

## Question Bank in Science Class-IX (Term-II)

# 11

## WORK AND ENERGY

### CONCEPTS

- 1. Work :** Work is said to be done, when a force causes displacement in its own direction.
- 2. No work is done,** if the displacement is not in the direction of applied force or its rectangular component.
- 3. Factors which determine work :**
  - (i) Work done is directly proportional to the magnitude of applied force.
  - (ii) Work done is directly proportional to the displacement in the direction of applied force.
- 4. Mathematical expression for work :**

If  $F$  is the force, which causes a displacement  $s$ , in its own direction, such that  $W$  is the work done, then

$$W = F \times s$$

- 5. SI unit of work :** SI unit of work is Joule (J).
- 6. Bigger units of work :**
  - (a) 1 kilojoule =  $10^3$  J = 1000 J
  - (b) 1 Megajoule =  $10^6$  J = 1000,000 J
  - (c) 1 Gigajoule =  $10^9$  J = 1000,000,000 J
- 7. Definition of Joule :** When a force of 1 N, causes a displacement of 1 m in its own direction, the work done is said to be one joule.

So,  $1 \text{ J} = 1 \text{ N} \times 1 \text{ m} = 1 \text{ kgms}^{-2} \times 1 \text{ m} = 1 \text{ kgm}^2\text{s}^{-2}$ .

- 8. Energy :** Capacity of doing work is called energy.
- 9. Units of energy :** Same as units of work, i.e., Joule.
- 10. Potential energy :** The energy possessed by a body on account of its position or configuration is called potential energy.
- 11. Mathematical expression for potential energy :**

$$\text{P.E.} = mgh$$

where ' $m$ ' is the mass, ' $g$ ' is the acceleration due to gravity and ' $h$ ' is the height.

- 12. Characteristics of potential energy :**
  - (a) Potential energy of a body at the surface of earth is taken as zero.
  - (b) When a body is raised above the ground level, its potential energy increases.
  - (c) When a body is brought from a height towards the ground, its potential energy decreases.
  - (d) At any point above the surface of the earth, potential energy is numerically equal to the work done in raising the body.
- 13. Kinetic energy :** The energy possessed by a body by virtue of its motion is called kinetic energy.
- 14. Mathematical expression for kinetic energy :**

$$\text{K.E.} = \frac{1}{2}mv^2$$

where ' $m$ ' is the mass of the body and ' $v$ ' is the uniform velocity.

15. **Power** : Rate of doing work is called power.

16. **SI unit of power** : SI unit of power is watt ( $W$ ), where  $1 W = 1 J s^{-1}$

17. **Mathematical expression for power** :

$$p = \frac{W}{t}$$

where ' $p$ ' is the power, ' $W$ ' is the work done (or energy used) and  $t$  is the time in seconds.

18. **Bigger units of power** :

(a) 1 kilowatt (kW) =  $10^3 W = 1000 W$       (b) 1 Megawatt (MW) =  $10^6 W = 1000,000 W$

(c) 1 Gigawatt (GW) =  $10^9 W = 1000,000,000 W$

19. **Definition of watt** : When a work of 1 J is done in 1 s, then the power is said to be 1 watt.

$$1 W = \frac{1 J}{1 s} = 1 \text{ kg} \frac{\text{m}^2}{\text{s}^2} \times \frac{1}{s} = 1 \text{ kgm}^2\text{s}^{-3}.$$

20. **Law of conservation of energy** : Energy in a system cannot be created, nor it can be destroyed. It may be transformed from one form to another form, but the total energy of the system remains constant.

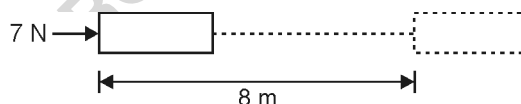
## I. SUMMATIVE ASSESSMENT

### NCERT QUESTIONS WITH THEIR ANSWERS

#### SECTION A : IN-TEXT QUESTIONS

#### Page 148

Q.1. A force of 7 N acts on an object. The displacement is say 8 m, in the direction of the force.



Let us take it that the force acts on the object through the displacement. What is the work done in this case?

Ans. Force = 7 N; Displacement = 8 m; Work done = Force  $\times$  Displacement = 7 N  $\times$  8 m = **56 J**

#### Page 149

Q.1. When do we say that work is done?

Ans. When a force causes displacement of an object in the direction of applied force, work is said to be done.

Q.2. Write an expression for the work done, when a force is acting on an object in the direction of its displacement.

Ans. Work done ( $W$ ) = Force ( $\vec{F}$ )  $\times$  Displacement ( $\vec{s}$ )

Q.3. Define 1J of work.

Ans. When a force of 1N causes a displacement of 1 m, in its own direction, the work done is said to be one Joule.

**Q.4.** A pair of bullocks exerts a force of 140 N on a plough. The field being ploughed is 15 m long. How much work is done in ploughing the length of field?

**Ans.** Work done = Force  $\times$  Displacement = 140 N  $\times$  15 m = **2100 J**.

**Page 152**

**Q.1.** What is kinetic energy of an object?

**Ans.** The energy possessed by an object on account of its motion is known as kinetic energy of that object.

**Q.2.** Write an expression for the kinetic energy of an object.

**Ans.** When 'm' is the mass of an object and 'v' the velocity, then

$$\text{Kinetic energy of an object (K.E.)} = \frac{1}{2}mv^2.$$

**Q.3.** The kinetic energy of an object of mass 'm', moving with a velocity of 5 ms<sup>-1</sup> is 25 J. What will be its kinetic energy, when the velocity is doubled? What will be its kinetic energy when its velocity is increased three times? **[2010]**

**Ans.** Mass of an object (m) = ?; Velocity of an object (v) = 5 ms<sup>-1</sup>

Kinetic energy of an object (K.E.) = 25 J

$$\text{Now, K.E.} = \frac{1}{2}mv^2 \Rightarrow 25 \text{ J} = \frac{1}{2} \times m \times (5\text{ms}^{-1})^2 \therefore m = 50 \text{ J}/25 \text{ m}^2\text{s}^{-2} = \mathbf{2 \text{ kg}}$$

**When the velocity doubles :**

$$\text{K.E.} = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \text{ kg} \times (10 \text{ ms}^{-1})^2 = \mathbf{100 \text{ J}}$$

**When the velocity triples :**

$$\text{K.E.} = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \text{ kg} \times (15 \text{ ms}^{-1})^2 = \mathbf{225 \text{ J}}$$

**Page 156**

**Q.1.** What is power?

**Ans.** Rate of doing work is called power.

**Q.2.** Define 1 watt of power.

**Ans.** When a work of 1 Joule is done in 1 second, the power is said to be one watt.

**Q.3.** A lamp consumes 1000 J of electrical energy in 10 s. What is its power?

**Ans.** 
$$\text{Power} = \frac{\text{Energy}}{\text{Time}} = \frac{1000 \text{ J}}{10 \text{ s}} = 100 \text{ W.}$$

**Q.4.** Define average power.

**Ans.** When a machine / person does different amounts of work or consumes energy in different intervals of time, the ratio between the total work / energy consumed to the total time is known as average power.

$$\text{Average power} = \frac{\text{Total workdone/energy consumed}}{\text{Total time}}.$$

**SECTION B : QUESTIONS AT THE END OF CHAPTER**

**Q.1.** Look at the activities listed below. Reason out whether or not work is done in the light of your understanding of the term 'work'.

