**

**MOP Connection:** Work and Energy: sublevel 2

**Review:**

1. A force acting upon an object to cause a displacement is known as _____.
   a. energy b. potential c. kinetic d. work

2. Two acceptable units for work are ________. Choose two.
   a. joule b. newton c. watt d. newton•meter

**Power as a Rate Quantity:**

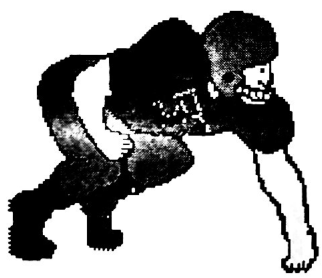
3. Power is defined as the _______ is done.
   a. amount of work which b. direction at which work
   c. angle at which work d. the rate at which work

4. Two machines (e.g., elevators) might do identical jobs (e.g., lift 10 passengers three floors) and yet the machines might have different power outputs. Explain how this can be so.

5. There are a variety of units for power. Which of the following would be *fitting* units of power (though perhaps not standard)? Include all that apply.
   a. Watt b. Joule c. Joule / second d. hp

6. Two physics students, Will N. Andable and Ben Pumpiniron, are in the weightlifting room. Will lifts the 100-pound barbell over his head 10 times in one minute; Ben lifts the 100-pound barbell over his head 10 times in 10 seconds. Which student does the most work? _____________ Which student delivers the most power? _____________ Explain your answers.


7. During the Powerhouse lab, Jack and Jill ran up the hill. Jack is twice as massive as Jill; yet Jill ascended the same distance in half the time. Who did the most work? _____________ Who delivered the most power? _____________ Explain your answers.



8. An often-used equation for power is

**Power = force x velocity**

Express an understanding of the meaning of this equation by using it to explain what type of individuals would be the best choice for lineman on a football team.

 **Name:** ____________________

## Work

Read from **Lesson 1** of the **Work, Energy and Power** chapter at **The Physics Classroom:**

**http://www.physicsclassroom.com/Class/energy/u5l1a.html**
**http://www.physicsclassroom.com/Class/energy/u5l1aa.html**

**MOP Connection:** Work and Energy: sublevel 1

1. An **impulse** is a force acting over some amount of time to cause a change in momentum. On the other hand, **work** is a ____________ acting over some amount of ______________ to cause a change in ______________.

2. Indicate whether or not the following represent examples of work.

| | Work Done? |
|---|---|
| a. A teacher applies a force to a wall and becomes exhausted.<br>Explanation: ____________________ | Yes or No? |
| b. A weightlifter lifts a barbell above her head.<br>Explanation: ____________________ | Yes or No? |
| c. A waiter carries a tray full of meals across a dining room at a constant speed.<br>Explanation: ____________________ | Yes or No? |
| d. A rolling marble hits a note card and moves it across a table.<br>Explanation: ____________________ | Yes or No? |
| e. A shot-putter launches the shot.<br>Explanation: ____________________ | Yes or No? |

3. Work is a ____________; a + or - sign on a work value indicates information about _______.
   a. vector; the direction of the work vector
   b. scalar; the direction of the work vector
   c. vector; whether the work adds or removes energy from the object
   d. scalar; whether the work adds or removes energy from the object

4. Which sets of units represent legitimate units for the quantity *work*? Circle all correct answers.

   a. Joule  b. N x m
   c. Foot x pound  d. kg x m / sec
   e. kg x m / $sec^2$  f. kg x $m^2$ / $sec^2$

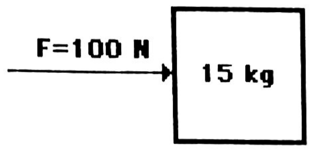
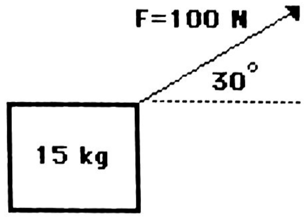
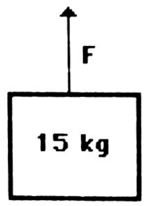
BEWARE

The amount of work (W) done on an object by a given force can be calculated using the formula

$$W = F\, d \cos \Theta$$

where **F** is the force and **d** is the distance over which the force acts and **Θ** is the angle between **F** and **d**. It is important to recognize that the angle included in the equation is not *just any old angle*; it has a distinct definition that must be remembered when solving such work problems.

