Work and Energy

Multiple Choice Questions

1. When a body falls freely towards the earth, then its total energy
(a) increases
(b) decreases
(c) remains constant
(d) first increases and then decreases

Ans. (c) remains constant
Explanation: When a body falls freely towards the earth, it obeys the law of conservation of energy. Due to this, its total energy remains constant.

2. A car is accelerated on a levelled road and attains a velocity 4 times of its initial velocity. In this process the potential energy of the car
(a) does not change
(b) becomes twice to that of initial
(c) becomes 4 times that of initial
(d) becomes 16 times that of initial

Ans. (a) does not change
Explanation: Potential energy depends on the height at which the object is situated. In this case, there is no change in height of the object. Hence, there is no change in its potential energy.

3. In case of negative work the angle between the force and displacement is
(a) 0^0 (b) 45^0 (c) 90^0 (d) 180^0

Ans. (d) 180^0
Explanation: When force and displacement are in mutually opposite direction, the work done is said to be negative. In this case, the angle between the force and displacement is 180^0.

4. An iron sphere of mass 10 kg has the same diameter as an aluminium sphere of mass is 3.5 kg. Both spheres are dropped simultaneously from a tower. When they are 10 m above the ground, they have the same
(a) acceleration
(b) momenta
(c) potential energy
(d) kinetic energy

Ans. (a) acceleration
Explanation: Momentum, potential energy and kinetic energy depend on mass of the object; as well as on some other factors. But acceleration in this case is the acceleration due to gravity; which does not depend on mass or velocity. So, options (a) is correct.

5. A girl is carrying a school bag of 3 kg mass on her back and moves 200 m on a levelled road. The work done against the gravitational force will be ($g = 10\ ms^{-2}$)
(a) $6 \times 10^3 J$

(b) 6 J
(c) 0.6 J
(d) zero

Ans. **(d)** zero

Explanation: In this case, direction of work done is perpendicular to the direction of gravitational force. Hence, work done against gravitational is zero.

6. Which one of the following is not the unit of energy?

(a) joule
(b) newton metre
(c) kilowatt
(d) kilowatt hour

Ans. **(c)** kilowatt

7. The work done on an object does not depend upon the

(a) displacement
(b) force applied
(c) angle between force and displacement
(d) initial velocity of the object

Ans. **(d)** initial velocity of the object

Explanation: Work done is the product of force and displacement. Hence, work done depends on displacement, force applied and on the angle between force and displacement. But it does not depend on initial velocity of the object.

8. Water stored in a dam possesses

(a) no energy
(b) electrical energy
(c) kinetic energy
(d) potential energy

Ans. **(d)** potential energy

Explanation: The energy stored in an object because of its position is called potential energy. Water stored in dam possesses energy because of its current position.

9. A body is falling from a height h. After it has fallen a height $\frac{h}{2}$, it will possess

(a) only potential energy
(b) only kinetic energy
(c) half potential and half kinetic energy
(d) more kinetic and less potential energy

Ans. **(c)** half potential and half kinetic energy

Explanation: When the body is at height h; its potential energy is at maximum and kinetic energy is zero. When the body hits the ground, its potential energy becomes zero and kinetic energy is at maximum. At mid-way, i.e. half the height; its potential energy becomes half of the maximum and same happens to the kinetic energy.

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Short Answer Questions

10. A rocket is moving up with a velocity v. If the velocity of this rocket is suddenly tripled, what will be the ratio of two kinetic energies?

Ans. Initial velocity = v, then v' = 3v

Initial kinetic energy $= \frac{1}{2}mv^2$

Final kinetic energy (K.E) $= \frac{1}{2}mv'^2 = \frac{1}{2}m(3v)^2 = 9(\frac{1}{2}mv^2)$

(K. E) initial: (K. E) final = 1:9

11. Avinash can run with a speed of 8 m s^{-1} against the frictional force of 10 N, and Kapil can move with a speed of 3 m s^{-1} against the frictional force of 25 N. Who is more powerful and why?

Ans. Power of Avinash $P_A = F_A \cdot v_A = 10 \times 8 = 80W$

The power of kapil $P_k = F_k \cdot v_k = 25 \times 3 = 75W$

So, Avinash is more powerful than kapil.

12. A boy is moving on a straight road against a frictional force of 5 N. After travelling a distance of 1.5 km he forgot the correct path at a round about (Fig. 11.1) of radius 100 m. However, he moves on the circular path for one and half cycle and then he moves forward upto 2.0 km. Calculate the work done by him.