- (a) Suma is swimming in a pond.
- (b) A donkey is carrying a load on its back.
- (c) A wind-mill is lifting water from a well.
- (d) A green plant is carrying out photosynthesis.
- (e) Food grains are getting dried in the sun.
- (f) A sail boat is moving due to wind energy.

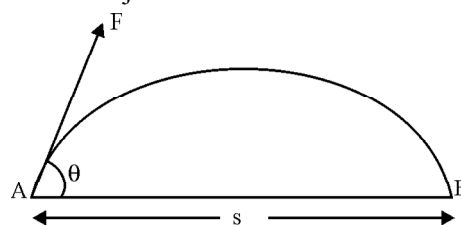
- Ans.** (a) Work is done, because the displacement of swimmer takes place in the direction of applied force.  
 (b) If the donkey is not moving, no work is done as the displacement of load does not take place in the direction of applied force.  
 (c) Work is done, as the displacement takes place in the direction of force.  
 (d) No work is done, as the displacement does not take place.  
 (e) No work is done, as no displacement takes place.  
 (f) Work is done, as displacement takes place in the direction of applied force.

**Q.2.** An object thrown at a certain angle to the ground moves in a curved path and falls back to the ground. The initial and the final points of the path of the object lie on the same horizontal line. What is the work done by the force of gravity on the object?

- Ans.** Consider an object at point A, thrown with a force  $F$  at an angle ' $\theta$ ' such that it lands at point B. If ' $s$ ' is the horizontal distance between the points A and B, then :

$$\text{Force of gravity of Earth} = mg$$

$$\text{Work done by the force of gravity} = mgs$$



**Q.3.** A battery lights a bulb. Describe the energy changes in the process.

- Ans.** (i) Within the electric cell of the battery, the chemical energy changes into the electric energy.  
 (ii) The electric energy on flowing through the filament of the bulb, first changes into heat energy and then into the light energy.

**Q.4.** Certain force acting on a 20 kg mass changes its velocity from  $5 \text{ ms}^{-1}$  to  $2 \text{ ms}^{-1}$ . Calculate the work done by the force.

**Ans.** Work done by the force when velocity is  $5 \text{ ms}^{-1} = \frac{1}{2} mv^2 = \frac{1}{2} \times 20 \text{ kg} \times (5 \text{ ms}^{-1})^2 = 250 \text{ J}$

Work done by the force when velocity is  $2 \text{ ms}^{-1} = \frac{1}{2} mv^2 = \frac{1}{2} \times 20 \text{ kg} \times (2 \text{ ms}^{-1})^2 = 40 \text{ J}$

$\therefore$  Resultant work done by the force =  $250 \text{ J} - 40 \text{ J} = \mathbf{210 \text{ J}}$ .

**Q.5.** A mass of 10 kg is at a point A on a table. It is moved to point B. If the line joining the A and B is horizontal, what is the work done on the object by the gravitational force? Explain your answer.

- Ans.** Zero, because displacement does not take place in the direction of gravitational force.

**Q.6.** The potential energy of a freely falling object decreases progressively. Does this violate the law of conservation of energy? Why?

**Ans.** It does not violate the law of conservation of energy. Whatsoever, is decrease in potential energy due to loss of height, same is the increase in the kinetic energy due to gain in velocity.

**Q.7.** What are various energy transformations occur, when you are riding a bicycle?

**Ans.** The chemical energy of the food changes into heat and then to muscular energy. The muscular energy changes to mechanical energy of cycle on paddling.

**Q.8.** Does the transfer of energy take place when you push a huge rock with all your might and fail to move it? Where is the energy spend going?

**Ans.** Energy transfer does not take place as no displacement takes place in the direction of applied force.

The energy spent is used to overcome inertia of rest of the rock.

**Q.9.** A certain household has consumed 250 units of energy during a month. How much energy is this in joules?

**Ans.** Energy consumed in a month = 250 units = 250 kWh = 250 kW × 1 h  
= 250 × 1000 W × 3600 s = 900,000,000 J = **900 MJ.**

**Q.10.** An object of mass 40 kg is raised to a height of 5 m above the ground. What is its potential energy? If the object is allowed to fall, find its kinetic energy, when it is half-way down.

**Ans.** Mass of object ( $m$ ) = 40 kg; height ( $h$ ) = 5 m; Acceleration due to gravity ( $g$ ) = 10 ms<sup>-2</sup>  
∴ Potential energy at a height of 5 m (PE) =  $mgh$  = 40 kg × 10 ms<sup>-2</sup> × 5 m = **2000 J**  
Potential energy at a half-way height, i.e., 2.5 m, PE =  $mgh$   
= 40 kg × 10 ms<sup>-2</sup> × 2.5 m = **1000 J**

Decrease in potential energy = Increase in kinetic energy = (2000 – 1000) J = **1000 J**

**Q.11.** What is the work done by the force of gravity on a satellite moving round the earth? Justify your answer.

**Ans.** The work done by the force of gravity on the satellite is zero. It is because, the force of gravity acts at right angles to the direction of motion of the satellite, and hence, no displacement is caused in the direction of applied force. The force of gravity only changes the direction of motion of the satellite.

**Q.12.** Can there be displacement of an object in the absence of any force acting on it? Think. Discuss this question with your friends and teacher.

**Ans.** The answer is both, yes and no.

Yes in a sense that when an object moves in deep space from one point to another point in a straight line the displacement takes place, without the application of force.

No, in a sense that force can not be zero for displacement on the surface of earth. Some force is essential.

**Q.13.** A person holds a bundle of hay over his head for 30 minutes and gets tired. Has he done some work or not? Justify your answer.

**Ans.** The person does no work. It is because, no displacement takes in the direction of applied force as the force acts in the vertically upward direction.

**Q.14.** An electric heater is rated 1500 W. How much energy does it used in 10 hours?

**Ans.** Energy used by heater = Power × Time = 1500 W × 10 h =  $\frac{1500 \text{ W} \times 10 \text{ h}}{1000}$  = **15 kWh**

**Q.15.** Illustrate the law of conservation of energy by discussing the energy changes which occur when we draw a pendulum bob to one side and allow it to oscillate. Why does the bob eventually come to rest? What happens to its energy eventually? Is it a violation of law of conservation of energy?

**Ans.** When the pendulum bob is pulled (say towards left), the energy supplied is stored in it in the form of potential energy on account of its higher position. When the pendulum is released so that it starts moving towards right, then its potential energy changes into kinetic energy, such that in mean position, it has maximum kinetic energy and zero potential energy. As the pendulum moves further towards extreme right, its kinetic energy changes into potential energy, such that at the extreme position, it has maximum potential energy and zero kinetic energy. On moving from this extreme position to mean position, its potential energy again changes to kinetic energy. This illustrates the law of conservation of energy.