5. For each situation below, calculate the amount of work done by the applied force. **PSYW**

| | | |
|---|---|---|
|   A 100 N force is applied to move a 15 kg object a horizontal distance of 5 meters at constant speed. |   A 100 N force is applied at an angle of 30° to the horizontal to move a 15 kg object at a constant speed for a horizontal distance of 5 m. |   An upward force is applied to lift a 15 kg object to a height of 5 meters at constant speed. |

6. Indicate whether there is positive (+) or negative (-) work being done on the object.

_____ a. An eastward-moving **car** skids to a stop across dry pavement.

_____ b. A freshman stands on his toes and lifts a **World Civilization book** to the top shelf of his locker.

_____ c. At Great America, **a roller coaster car** is lifted to the peak of the first hill on the Shock Wave.

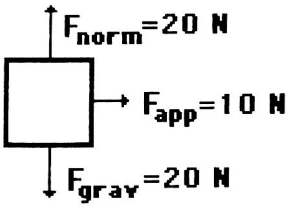
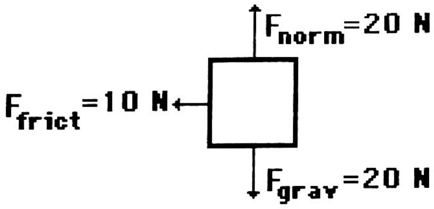
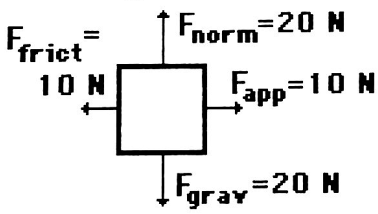
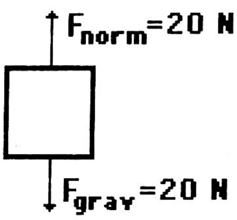
_____ d. A catcher puts out his mitt and catches the **baseball**.

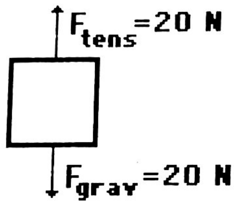
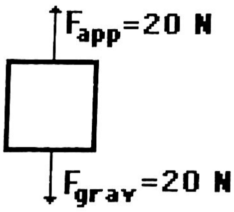
_____ e. A falling **parachutist** opens the chute and slows down.

7. Before beginning its initial descent, a roller coaster car is always pulled up the first hill to a high initial height. Work is done on the car (usually by a chain) to achieve this initial height. A coaster designer is considering three different angles at which to drag the 2000-kg car train to the top of the 60-meter high hill. Her big question is: which angle would require the most work? ____________ Show your answers and explain.

| Angle | Force | Distance | Work |
|---|---|---|---|
| 35° | $1.15 * 10^4$ N | 105 m | |
| 45° | $1.41 * 10^4$ N | 84.9 m | |
| 55° | $1.64 * 10^4$ N | 73.2 m | |

8. The following descriptions and their accompanying free-body diagrams show the forces acting upon an object. For each case, calculate the work done by these forces; use the format of force • displacement • cosine(Θ). Finally, calculate the total work done by all forces.