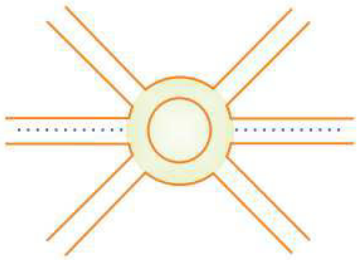

Fig. 11.1

Ans. Displacement = 1500 m + 200 m + 2000 m = 3700 m

Work done = Force × displacement = 5 N × 3700 m = 18500 J

(Note: We do not need to calculate the circumference because we need to take displacement and not distance)

13. Can any object have mechanical energy even if its momentum is zero? Explain.

Ans. Yes, mechanical energy comprises both potential energy and kinetic energy. Momentum is zero which means velocity is zero. Hence, there is no kinetic energy but the object may possess potential energy.

14. Can any object have momentum even if its mechanical energy is zero? Explain.

Ans. No. Since mechanical energy is zero, there is no potential energy and no kinetic energy. Kinetic energy being zero, velocity is zero. Hence, there will be no momentum.

15. The power of a motor pump is 2 kW. How much water per minute the pump can raise to a height of 10 m? (Given g = 10 m s^{-2})

Ans. $P = \frac{W}{\Delta t} = \frac{mgh}{\Delta t} \Rightarrow \frac{m \times 10 \times 10}{60} = 2000w$

Or $m = \frac{12000}{10} = 1200kg$

16. The weight of a person on a planet A is about half that on the earth. He can jump upto 0.4 m height on the surface of the earth. How high he can jump on the planet A?

Ans. Since, weight of the person on planet A is half that on the earth, acceleration due to gravity there, will be 1/2 that on the earth. Hence he can jump double the height with the same muscular force.

Or

The potential energy of the person will remain the same on the earth and on planet A.

Thus, $mg_1h_1 = mg_2h_2$

If $g_1 = g$ then $g_2 = \frac{1}{2}g, h_1 = 0.4$

Then $h_2 = \frac{g_1h_1}{g_2} = \frac{g \times 0.4}{g/2}$

Or $h_2 = 0.4 \times 2 = 0.8m$

17. The velocity of a body moving in a straight line is increased by applying a constant force F, for some distance in the direction of the motion. Prove that the increase in the kinetic energy of the body is equal to the work done by the force on the body.

Ans. $v^2 - u^2 = 2a.s$

This give $s = \frac{v^2 - u^2}{2a}$

F = ma

We can write work done (W) by this force F as

$$W = ma\left(\frac{v^2 - u^2}{2a}\right) = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = (K.E)_f - (K.E)_i$$

18. Is it possible that an object is in the state of accelerated motion due to external force acting on it, but no work is being done by the force. Explain it with an example.

Ans. Yes, it is possible, if an object is moving in a circular path. Because force is always acting perpendicular to the direction of displacement.

19. A ball is dropped from a height of 10 m. If the energy of the ball reduces by 40% after striking the ground, how much high can the ball bounce back? (g= 10 m s^{-2})

Ans. $mgh = m \times 10 \times 10 = 100mJ.$

Energy is reduced by 40% then the remaining energy is 60mJ.

Therefore, $60m = m \times 10 \times h'$ or $h' = 6m$

20. If an electric iron of 1200 W is used for 30 minutes every day, find electric energy consumed in the month of April.

Ans. $P = \frac{1200}{1000} = 1.2kW$

$t = \frac{30}{50} = 0.5h$

E = Power × time × days

= 1.2 × .5 × 30

= 18 kWh

Work and Energy

Long Answer Questions

21. A light and a heavy object have the same momentum. Find out the ratio of their kinetic energies. Which one has a larger kinetic energy?

Ans. $p_1 = m_1 v_1$

$p_2 = m_2 v_2$

But $p_1 = p_2$ or $m_1 v_1 = m_2 v_2$

If $m_1 < m_2$ then $v_1 < v_2$

$$(K.E)_1 = \frac{1}{2} m_1 v_1^2$$

$$(K.E)_2 = \frac{1}{2} m_2 v_2^2$$

$$(K.E)_1 = \frac{1}{2}(m_1 v_1) v_1 = \frac{1}{2} p_1 v_1$$

$$(K.E)_2 = \frac{1}{2}(m_2 v_2) v_2 = \frac{1}{2} p_2 v_2$$

$$\frac{(K.E)_1}{(K.E)_2} = \frac{\frac{1}{2} p_2 v_1}{\frac{1}{2} p_2 v_2} = \frac{v_1}{v_2}$$

But $v_1 > v_2$ Therefore $(K.E)_1 > (K.E)_2$

22. An automobile engine propels a 1000 kg car (A) along a levelled road at a speed of 36 km h–1. Find the power if the opposing frictional force is 100 N. Now, suppose after travelling a distance of 200 m, this car collides with another stationary car (B) of same mass and comes to rest. Let its engine also stop at the same time. Now car (B) starts moving on the same level road without getting its engine started. Find the speed of the car (B) just after the collision.