The bob eventually comes to rest, because during each oscillation a part of the energy possessed by it is transferred to air and in overcoming friction at the point of suspension. Thus, gradually the energy of the pendulum is dissipated in air.

The law of conservation of energy is not violated because the energy merely changes its form and is not destroyed.

**Q.16.** An object of mass ' $m$ ' is moving with a constant velocity ' $v$ '. How much work should be done on the object in order to bring the object to rest?

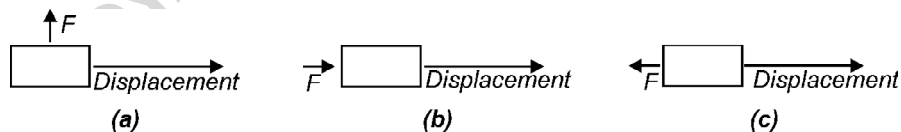
**Ans.** The work done to bring the object to rest = Kinetic energy of the object =  $\frac{1}{2}mv^2$

**Q.17.** Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 kmh<sup>-1</sup>?

**Ans.** Mass of car = 1500 kg; Velocity of car = 60 kmh<sup>-1</sup> =  $\frac{60 \times 1000 \text{ m}}{60 \times 60 \text{ s}} = 16.67 \text{ ms}^{-1}$

$$\begin{aligned} \therefore \text{Work done} &= \text{KE of the car} = \frac{1}{2}mv^2 = \frac{1}{2} \times 1500 \text{ kg} \times (16.67 \text{ ms}^{-1})^2 \\ &= \frac{1}{2} \times 1500 \text{ kg} \times 277.89 \text{ m}^2\text{s}^{-2} = \mathbf{208416.68 \text{ J}} \end{aligned}$$

**Q.18.**



In each of the above diagrams a force ' $F$ ' is acting on an object of mass ' $m$ '. The direction of displacement is from west to east shown by the longer arrow. Observe the diagrams carefully and state whether the work done by the force is negative, positive or zero.

**Ans.** In case of Fig. (a) work done is zero, as the force does not act in the direction of displacement. In case of Fig. (b) work done is positive, as the force acts in the direction of displacement. In case of Fig. (c) work done is negative, as the force acts in the direction opposite to the displacement.

**Q.19.** Soni says that the acceleration in an object could be zero even when several forces are acting on it. Do you agree with her? Why?

**Ans.** Yes, we do agree, when the number of forces act on a body, such that they constitute balanced forces then net force acting on the body is zero. In such a situation no acceleration acts on the object.

**Q.20.** Find the energy in kWh consumed in 10 hours by four devices of power 500 W each.

**Ans.** Total power of 4 devices =  $4 \times 500 \text{ W} = 2000 \text{ W} = \frac{2000\text{W}}{1000} = 2 \text{ kW}$

Time = 10 h.

$\therefore$  Energy consumed = Power  $\times$  time =  $2 \text{ kW} \times 10 \text{ h} = 20 \text{ kWh}$

**Q.21.** A freely falling object eventually stops on reaching the ground. What happens to its kinetic energy?

**Ans.** The kinetic energy to reaching the ground changes into heat energy, sound energy, etc., and hence gets dissipated in air.

## ADDITIONAL QUESTIONS (As Per CCE Pattern)

### A. Very Short Answer Questions

(1 Mark)

#### Previous Years' Questions

**Q.1.** Seema tried to push a heavy rock of 100 kg for 200 s but could not move it. Find the work done by Seema at the end of 200 s. [2011 (T-II)]

**Ans.** Zero, because there is no displacement in the direction of applied force.

**Q.2.** At what speed a body of mass 1 kg will have a kinetic energy of 1J? [2011 (T-II)]

**Ans.** Kinetic energy =  $\frac{1}{2} mv^2$

$$\Rightarrow 1\text{J} = \frac{1}{2} \times 1 \text{ kg} \times v^2 \Rightarrow 2\text{J/kg} = v^2 \therefore v = \sqrt{2} \text{ m/s} = 1.41 \text{ m/s.}$$

**Q.3.** Define 1 Joule of work. [2011 (T-II)]

**Ans.** When a force of 1 newton, causes a displacement of 1 m in its own direction, the work done is said to be 1 joule.

**Q.4.** Identify the energy possessed by a rolling stone. [2011 (T-II)]

**Ans.** Kinetic energy.

**Q.5.** Identify the kind of energy possessed by a running athlete. [2011 (T-II)]

**Ans.** Kinetic energy.

**Q.6.** What would be the amount of work done on an object by a force, if the displacement of the object is zero? [2011 (T-II)]

**Ans.** Zero.

**Q.7.** How much work is done by a weight lifter when he holds a weight of 80 kgs on his shoulders for two minutes? [2011 (T-II)]

**Ans.** Zero, because there is no displacement.

**Q.8.** A car and a truck are moving with the same velocity of 60 km/hr. Which one has more kinetic energy? (Mass of truck > Mass of car). **[2011 (T-II)]**

**Ans.** Kinetic energy =  $\frac{1}{2} mv^2$ . Having same velocity, but truck has greater mass, so it has more kinetic energy.

**Q.9.** A body is thrown vertically upwards. Its velocity goes on decreasing. Write the change in kinetic energy when its velocity becomes zero. **[2011 (T-II)]**

**Ans.** Kinetic energy of the body changes into its potential energy.

**Q.10.** A force of 10 N moves a body with a constant speed of 2 m/s. Calculate the power of the body. **[2011 (T-II)]**

**Ans.** Power = Force  $\times$  Velocity = 10 N  $\times$  2 m/s = 20 W.

**Q.11.** What will be the kinetic energy of a body when its mass is made four times and the velocity is doubled? **[2011 (T-II)]**

**Ans.** Kinetic energy =  $\frac{1}{2} mv^2$  ... (i)

Now, mass = 4  $m$ , velocity = 2 $v$

Then, new kinetic energy =  $\frac{1}{2} \times 4 m \times (2v)^2 = 4 \times 4 \times \frac{1}{2} mv^2 = 16 \times \frac{1}{2} mv^2$

Thus new kinetic energy becomes 16 times of the initial value.

**Q.12.** A freely falling object eventually stops on reaching the ground. What happens to its kinetic energy on reaching the ground? **[2011 (T-II)]**

**Ans.** On reaching the ground the kinetic energy changes into heat energy, sound energy etc., and hence gets dissipated in air.

**Q.13.** State the energy conversions in a dry cell. **[2011 (T-II)]**

**Ans.** Chemical energy first changes into heat energy then light energy.

**Q.14.** What is the work done by the earth in moving around the sun? **[2011 (T-II)]**

**Ans.** Zero, because displacement is at right angles to the direction of applied force.

**Q.15.** A coolie is walking on a railway platform with a load of 30 kg on his head. How much work is done by coolie? **[2011 (T-II)]**

**Ans.** Zero, because force acts at right angles to the direction of displacement.

**Q.16.** How many times does the kinetic energy of a body become when its speed is doubled? **[2011 (T-II)]**

**Ans.** Kinetic energy =  $\frac{1}{2} mv^2$

New speed = 2  $v$

Then, new kinetic energy =  $\frac{1}{2} m (2v)^2 = 4 \cdot \frac{1}{2} mv^2$

Thus, kinetic energy becomes four times of the initial value.

