



## Grade 12 Physics Energy Key

First Name: \_\_\_\_\_ **KEY** \_\_\_\_\_

Last Name: \_\_\_\_\_

### Directions:

- Please answer to 2 decimal points
- The test is designed to be completed in 75 minutes

*For grading use only*

Page:	2	3	4	5	6	7	Total
Points:	6	7	21	10	15	15	74
Score:							

## Multiple Choice (10 marks)

1. (1 point) What is the kinetic energy of a 2 kg object moving at 5 m/s?
  - A. 5 J
  - B. 25 J**
  - C. 50 J
  - D. 10 J
  
2. (1 point) How much gravitational potential energy does a 5 kg object have at 10 m height?
  - A. 50 J
  - B. 490 J**
  - C. 980 J
  - D. 245 J
  
3. (1 point) Which energy transformation occurs in a photovoltaic cell?
  - A. Thermal to electrical
  - B. Light to electrical**
  - C. Chemical to electrical
  - D. Mechanical to electrical
  
4. (1 point) What is the work done by a 20 N force pushing an object 5 m?
  - A. 4 J
  - B. 100 J**
  - C. 25 J
  - D. 200 J
  
5. (1 point) What power is developed by doing 600 J of work in 10 seconds?
  - A. 6 W
  - B. 60 W**
  - C. 6000 W
  - D. 10 W
  
6. (1 point) Which statement best describes energy conservation?
  - A. Energy can be destroyed
  - B. Energy changes form but total remains constant**
  - C. Energy becomes less useful over time
  - D. Energy creation is possible in closed systems

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7. (1 point) What is the efficiency of a device that outputs 150 J from 200 J input?
- A. 133%
  - B. 50%
  - C. 75%**
  - D. 25%
8. (1 point) How much energy is stored in a spring ( $k=400$  N/m) compressed 0.2 m?
- A. 8 J
  - B. 8 J**
  - C. 16 J
  - D. 80 J
9. (1 point) A 5 kg object has a kinetic energy of 50 J. What is its speed?
- A. 2 m/s
  - B. 4.47 m/s**
  - C. 10 m/s
  - D. 20 m/s
10. (1 point) A spring with a spring constant of 150 N/m is stretched by 0.2 m. What is the elastic potential energy stored in the spring?
- A. 1 J
  - B. 3 J
  - C. 3 J**
  - D. 6 J
11. (1 point) A 2 kg block slides down a frictionless ramp from a height of 10 m. What is its speed at the bottom?
- A. 10 m/s
  - B. 14.14 m/s**
  - C. 20 m/s
  - D. 30 m/s
12. (1 point) A car of mass 800 kg is moving at 20 m/s. What is its kinetic energy?
- A. 80,000 J
  - B. 160,000 J**
  - C. 240,000 J
  - D. 320,000 J
13. (1 point) Work is defined as:
- A. Force divided by distance
  - B. Force times distance times the cosine of the angle between them**
  - C. Change in momentum
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- D. Change in kinetic energy
14. (1 point) A pendulum's potential energy is maximum at:
- A. Its lowest point
  - B. Its highest point**
  - C. The midpoint of its swing
  - D. None of the above

## Long Answer (40 marks)

15. A 50 kg roller coaster car starts from rest at 60 m height.
- (a) (4 points) Calculate initial potential energy
  - (b) (6 points) Find speed at 20 m height (no friction)
  - (c) (6 points) Calculate actual speed at 20 m height if 10% energy is lost to friction
  - (d) (4 points) Determine average frictional force

**Solution: (a) Initial potential energy:**

**The potential energy is given by:**

$$PE = mgh$$

**Substituting the values:**

$$PE = 50 \cdot 9.8 \cdot 60 = 29,400 \text{ J}$$

**(b) Speed at 20 m (no friction):**

**Using conservation of energy:**

$$mgh_{\text{initial}} = mgh_{\text{final}} + \frac{1}{2}mv^2$$

**Simplify:**

$$gh_{\text{initial}} = gh_{\text{final}} + \frac{1}{2}v^2$$

**Solve for  $v$ :**

$$v = \sqrt{2g(h_{\text{initial}} - h_{\text{final}})}$$

**Substituting:**

$$v = \sqrt{2 \cdot 9.8 \cdot (60 - 20)} = \sqrt{784} = 28.0 \text{ m/s}$$

**(c) Actual speed at 20 m height with 10% energy loss:**

**If 10% of energy is lost to friction, only 90% of the initial energy is available. The remaining energy:**

$$E_{\text{remaining}} = 0.9 \cdot (mgh_{\text{initial}})$$

**Substitute:**

$$E_{\text{remaining}} = 0.9 \cdot 29,400 = 26,460 \text{ J}$$

**At a height of 20 m, the remaining energy is the sum of potential and kinetic energy:**

$$E_{\text{remaining}} = mgh_{\text{final}} + \frac{1}{2}mv^2$$

**Solve for  $v$ :**

$$\frac{1}{2}mv^2 = E_{\text{remaining}} - mgh_{\text{final}}$$

$$v = \sqrt{\frac{2(E_{\text{remaining}} - mgh_{\text{final}})}{m}}$$

**Substituting:**

$$v = \sqrt{\frac{2(26,460 - 50 \cdot 9.8 \cdot 20)}{50}}$$

$$v = \sqrt{\frac{2(26,460 - 9,800)}{50}} = \sqrt{\frac{33,320}{50}} = \sqrt{666.4} = 25.86 \text{ m/s}$$