| Free-Body Diagram | Forces Doing Work on the Object<br>Amount of Work Done by Each Force |
|---|---|
| a. A 10-N force is applied to push a block across a frictionless surface for a displacement of 5.0 m to the right.<br> | $W_{norm}$ = ______ • ______ • cos(______) = ______ J<br>$W_{app}$ = ______ • ______ • cos(______) = ______ J<br>$W_{grav}$ = ______ • ______ • cos(______) = ______ J<br>$W_{total}$ = ______ J |
| b. A 10-N frictional force slows a moving block to a stop along a horizontal surface after a displacement of 5.0 m to the right.<br> | $W_{norm}$ = ______ • ______ • cos(______) = ______ J<br>$W_{grav}$ = ______ • ______ • cos(______) = ______ J<br>$W_{frict}$ = ______ • ______ • cos(______) = ______ J<br>$W_{total}$ = ______ J |
| c. A 10-N forces is applied to push a block across a frictional surface at constant speed for a displacement of 5.0 m to the right.<br> | $W_{norm}$ = ______ • ______ • cos(______) = ______ J<br>$W_{app}$ = ______ • ______ • cos(______) = ______ J<br>$W_{grav}$ = ______ • ______ • cos(______) = ______ J<br>$W_{frict}$ = ______ • ______ • cos(______) = ______ J<br>$W_{total}$ = ______ J |
| d. A 2-kg object is sliding at constant speed across a frictionless surface for a displacement of 5.0 m to the right.<br> | $W_{norm}$ = ______ • ______ • cos(______) = ______ J<br>$W_{grav}$ = ______ • ______ • cos(______) = ______ J<br>$W_{total}$ = ______ J |

| Free-Body Diagram | Forces Doing Work on the Object<br>Amount of Work Done by Each Force |
|---|---|
| e. A 2-kg object is pulled upward at constant speed by a 20-N force for a vertical displacement of 5.0 m.<br> | $W_{tens}$ = ______ • ______ • cos(______) = ______ J<br>$W_{grav}$ = ______ • ______ • cos(______) = ______ J<br>$W_{total}$ = ______ J |
| f. A 2-kg tray of dinner plates is held in the air and carried a distance of 5.0 m to the right.<br> | $W_{app}$ = ______ • ______ • cos(______) = ______ J<br>$W_{grav}$ = ______ • ______ • cos(______) = ______ J<br>$W_{total}$ = ______ J |

9. When a force is applied to do work on an object, does the object always accelerate? ________
Explain why or why not.

10. Determine the work done in the following situations.
   a. Jim Neysweeper is applying a 21.6-N force downward at an angle of 57.2° with the horizontal to displace a broom a distance of 6.28 m.

   b. Ben Pumpiniron applies an upward force to lift a 129-kg barbell to a height of 1.98 m at a constant speed.

   c. An elevator lifts 12 occupants up 21 floors (76.8 meters) at a constant speed. The average mass of the occupants is 62.8 kg.

 Name: ____________________

# Energy

Read from **Lesson 1** of the **Work, Energy and Power** chapter at **The Physics Classroom:**

**http://www.physicsclassroom.com/Class/energy/u5l1b.html**
**http://www.physicsclassroom.com/Class/energy/u5l1c.html**
**http://www.physicsclassroom.com/Class/energy/u5l1d.html**

**MOP Connection:** Work and Energy: sublevels 3 and 4

1. Read each of the following statements and identify them as having to do with kinetic energy (KE), potential energy (PE) or both (B).

| KE, PE or B? | Statement: |
|---|---|
| ________ | 1. If an object is at rest, it certainly does NOT possess this form of energy. |
| ________ | 2. Depends upon object mass and object height. |
| ________ | 3. The energy an object possesses due to its motion. |
| ________ | 4. The amount is expressed using the unit joule (abbreviated J). |
| ________ | 5. The energy stored in an object due to its position (or height). |
| ________ | 6. The amount depends upon the arbitrarily assigned *zero level.* |
| ________ | 7. Depends upon object mass and object speed. |
| ________ | 8. If an object is at rest on the ground (zero height), it certainly does NOT possess this form of energy. |

2. A toy car is moving along with 0.40 joules of kinetic energy. If its speed is doubled, then its new kinetic energy will be _______.
a. 0.10 J b. 0.20 J c. 0.80 J d. 1.60 J e. still 0.40 J

3. A young boy's glider is soaring through the air, possessing 0.80 joules of potential energy. If its speed is doubled and its height is doubled, then the new potential energy will be _______.
a. 0.20 J b. 0.40 J c. 1.60 J d. 3.20 J e. still 0.80 J

4. Which would ALWAYS be true of an object possessing a kinetic energy of 0 joules?
a. It is on the ground. b. It is at rest. c. It is moving on the ground
d. It is moving. e. It is accelerating. f. It is at rest above ground level
g. It is above the ground. h. It is moving above ground level.