**Q.17.** Define 1 kWh. **[2011 (T-II)]**

**Ans.** The amount of energy used / produced at a rate of one kilowatt (kW) for one hour is called 1 kWh.

- Q.18.** In an oscillating pendulum, at what positions the potential and kinetic energy are maximum? [2011 (T-II)]  
**Ans.** The potential energy is maximum at extreme positions and kinetic energy is maximum at mean-position of an oscillating pendulum.
- Q.19.** Name the type of energy possessed by a raised hammer? [2011 (T-II)]  
**Ans.** Potential energy.
- Q.20.** What is the form of energy possessed by a running car? [2011 (T-II)]  
**Ans.** Kinetic energy.
- Q.21.** State the value of commercial unit of electrical energy in Joules? [2011 (T-II)]  
**Ans.** 1 kWh = 3.6 MJ.
- Q.22.** A horse of mass 210 kg and a dog of mass 25 kg are running at the same speed. Which of the two possesses more kinetic energy ? How? [2011 (T-II)]  
**Ans.** Both have same speed but having greater mass the horse possesses more kinetic energy.
- Q.23.** If the speed of the body is halved, what is the change in its kinetic energy? [2011 (T-II)]  
**Ans.** Kinetic energy =  $\frac{1}{2}mv^2$   
 Now, speed =  $\frac{1}{2}v$   
 Then, new kinetic energy =  $\frac{1}{2}m \times \left(\frac{1}{2}v\right)^2 = \frac{1}{4} \cdot \frac{1}{2}mv^2$   
 Thus, new kinetic energy becomes one-fourth of the initial value.
- Q.24.** Give the formula for calculating work done. What is the SI unit of work? [2011 (T-II)]  
**Ans.** If  $F$  be the force applied and  $s$  displacement, then  
 Work done,  $W = F \times s$ .  
 SI unit of work is joule (J).
- Q.25.** Define 1 watt of power. [2011 (T-II)]  
**Ans.** When a work of 1 J is done in 1 second, then power is said to be 1 watt.
- Q.26.** Name the type of energy possessed by the following : [2011 (T-II)]  
 (i) Stretched slinky (ii) Speeding car  
**Ans.** (i) Potential energy (ii) Kinetic energy.
- Q.27.** A ball is thrown vertically upwards. Its velocity keeps on decreasing. What happens to its kinetic energy when it reaches the maximum height? [2011 (T-II)]  
**Ans.** At maximum height its velocity is zero, so kinetic energy changes into potential energy.
- Q.28.** Write the formula to measure the work done, if the displacement of the object is at an angle of  $90^\circ$  to the direction of force. [2011 (T-II)]  
**Ans.**  $W = Fs \cos \theta = Fs \times \cos 90^\circ = Fs \times 0 = 0$
- Q.29.** At what rate is electrical energy consumed by a bulb of 60 watt? [2011 (T-II)]  
**Ans.** 60 joule of energy is consumed per second.
- Q.30.** What should be the change in velocity of a body required to increase its kinetic energy to four times of its initial value? [2011 (T-II)]  
**Ans.** Kinetic energy =  $\frac{1}{2}mv^2$ .  
 Velocity should be increase twice to increase its kinetic energy to four times of its initial value.

**Q.31.** Give an example of a body having potential energy due to change of shape. [2011 (T-II)]

**Ans.** A wound up spring of a watch or a toy car.

**Q.32.** When is work done by a force zero? [2011 (T-II)]

**Ans.** When force acts at right angles to the direction of displacement.

**Q.33.** If the heart works 60 joules in one minute, what is its power? [2011 (T-II)]

**Ans.**  $W = 60$  joules,  $t = 1$  minute = 60 second

$$\text{Power} = \frac{W}{t} = \frac{60 \text{ joules}}{60 \text{ second}} = 1 \text{ W}$$

**Q.34.** Name the term used for the sum of kinetic energy and potential energy of a body.

[2011 (T-II)]

**Ans.** Mechanical energy.

**Q.35.** Write the observed energy transformation that takes place at thermal power station.

[2011 (T-II)]

**Ans.** Chemical energy  $\rightarrow$  Heat energy  $\rightarrow$  Kinetic energy  $\rightarrow$  Electrical energy.

**Q.36.** Calculate the work done when a force of 15 N moves a body by 5 m in its direction.

[2011 (T-II)]

**Ans.** Work done = Force  $\times$  displacement = 15 N  $\times$  5 m = 75 J

**Q.37.** The potential energy of a free falling object decreases progressively. Does this violate the law of conservation of energy? Why? [2011 (T-II)]

**Ans.** No, because with decrease of height, its velocity increases progressively, thus kinetic energy increases.

**Q.38.** Write the S.I. unit of power.

[2011 (T-II)]

**Ans.** Watt (W).

**Q.39.** A student is writing a three hours science paper. How much work is done by the student? Give reasons to your answer. [2011 (T-II)]

**Ans.** Zero, because applied force does not cause any displacement of a body in its direction.

**Q.40.** How many joules make one kilowatt hour? [2011 (T-II)]

**Ans.** 1 kilowatt hour =  $3.6 \times 10^6$  joules.

**Q.41.** When displacement is in a direction opposite to the direction of force applied, what is the type of work done? [2011 (T-II)]

**Ans.** Negative work.

### Other Important Questions

**Q.1.** When does a force do work? How is this work measured?

**Ans.** Work is done by a force acting on a body only, if it displaces the body along the direction of force.

**Q.2.** State the mathematical expression for work.

**Ans.** When  $F$  is the force acting on the body and  $s$  is the displacement moved by the body in the direction of force, then work,  $W = Fs$ .

**Q.3.** What are the conditions for doing work?

**Ans.** Work is done only if the force displaces the body in its own direction of action.

**Q.4.** Is work a scalar or a vector quantity?

**Ans.** Work is a scalar quantity.

**Q.5.** Give one example of a moving body, where no work is done.

**Ans.** Work done by centripetal force on a body moving along a circular path is always zero.

**Q.6.** Explain, why no work is done when a man pushes a wall?

**Ans.** When a man pushes a wall but fails to displace it, then the work done by the man is zero.

**Q.7.** Define the term 'power'.

**Ans.** The rate of doing work is called power.

**Q.8.** A boy climbs 100 stairs to reach at the top of a building. What happens to the potential energy of the boy?

**Ans.** Potential energy of the boy will increase.

**Q.9.** Water flows down the mountains to the plains. What happens to the potential energy of water?

**Ans.** Potential energy of water will decrease. It will change to kinetic energy of water.

**Q.10.** Give two examples in which a body possesses potential energy.

**Ans.** (i) Potential energy possessed by the stone at the roof of the building.

(ii) Potential energy possessed by the stretched string.

