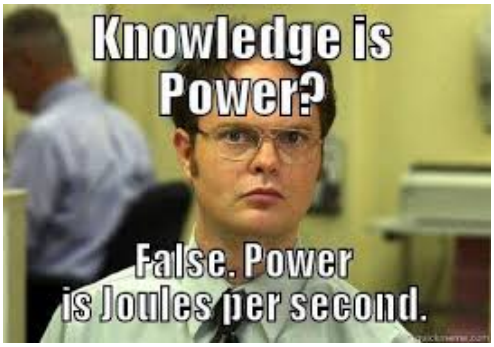
Grade 12 Physics
Energy Key
Energy Unit Test



First Name: _____

Last Name: _____

Directions:

- Show all work for full marks
- Test duration: 75 minutes
- For calculations, round final answers to 2 decimal places

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

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

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:

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

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

Using conservation of energy:

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

Simplify:

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

Solve for v:

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

Substituting:

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

(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:

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

Substitute:

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

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

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

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:

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

$$v = \sqrt{\frac{2(26,460 - 9,800)}{50}} = \sqrt{\frac{33,320}{50}} = \sqrt{668.4} = 25.86\,\mathbf{m/s}$$

(d) Average frictional force:

The work done by friction is the energy lost:

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

Substitute:

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

Work done by friction is also given by:

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

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

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

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.
    (a) (5 points) Calculate the elastic potential energy stored in the spring.
    (b) (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:

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

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

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

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

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

Solving for v:

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

Substituting the values:

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

17. A 15.0 kg branch falls from a tree onto a trampoline 8.0 m below.
    (a) (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.
    (b) (5 points) Determine the velocity of the branch just before it hits the trampoline.
    (c) (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:

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

(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:

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

(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:

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

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:

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

(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:

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

(c) Energy absorbed as heat:

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

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

Substituting:

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