5. Which would ALWAYS be true of an object possessing a potential energy of 0 joules?
a. It is on the ground. b. It is at rest. c. It is moving on the ground
d. It is moving. e. It is accelerating. f. It is at rest above ground level
g. It is above the ground. h. It is moving above ground level.

6. Calculate the kinetic energy of a 5.2 kg object moving at 2.4 m/s. **PSYW**

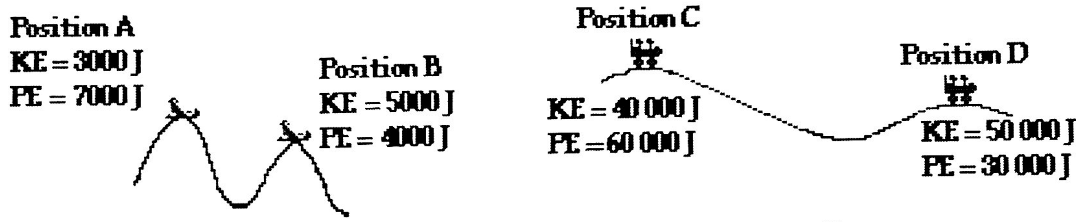
7. Calculate the potential energy of a 5.2 kg object positioned 5.8 m above the ground. **PSYW**

8. Calculate the speed of a 5.2 kg object that possesses 26.1 J of kinetic energy. **PSYW**

9. The total mechanical energy of an object is the ______.
   a. KE minus the PE of the object
   b. PE minus the KE of the object
   c. the initial KE plus the initial PE of the object
   d. KE plus the PE of the object at any instant during its motion
   e. final amount of KE and PE minus the initial amount of KE and PE

10. If an object moves in such a manner as to conserve its total mechanical energy, then ______.
    a. the amount of kinetic energy remains the same throughout its motion
    b. the amount of potential energy remains the same throughout its motion
    c. the amount of both the kinetic and the potential energy remains the same throughout its motion
    d. the sum of the kinetic energy and the potential energy remains the same throughout its motion

11. Determine the total mechanical energy (TME) of the objects at positions A, B, C and D.




A: ____________ B: ____________ C: ____________ D: ____________

12. Calculate the total mechanical energy (TME) of a 5.2 kg object moving at 2.4 m/s and positioned 5.8 m above the ground. **PSYW**

13. Read the following descriptions and indicate whether the objects' KE, PE and TME increases, decreases or remains the same (=). If it is impossible to tell, then answer ???.

    a. A marble begins at an elevated position on top of an inclined ruler and rolls down to the bottom of the ruler.
    KE: ↑ ↓ = ??? PE: ↑ ↓ = ??? TME: ↑ ↓ = ???

    b. A marble is rolling along a level table when it hits a note card and slides to a stop.
    KE: ↑ ↓ = ??? PE: ↑ ↓ = ??? TME: ↑ ↓ = ???

    c. A cart is pulled from the bottom of an incline to the top of the incline at a constant speed.
    KE: ↑ ↓ = ??? PE: ↑ ↓ = ??? TME: ↑ ↓ = ???

    d. A physics student runs up a staircase at a constant speed.
    KE: ↑ ↓ = ??? PE: ↑ ↓ = ??? TME: ↑ ↓ = ???

    e. A force is applied to a root beer mug to accelerate it from rest across a level countertop.
    KE: ↑ ↓ = ??? PE: ↑ ↓ = ??? TME: ↑ ↓ = ???

    f. A pendulum bob is released from rest from an elevated position and swings to its lowest point.
    KE: ↑ ↓ = ??? PE: ↑ ↓ = ??? TME: ↑ ↓ = ???

    g. A car skids from a high speed to a stopping position along a level highway.
    KE: ↑ ↓ = ??? PE: ↑ ↓ = ??? TME: ↑ ↓ = ???