**Q.11.** What do you understand by the term kinetic energy?

**Ans.** The energy possessed by a body due to its motion is called kinetic energy.

**Q.12.** What determines the kinetic energy of a body of a given mass?

**Ans.** If  $m$  and  $v$  are the mass and velocity of a body, then its

$$\text{Kinetic energy, KE} = \frac{1}{2} mv^2$$

**Q.13.** What is the biggest source of energy ?

**Ans.** Sun is the biggest source of energy.

**Q.14.** How is power related to work and time?

**Ans.** Power =  $\frac{\text{Work}}{\text{Time}}$

**Q.15.** What do you understand by the term mechanical energy?

**Ans.** The energy possessed by a body due to its state of rest or motion is called mechanical energy.

**Q.16.** What do you understand by the term potential energy?

**Ans.** The energy possessed by a body due to its position or deformation is called potential energy.

**Q.17.** State the law of conservation of energy.

**Ans.** **Law of conservation of energy :** Energy can neither be created nor destroyed, but it may simply be transformed from one form to another.

**Q.18.** What do you understand by the term energy transformation?

**Ans.** The process of changing of one form of energy into another form of energy is called transformation of energy.

**Q.19.** What kind of energy transformation takes place when the hands are rubbed?

**Ans.** When the hands are rubbed, then mechanical energy is converted into heat energy, due to friction between the hands.

**Q.20.** What will cause greater change in kinetic energy of a body? Changing its mass or changing its velocity.

**Ans.** Changing its velocity

**Q.21.** List two essential condition for work to be done.

**Ans.** (i) A force must act on a body.

(ii) The body must get displaced in the direction of force.

**B. Short Answer Questions - I**

**(2 Marks)**

**Previous Years' Questions**

**Q.1.** 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. **[2011 (T-II)]**

**Ans.** Consider initial velocity =  $u$  and final velocity =  $v$ , after applying the force  $F$ . If mass of the body be  $m$  and covered displacement =  $s$ , during the accelerated motion.

$$\text{Then, acceleration, } a = \frac{v^2 - u^2}{2s}$$

$$\therefore \text{Accelerating force acting on the body} = ma \Rightarrow F = \frac{m(v^2 - u^2)}{2s}$$

$$\text{Thus, work done by the accelerating force} = F \times s = \frac{m(v^2 - u^2)}{2s} \times s = \frac{m(v^2 - u^2)}{2}$$

$\Rightarrow$  Work done =  $\frac{1}{2} mv^2 - \frac{1}{2} mu^2$  = Increase in kinetic energy. Hence, increase in kinetic energy of the body is equal to the work done by the force on the body.

**Q.2.** (a) Define 1 watt.

(b) An electric bulb of 60 W (sixty watt) is used for 6 (six) hours per day. Calculate the units of energy consumed in one day by the bulb. **[2011 (T-II)]**

**Ans.** (a) When a work of one joule is done in one second, then the power is said to be 1 watt.

$$\text{Thus, } 1 \text{ W} = \frac{1 \text{ J}}{1 \text{ s}} = 1 \text{ J/s}$$

(b) Energy consumed in one day = Power  $\times$  time = 60 W  $\times$  6 h = 360 Wh =  $\frac{360}{1000}$  kWh  
= 0.36 kWh = **0.36 unit** ( $\because$  1kWh = 1 unit)

**Q.3.** (a) Is it possible that a force is acting on a body but still work done is zero? Explain giving one example. **[2011 (T-II)]**

(b) Two bodies of equal masses move with uniform velocities of  $v$  and  $3v$  respectively. Find the ratio of their kinetic energies.

**Ans.** (a) Yes, when a boy pushes a wall with all the force he has, and no displacement is caused, then no work is done.

$$(b) \text{Ratio of their kinetic energies} = \frac{1}{2} mv^2 : \frac{1}{2} m(3v)^2 = \frac{1}{2} mv^2 : 9 \cdot \frac{1}{2} mv^2 = \mathbf{1 : 9}$$

**Q.4.** (a) How much work is done when a force of 1 N moves a body through a distance of 1 m in its direction? **[2011 (T-II)]**

(b) Is it possible that a force is acting on a body but still the work done is zero? Explain giving one example.

**Ans.** (a) Work done = Force  $\times$  Displacement = 1 N  $\times$  1 m = **1 J**

(b) See Ans 3. (a) of this section.

**Q.5.** (a) What is meant by potential energy? Is potential energy a vector or scalar quantity?

[2011 (T-II)]

(b) Give one example of a body having potential energy.

**Ans.** (a) The energy possessed by a body on account of its position or configuration is called potential energy. Potential energy is dormant or latent in nature.

Potential energy = mass  $\times$  acceleration due to gravity  $\times$  height.  $\Rightarrow$  P.E. =  $mgh$ .

Potential energy is a scalar quantity.

(b) Water contained in the clouds in the form of tiny droplets possesses potential energy due to position of the body.

### Other Important Questions

**Q.1.** A sparrow and a crow are having the same kinetic energy during a flight. Which of the two is moving fast and why?

**Ans.** Kinetic energy of a moving body =  $\frac{1}{2} mv^2$ . Having the same kinetic energy for sparrow and crow, velocity of the sparrow will be greater because mass of sparrow is smaller than crow. Thus, the sparrow is moving fast.

**Q.2.** Why does a satellite going around the Earth in a circular path does no work?

**Ans.** When a satellite goes around the earth in a circular path with uniform speed, the centripetal force acts towards the centre. Thus the angle between the force and instantaneous velocity of the particle is  $90^\circ$ . Thus, work done,  $W = Fs \cos 90^\circ = Fs \times 0 = 0$

**Q.3.** A locomotive exerts a force of 7500 N and pulls a train by 1.5 km. How much work is done by the locomotive in mega joules?

**Ans.**  $F = 7500$  N,  $s = 1.5$  km = 1500 m

Work done,  $W = Fs = 7500 \times 1500 = 11250000$  J =  $11.25 \times 10^6$  J = **11.25 MJ**

**Q.4.** Why is no work done, when a force acts at right angle to the direction of displacement?

**Ans.** When a force acts at right angle to the direction of displacement, then  $\theta = 90^\circ$ ,

So, work done,  $W = Fs \cos \theta$

$= Fs \cos 90^\circ = Fs \times 0 = 0$

**Q.5.** The energy of a torch cell is converted into two other forms of energy in a flashlight bulb. Name the energy conversions.

**Ans.** (i) The chemical energy of the cells in flash light changes to electric energy.

(ii) The electric energy in the bulb of flash light changes into heat energy.

(iii) A part of heat energy on account of high temperature changes to light energy.

**Q.6.** A man climbs a slope and another walks the same distance on a level road. Which of the two expends more energy and why?

**Ans.** When a man climbs a slope and another walks the same distance on a level road then the former expends more energy, because he spends extra energy against the force of gravity to climb up a slope.