**(d) Average frictional force:**

The work done by friction is the energy lost:

$$W_{\text{friction}} = E_{\text{lost}}$$

**Substitute:**

$$W_{\text{friction}} = 0.1 \cdot (mgh_{\text{initial}}) = 0.1 \cdot 29,400 = 2,940 \text{ J}$$

Work done by friction is also given by:

$$W_{\text{friction}} = F_{\text{friction}} \cdot d$$

**Where  $d = h_{\text{initial}} - h_{\text{final}} = 60 - 20 = 40 \text{ m}$ . Solve for  $F_{\text{friction}}$ :**

$$F_{\text{friction}} = \frac{W_{\text{friction}}}{d} = \frac{2,940}{40} = 73.5 \text{ N}$$

16. A spring with a spring constant of 200 N/m is compressed by 0.3 m and used to launch a 2 kg block horizontally on a frictionless surface.
- (5 points) Calculate the elastic potential energy stored in the spring.
  - (5 points) Determine the speed of the block as it leaves the spring.

**Solution: (a) Elastic potential energy stored in the spring:**

The formula for elastic potential energy is:

$$PE_{\text{elastic}} = \frac{1}{2}kx^2$$

**Substituting the given values:**

$$PE_{\text{elastic}} = \frac{1}{2}(200)(0.3)^2$$

$$PE_{\text{elastic}} = \frac{1}{2}(200)(0.09) = 9 \text{ J}$$

**(b) Speed of the block as it leaves the spring:**

**On a frictionless surface, all the elastic potential energy is converted to kinetic energy:**

$$PE_{elastic} = KE = \frac{1}{2}mv^2$$

**Solving for  $v$ :**

$$v = \sqrt{\frac{2 \cdot PE_{elastic}}{m}}$$

**Substituting the values:**

$$v = \sqrt{\frac{2 \cdot 9}{2}} = \sqrt{9} = 3 \text{ m/s}$$

17. A 15.0 kg branch falls from a tree onto a trampoline 8.0 m below.

- (5 points) Calculate the total mechanical energy of the branch at the top of the tree just before it falls, assuming it starts from rest and air resistance is negligible.
- (5 points) Determine the velocity of the branch just before it hits the trampoline.
- (5 points) If the trampoline compresses by 0.25 m to bring the branch to a stop, calculate the spring constant of the trampoline.

**Solution: (a) Total mechanical energy at the top of the tree:**

**Total mechanical energy is given by:**

$$E = mgh$$

**Substituting the given values:**

$$E = (15.0)(9.8)(8.0) = 1176 \text{ J}$$

**(b) Velocity of the branch just before it hits the trampoline:**

**Using the conservation of mechanical energy:**

$$mgh = \frac{1}{2}mv^2$$

**Solving for  $v$ :**

$$v = \sqrt{2gh}$$

**Substituting:**

$$v = \sqrt{2(9.8)(8.0)} = \sqrt{156.8} \approx 12.52 \text{ m/s}$$

**(c) Spring constant of the trampoline:**

**The potential energy of the trampoline is equal to the mechanical energy of the branch:**

$$\frac{1}{2}kx^2 = mgh$$

**Solving for  $k$ :**

$$k = \frac{2mgh}{x^2}$$

**Substituting:**

$$k = \frac{2(15.0)(9.8)(8.0)}{(0.25)^2} = \frac{2352}{0.0625} = 37632 \text{ N/m}$$

18. A 0.020 kg bullet is fired at a wooden target with an initial velocity of 250 m/s. Upon hitting the target, the bullet becomes embedded and stops after penetrating 0.12 m into the wood.
- (a) (5 points) Calculate the initial kinetic energy of the bullet.
  - (b) (5 points) Determine the average force exerted by the target to stop the bullet.
  - (c) (5 points) If 20% of the bullet's kinetic energy is converted into heat, how much energy is absorbed as heat?

**Solution: (a) Initial kinetic energy of the bullet:**

**Kinetic energy is given by:**

$$KE = \frac{1}{2}mv^2$$

**Substituting the values:**

$$KE = \frac{1}{2}(0.020)(250)^2 = 625 \text{ J}$$

**(b) Average force exerted by the target:**

**The work-energy principle states that the work done by the force equals the kinetic energy:**

$$W = Fd = KE$$

**Solving for  $F$ :**

$$F = \frac{KE}{d}$$

**Substituting:**

$$F = \frac{625}{0.12} \approx 5208.33 \text{ N}$$

**(c) Energy absorbed as heat:**

**If 20% of the kinetic energy is converted to heat:**

$$E_{\text{heat}} = 0.20 \cdot KE$$

**Substituting:**

$$E_{\text{heat}} = 0.20 \cdot 625 = 125 \text{ J}$$