## Work-Energy Calculations

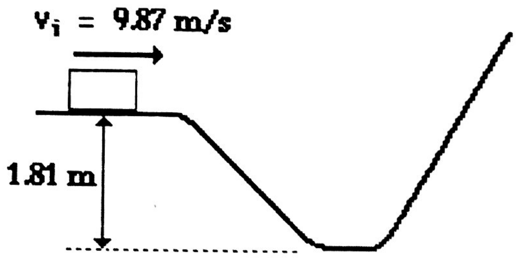
Study **Lesson 2** of the **Work, Energy and Power** chapter at **The Physics Classroom:**

**http://www.physicsclassroom.com/Class/energy/u512bc.html**

For the following questions, begin with the work-energy equation, cancel terms, substitute and solve.

1. A glider is gliding through the air at a height of 416 meters with a speed of 45.2 m/s. The glider dives to a height of 278 meters. Determine the glider's new speed.

$$KE_i \quad + \quad PE_i \quad + \quad W_{ext} \quad = \quad KE_f \quad + \quad PE_f$$




2. A box with mass **m** is sliding along on a friction-free surface at 9.87 m/s at a height of 1.81 m. It travels down the hill and then up another hill.
   a. Find the speed at the bottom of the hill.

$$KE_i \quad + \quad PE_i \quad + \quad W_{ext} \quad = \quad KE_f \quad + \quad PE_f$$

   b. Find the maximum vertical height to which the box will rise on the opposite hill.

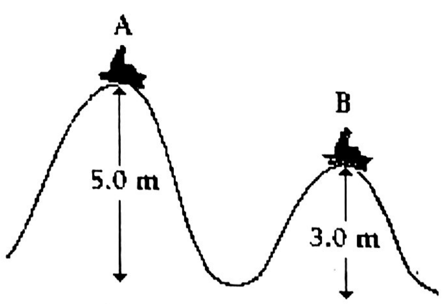
$$KE_i \quad + \quad PE_i \quad + \quad W_{ext} \quad = \quad KE_f \quad + \quad PE_f$$

3. A 1423-kg car is moving along a level highway with a speed of 26.4 m/s. The driver takes the foot off the accelerator and the car experiences a retarding force of 901-N over a distance of 106 m. Determine the speed of the car after traveling this distance.

$$KE_i \quad + \quad PE_i \quad + \quad W_{ext} \quad = \quad KE_f \quad + \quad PE_f$$

4. A sledder starts from rest atop a 5.0-m high hill (A). She sleds to the bottom and up to the top of the adjacent 3.0-m high hill. How fast is the sledder going at point B? Ignore friction.

$$KE_i + PE_i + W_{ext} = KE_f + PE_f$$



5. A 4768-kg roller coaster train full of riders approaches the loading dock at a speed of 17.1 m/s. It is abruptly decelerated to a speed of 2.2 m/s over a distance of 13.6 m. Determine the retarding force that acts upon the roller coaster cars.

$KE_i + PE_i + W_{ext} = KE_f + PE_f$

6. A catcher's mitt recoils a distance of 12.9 cm in bringing a 142-gram baseball to a stop. If the applied force is 588 N, then what was the speed of the baseball at the moment of contact with the catcher's mitt?

$KE_i + PE_i + W_{ext} = KE_f + PE_f$

7. An unknown force is applied to a 12 kg mass. The force acts at an angle of 30 degrees above the horizontal. Determine the force acting if the force acts for a horizontal displacement of 22 meters and increases the 12 kg mass's speed from 11 m/s to 26 m/s.

$KE_i + PE_i + W_{ext} = KE_f + PE_f$

8. A physics teacher exerts a force upon a 3.29-kg pile of snow to both lift it and set it into motion. The snow leaves the shovel with a speed of 2.94 m/s at a height of 0.562 m. Determine the work done upon the pile of snow.

$KE_i + PE_i + W_{ext} = KE_f + PE_f$

9. A 250.-gram cart starts from rest and rolls down an inclined plane from a height of 0.541 m. Determine its speed at a height of 0.127 m above the bottom of the incline.

$KE_i + PE_i + W_{ext} = KE_f + PE_f$

10. A 4357-kg roller coaster car starts from rest at the top of a 36.5-m high track. Determine the speed of the car at the top of a loop that is 10.8 m high.

$KE_i + PE_i + W_{ext} = KE_f + PE_f$