**Q.7.** A nail becomes hot when hammered into a plank. Explain, why?

**Ans.** A nail becomes hot when hammered into a plank because some mechanical energy due to friction is converted into heat energy.

**Q.8.** If you apply 1 J of energy to lift a book of 0.5 kg, how high will it rise? [Take  $g = 10 \text{ ms}^{-2}$ ]

**Ans.**  $W = 1 \text{ J}$ ,  $m = 0.5 \text{ kg}$ ,  $g = 10 \text{ ms}^{-2}$ ,  $h = ?$

$$W = mgh \Rightarrow 1 = 0.5 \times 10 \times h \Rightarrow h = \frac{1}{5} = 0.2 \text{ m} = \mathbf{20 \text{ cm.}}$$

**Q.9.** What force will cause a displacement of 2 m, while doing a work of 60 J?

**Ans.**  $s = 2 \text{ m}$ ,  $W = 60 \text{ J}$ ,  $F = ?$

$$W = Fs \Rightarrow 60 = F \times 2 \Rightarrow F = \frac{60}{2} = \mathbf{30 \text{ N.}}$$

**Q.10.** Calculate the work done by a machine of 50 W power rating in 30 s.

**Ans.**  $p = 50 \text{ W}$ ,  $t = 30 \text{ s}$ ,  $W = ?$

$$W = pt = 50 \times 30 = \mathbf{1500 \text{ J.}}$$

**Q.11.** Identify the energy transformation in the following :

(a) steam engine (b) solar cell

**Ans.** (a) (i) The chemical energy of the coil changes into the heat energy.

(ii) The heat energy changes into the kinetic energy of the steam.

(iii) The kinetic energy of the steam changes into the mechanical energy of the engine.

(b) (i) The heat energy of the sun changes into the chemical energy of the battery.

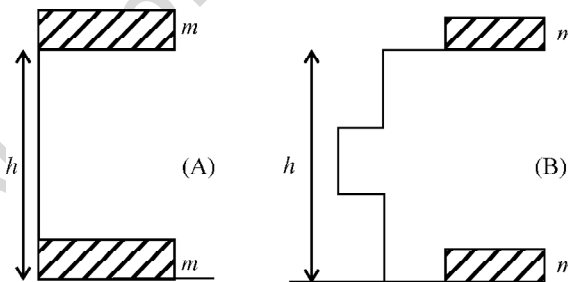
(ii) The chemical energy of the battery changes into electric energy.

(iii) The electric energy changes into heat and light energy.

**Q.12.** Describe the various energy transformation that take place when a body is riding a bicycle.

**Ans.** The chemical energy of the food changes into heat and then to muscular energy. The muscular energy changes into mechanical energy of the cycle on paddling.

**Q.13.**



(a) What is meant by potential energy of a body ?

(b) A body of mass 'm' is raised to a vertical height 'h' through two different paths A and B. What will be the potential energy of the body in the two cases? Give reason for your answer.

**Ans.** (a) The energy possessed by a body on account of its position or configuration is called potential energy.

(b) The potential energy in both cases will  $mgh$ , where  $h$  is the height.

**Reason :**  $m$ ,  $g$  and  $h$  are same in both cases.

**Q.14.** A pair of bullocks exert a force of 16 N while ploughing a field which is 20 m long. How much work is done ploughing length of this field?

**Ans.** Force (F) = 16 N; Length (or displacement, D) = 20 m

$$\text{Work (W)} = F \times D = 16 \text{ N} \times 20 \text{ m} = \mathbf{320 \text{ J.}}$$

**Q.15.** An archer stretches his bow to shoot an arrow. Name :

- (a) the type of energy he uses in the process
- (b) the type of energy into which it is converted
- (c) the energy transformation taking place when the arrow is shot.

**Ans.** (a) Muscular energy  
(b) Potential energy  
(c) The potential energy changes into kinetic energy.

**Q.16.** Find the energy in kWh consumed in 24 hours by two electric devices, one of 100 W and other of 500 W.

**Ans.** Total power ( $p$ ) = 100 W + 500 W = 600 W = 0.6 kW; time ( $t$ ) = 24 hours  
Energy consumed in 24 hours = 0.6 kW  $\times$  24 h = **14.4 kWh**.

**Q.17.** Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h.

**Ans.** Mass ( $m$ ) = 1500 kg; Velocity ( $v$ ) = 60 km/h =  $\frac{60 \times 1000}{3600} = 16.67 \text{ ms}^{-1}$

$$\begin{aligned} \therefore \text{Work done} &= \text{K.E. of the car} = \frac{1}{2} mv^2 = \frac{1}{2} \times 1500 \text{ kg} \times (16.67 \text{ ms}^{-1})^2 \\ &= \frac{1}{2} \times 1500 \times 277.89 \text{ J} = \mathbf{208416.685 \text{ J}}. \end{aligned}$$

**Q.18.** An electric bulb of 100 W works for 6 hrs a day. Calculate the units of energy consumed in 1 month of 30 days.

**Ans.** Power of electric bulb = 100 W = 0.1 kW; time ( $t$ ) = 6 h  
Energy consumed in a day = 0.6 kWh  
 $\therefore$  Energy consumed in 30 days = 0.6 kWh  $\times$  30 = 18 kWh.

**Q.19.** A boy lifts a suitcase of 20 kg from the ground to a height of 1.2 m. Calculate the work done by him on the suitcase (given  $g = 10 \text{ ms}^{-2}$ ).

**Ans.** Force exerted by the boy =  $mg = 20 \text{ kg} \times 10 \text{ ms}^{-2} = 200 \text{ N}$   
 $\therefore$  Work done by the boy = force  $\times$  displacement = 200 N  $\times$  1.2 m = **240 J**.

### C. Short Answer Questions - II

(3 Marks)

#### Previous Years' Questions

**Q.1.** A mass of 10 kg is dropped from a height of 50 cm. Find its :

[2011 (T-II)]

- (a) Potential energy just before dropping
- (b) Kinetic Energy just on touching the ground
- (c) Velocity with which it hits the ground [Given  $g = 10 \text{ ms}^{-2}$ ]

**Ans.**  $m = 10 \text{ kg}$ ,  $h = 50 \text{ cm} = \frac{50}{100} \text{ m} = 0.5 \text{ m}$ ,  $g = 10 \text{ ms}^{-2}$

(a) Potential energy =  $mgh = 10 \text{ kg} \times 0.5 \text{ m} \times 10 \text{ ms}^{-2} = \mathbf{50 \text{ J}}$

(b)  $u = 0$ ,  $h = 0.5 \text{ m}$ ,  $g = 10 \text{ ms}^{-2}$

$$v^2 = u^2 + 2gh = 0^2 + 2 \times 10 \times 0.5 = 10 \text{ m}^2\text{s}^{-2}$$

$$\text{Required kinetic energy} = \frac{1}{2} mv^2 = \frac{1}{2} \times 10 \text{ kg} \times 10 \text{ m}^2\text{s}^{-2} = \mathbf{50 \text{ J}}$$

(c) It is calculated in (b), that

$$v^2 = 10 \text{ m}^2\text{s}^{-2} \Rightarrow v = \sqrt{10 \text{ m}^2 \text{ s}^{-2}}$$

$$\therefore v = 3.16 \text{ ms}^{-1}$$

Thus it hits the ground with a velocity of  $3.16 \text{ ms}^{-1}$ .