Ans. $m_{(A)} = m_{(B)} = 1000$ kg. v = 36 km/h = 10 m/s

Frictional force = 100 N

Since, the car A moves with a uniform speed, it means that the engine of car applies a force equal to the frictional force

$$\text{Power} = \frac{\text{force} \times \text{distance}}{\text{time}} = F.v$$

= 100 N × 10 m/s

= 1000 W

After collision

$m_A u_A + m_B u_B = m_A v_A + m_B v_B.$

$1000 \times 10 + 1000 \times 0 = 1000 \times 0 + 1000 \times v_B$

$v_B = 10 ms^{-1}$

23. A girl having mass of 35 kg sits on a trolley of mass 5 kg. The trolley is given an initial velocity of 4 m s^{-1} by applying a force. The trolley comes to rest after traversing a distance of 16 m. (a) How much work is done on the trolley? (b) How much work is done by the girl?

Ans. Mass of girl = 35 kg, mass of trolley = 5kg, u = 4 m/s, v =0 and s = 16m

(a) Work = F × s = m × a × s

We need to calculate acceleration as follows:

$$a = \frac{v^2 - u^2}{2s} = \frac{0-16}{2\times 16} = -0.5 ms^{-2}$$

Using the above value of a; work done on trolley can be calculated as follows:

W = mas = 40 × 0.5 × 16 = 320 J

(b) In this case, the girl is not applying any force and so work done by girl = 0

24. Four men lift a 250-kg box to a height of 1 m and hold it without raising or lowering it. (a) How much work is done by the men in lifting the box? (b) How much work do they do in just holding it? (c) Why do they get tired while holding it? (g= 10 ms^{-2})

Ans. (a) F = 250 kg × g (g = 10ms^{-2})

= 2500 N

S = 1m

W = F.s = 2500 Nm

= 2500 J

(b) Zero, as the box does not move at all, while holding it.

(c) In order to hold the box, men are applying a force which is opposite and equal to the gravitational force acting on the box. While applying the force, muscular effort is involved. So, they feel tired.

25. What is power? How do you differentiate kilowatt from kilowatt hour? The Jog Falls in Karnataka state are nearly 20 m high. 2000 tonnes of water falls from it in a minute. Calculate the equivalent power if all this energy can be utilized?(g=10 ms^{-2})

Ans. Power is the rate of doing work. Kilowatt is the unit of power and kilowatt hour is the unit of energy.

h= 20 m, and mass = 2000 × 10^3 kg = 2 × 10^6 kg

$$\text{Power} = \frac{mgh}{t} = \frac{2\times 10^6 \times 10 \times 20}{60} W$$

$$= \frac{4}{6}\times 10^7 W = \frac{2}{3}\times 10^7 W$$

26. How is the power related to the speed at which a body can be lifted? How many kilograms will a man working at the power of 100 W, be able to lift at constant speed of 1 ms^{-1} vertically? (g= 10 ms^{-2})

Ans. Power $= \frac{\text{work done or energy}}{\text{time}} = \frac{mgh}{t} = m.g.\left(\frac{h}{t}\right)$

Here $\frac{h}{t}$ = speed

Therefore, $m = \frac{power}{g \times speed} = \frac{100}{10 \times 1} = 10kg$

27. Define watt. Express kilowatt in terms of joule per second. A 150-kg car engine develops 500 W for each kg. What force does it exert in moving the car at a speed of 20 ms^{-1}?

Ans. One watt is the power of an agent which does work at the rate of $1Js^{-1}$

1 kilowatt = $1000\ Js^{-1}$

Total power = $150 \times 500 = 7.5 \times 10^4$ W

$\text{Force} = \frac{\text{power}}{\text{velocity}} = \frac{7.5 \times 10^4}{20} = 3.75 \times 10^3 \text{ N}$

Force = 3750 N.

28. Compare the power at which each of the following is moving upwards against the force of gravity? (given g = 10 ms^{-2})
(i) a butterfly of mass 1.0 g that flies upward at a rate of 0.5 ms^{-1}.
(ii) a 250-g squirrel climbing up on a tree at a rate of 0.5 ms^{-1}.

Ans. (i) power = mg × velocity, g = $10ms^{-2}$

$= \frac{1}{1000} \times 10 \times 0.5W$

$= \frac{0.5}{100} W = 5 \times 10^{-3} W$

(ii) Power $= \frac{250}{1000} \times 10 \times 0.5W$

$= \frac{1}{4} \times 10 \times 0.5 = 1.25W$

Hence, the power with which the squirrel is climbing is much higher than that of a butterfly flying.