**Q.2.** (i) Define the term potential energy. Write the S.I unit of potential energy.

(ii) A body of mass  $50 \text{ kg}$  is situated at a height of  $10 \text{ m}$ . What is its potential energy? (Given,  $g = 10 \text{ ms}^{-2}$ ). **[2011 (T-II)]**

**Ans.** (i) The energy possessed by a body on account of its position or configuration, is called potential energy. Potential energy = mass  $\times$  acceleration due to gravity  $\times$  height.

(ii)  $m = 50 \text{ kg}$ ,  $h = 10 \text{ m}$ ,  $g = 10 \text{ ms}^{-2}$

$$\text{Potential energy} = mgh = 50 \text{ kg} \times 10 \text{ m} \times 10 \text{ ms}^{-2} = 5000 \text{ J.}$$

**Q.3.** (i) Define Power. Mention its S.I. unit.

(ii) A body of mass  $50 \text{ kg}$  runs up a staircase of  $40$  steps in  $8 \text{ s}$ . If the height of each step is  $15 \text{ cm}$ , find his power. (Given,  $g = 10 \text{ ms}^{-2}$ ) **[2011 (T-II)]**

**Ans.** (i) The rate at which energy is produced or utilised, is called power. If  $W$  is the workdone in

time  $t$ , such that  $P$  is the power, then,  $p = \frac{W}{t}$

Thus, it is a ratio of two scalar quantities, so it is a scalar quantity. SI unit of power is watt (W). When a work of one joule is done in one second, then the power is said to be one watt (W).

(ii) Mass =  $50 \text{ kg}$ , height,  $h = 40 \times 15 \text{ cm} = 600 \text{ cm} = \frac{600}{100} \text{ m} = 6 \text{ m}$ ,  $t = 8 \text{ s}$

$$\text{Work done, } W = mgh = 50 \text{ kg} \times 10 \text{ ms}^{-2} \times 6 \text{ m} = 3000 \text{ J}$$

$$\text{Power} = \frac{W}{t} = \frac{3000 \text{ J}}{8 \text{ s}} = 375 \text{ W}$$

**Q.4.** A light and heavy object have the same momentum, find out the ratio of their kinetic energies. Which one has a larger kinetic energy? **[2011 (T-II)]**

**Ans.** Consider  $m_1$  and  $m_2$  be the masses of light and heavy objects in which  $m_1 < m_2$  and  $v_1$  and  $v_2$  are the velocities of light and heavy objects. Then

$$m_1 v_1 = m_2 v_2, \text{ having same momentum.}$$

But,  $m_1 < m_2$  then,  $v_1 > v_2$

Thus, ratio of their kinetic energies are

$$\frac{1}{2} m_1 v_1^2 : \frac{1}{2} m_2 v_2^2 = \frac{1}{2} m_1 v_1 \times v_1 : \frac{1}{2} m_2 v_2 \times v_2 = v_1 : v_2 \quad (\because m_1 v_1 = m_2 v_2)$$

But,  $v_1 > v_2$ , so kinetic energy of light object has a larger value.

**Q.5.** (a) Define potential energy. Write an expression for potential energy of an object of mass  $m$  raised through a height  $h$ .

(b) Find the energy possessed by an object of mass  $10 \text{ kg}$  when it is raised to a height of six metre above the ground given  $g = 9.8 \text{ ms}^{-2}$ . **[2011 (T-II)]**

**Ans.** (a) Consider an object of mass  $m$  raised vertically upward through height  $h$  from the ground level against the force of gravity, such that acceleration due to gravity is  $g$ .

Now force acting on the object =  $mg$ .

Total work done in lifting the object = Force  $\times$  distance =  $mg \times h = mgh$

This amount of workdone is equal to energy spent, which is stored in the object in the form of potential energy.

Thus, potential energy = energy spent in lifting the object.

$$= \text{mass} \times \text{acceleration due to gravity} \times \text{height} = mgh.$$

(b)  $m = 10 \text{ kg}$ ,  $h = 6 \text{ m}$ ,  $g = 9.8 \text{ ms}^{-2}$

$$\begin{aligned} \text{Energy possessed by the object} &= \text{potential energy} = mgh = 10 \text{ kg} \times 9.8 \text{ ms}^{-2} \times 6 \text{ m} \\ &= 10 \text{ kg} \times 9.8 \text{ ms}^{-2} \times 6 \text{ m} = \mathbf{588 \text{ J}} \end{aligned}$$

**Q.6.** Define-Power. A boy of mass 45 kg climbs up 20 steps in 20 sec. If each step is 25 cm high, calculate the power of the boy used in climbing. (Take  $g = 10 \text{ m/s}^2$ ) [2011 (T-II)]

**Ans.** The rate of which energy is produced or utilised, is called power.

Power =  $\frac{\text{Work done}}{\text{Time}}$ . Its SI unit is watt (W).

$$m = 45 \text{ kg}, h = 20 \times 25 \text{ cm} = 500 \text{ cm} = 5 \text{ m}, g = 10 \text{ m/s}^2$$

$$\text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{mgh}{t} = \frac{45 \text{ kg} \times 10 \text{ m/s}^2 \times 5 \text{ m}}{20 \text{ s}} = \mathbf{112.50 \text{ W}}$$

**Q.7.** (a) When is work done by a force is negative?

(b) Two bodies have their masses  $\frac{m_1}{m_2} = 3$  and their kinetic energies  $\frac{E_1}{E_2} = \frac{1}{3}$ . What will be the ratio of their velocities? [2011 (T-II)]

**Ans.** (a) When a force acting on a body is opposite to the direction of displacement of the body, then the work done by that force is said to be negative. For example work done by the force of friction is negative, because it is always acting opposite to the direction of displacement.

(b)  $\frac{m_1}{m_2} = 3$ ,  $\frac{E_1}{E_2} = \frac{1}{3}$ ,  $\frac{v_1}{v_2} = ?$

$$\frac{E_1}{E_2} = \frac{\frac{1}{2} m_1 v_1^2}{\frac{1}{2} m_2 v_2^2} = \frac{1}{3} \Rightarrow \frac{m_1}{m_2} \cdot \frac{v_1^2}{v_2^2} = \frac{1}{3} \Rightarrow 3 \cdot \frac{v_1^2}{v_2^2} = \frac{1}{3} \Rightarrow \frac{v_1^2}{v_2^2} = \frac{1}{9} \quad \left( \because \frac{m_1}{m_2} = 3 \right)$$

$$\therefore \frac{v_1}{v_2} = \sqrt{\frac{1}{9}} = \frac{1}{3}$$

Thus, ratio of their velocities = **1 : 3**

**Q.8.** (a) Define one Watt.

(b) A lamp consumes 1000 J electrical energy in 10 s. What is its power? [2011 (T-II)]

**Ans.** (a) When a work done of one joule is done in one second, then the power is said to be one watt.  $1 \text{ W} = 1 \text{ J/s}$ .

(b) Power =  $\frac{\text{Energy consumed}}{\text{Time}} = \frac{1000 \text{ J}}{10 \text{ s}} = \mathbf{100 \text{ W}}$

**Q.9.** The kinetic energy of an object of mass  $m$  moving with a velocity of 5 m/s is 25 J. Calculate its kinetic energy when its velocity is doubled? What will be its kinetic energy when its velocity is increased three times? **[2011 (T-II)]**

**Ans.** Kinetic energy =  $\frac{1}{2} mv^2 \Rightarrow 25 \text{ J} = \frac{1}{2} m \times (5 \text{ m/s})^2 \Rightarrow m = \frac{25 \text{ J} \times 2}{25 \text{ m}^2/\text{s}^2} = 2 \text{ kg}$ .

Now, mass = 2 kg,  $v = 5 \text{ m/s}$

Then, kinetic energy =  $\frac{1}{2} mv^2 = \frac{1}{2} \times 2 \text{ kg} \times (5 \text{ m/s})^2 = 25 \text{ J}$

Again,  $m = 2 \text{ kg}$ , velocity =  $3 \times 5 \text{ m/s} = 15 \text{ m/s}$

Now, kinetic energy =  $\frac{1}{2} mv^2 = \frac{1}{2} \times 2 \text{ kg} \times (15 \text{ m/s})^2 = 225 \text{ J}$

**Q.10.** An object is made to fall from different heights 20 cm, 40 cm and 60 cm on a wet sand.

(a) What do you observe on the sand?

(b) Explain the reasons of the observations.

**[2011 (T-II)]**

**Ans.** (a) These objects create depressions in the wet sand. The largest depression is created by the object falling from largest height i.e. 60 cm and the smallest depression by the object falling from lowest height i.e., 20 cm.

(b) It is because on falling through a greater height, the object has more velocity and thus having more kinetic energy.

**Q.11.** Calculate the electricity bill amount for a month of April, if 4 bulbs of 40 W for 5 hrs, 4 tube lights of 60 W for 5 hrs, a T.V of 100 W for 6 hrs, a washing machine of 400 W for 3 hrs are used per day. The cost per unit is Rs 1.80. **[2011 (T-II)]**

**Ans.** The amount of consumed electricity per day

$$= 4 \times 40 \text{ W} \times 5 \text{ h} + 4 \times 60 \text{ W} \times 5 \text{ h} + 100 \text{ W} \times 6 \text{ h} + 400 \text{ W} \times 3 \text{ h}$$

$$= 800 \text{ Wh} + 1200 \text{ Wh} + 600 \text{ Wh} + 1200 \text{ Wh}$$

$$= 3800 \text{ Wh} = \frac{3800}{1000} \text{ kWh} = 3.8 \text{ kWh} = 3.8 \text{ Unit} \quad (\because 1 \text{ kWh} = 1 \text{ unit})$$

Thus, amount of consumed electricity in the month of April =  $30 \times 3.8 \text{ unit} = 114 \text{ unit}$

The electricity bill for the month of April =  $114 \text{ unit} \times \text{Rs } 1.80/\text{unit} = \text{Rs. } 205.20$

**Q.12.** A 5 kg ball is thrown upwards with a speed of 10 m/s. (take  $g = 10 \text{ m/s}^2$ )

(a) Calculate the maximum height attained by it.

(b) Find the potential energy when it reaches the highest point.

**[2011 (T-II)]**

**Ans.**  $m = 5 \text{ kg}$ ,  $u = 10 \text{ m/s}$ ,  $g = 10 \text{ m/s}^2$ ,  $v = 0$

(a)  $v^2 = u^2 - 2gh$  (For upward motion,  $g$  is negative)

$$\Rightarrow 0^2 = 10^2 - 2 \times 10 \times h \Rightarrow h = \frac{100}{20} = 5 \text{ m}$$

Thus, maximum height = 5 m.

(b) At highest point,

$$\text{potential energy} = mgh = 5 \text{ kg} \times 10 \text{ m/s}^2 \times 5 \text{ m} = 250 \text{ J}$$

**Q.13.** Calculate the potential energy of an object of mass 50 kg raised to a height of 4 m above the ground. If the object falls down, what is the kinetic energy when it has fallen through 2 m? Take  $g = 9.8 \text{ m/s}^2$ . **[2011 (T-II)]**

**Ans.**  $m = 50 \text{ kg}$ ,  $h = 4 \text{ m}$ ,  $g = 9.8 \text{ m/s}^2$

Potential energy =  $mgh = 50 \text{ kg} \times 9.8 \text{ m/s}^2 \times 4 \text{ m} = \mathbf{1960 \text{ J}}$

Again,  $m = 50 \text{ kg}$ ,  $h = 4 \text{ m} - 2 \text{ m} = 2 \text{ m}$ ,  $g = 9.8 \text{ m/s}^2$ ,  $u = 0$ ,

$v^2 = u^2 + 2gh$  (For downward motion,  $g$  is positive)

$\Rightarrow v^2 = 0^2 + 2 \times 9.8 \times 2 = 39.2 \text{ m}^2/\text{s}^2$

Thus, required kinetic energy =  $\frac{1}{2} mv^2 = \frac{1}{2} \times 50 \text{ kg} \times 39.2 \text{ m}^2/\text{s}^2 = \mathbf{980 \text{ J}}$

**Q.14.** (a) Name the form of energy associate in each case.

- (i) A flying bird. (ii) A man climbing the stairs  
(iii) A compressed watch spring (iv) A fast moving object. **[2011 (T-II)]**

(b) What is the commercial unit of energy? And state its relation with SI unit of energy.

**Ans.** (a) (i) Kinetic energy (ii) Potential energy  
(iii) Potential energy (iv) Kinetic energy  
(b) The commercial unit of energy is kilowatt-hour (kWh).  
 $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$

**Q.15.** (a) Name the energy transformations taking place in the following devices :-

- (i) a motor (ii) a car engine  
(iii) a radio (iv) a nuclear reactor. **[2011 (T-II)]**

(b) How much the work is done, when earth moves around the sun in its orbit?

**Ans.** (a) (i) Electrical energy is converted into mechanical energy.  
(ii) Chemical energy is converted into heat and mechanical energies.  
(iii) Electrical energy is converted into sound energy.  
(iv) Nuclear energy is converted into electrical energy.  
(b) When earth moves around the Sun in its orbit, the centripetal force acts towards the centre, i.e., at right angles to the direction of displacement.  
Thus, work done = zero.

**Q.16.** Four persons jointly lift a 350 kg box to a height of 1 m and hold it.

- (a) Calculate the work done by the persons in lifting the box.  
(b) How much work do they do in just holding it?  
(c) Why do they get tired while holding it?  
( $g = 10 \text{ ms}^{-2}$ ) **[2011 (T-II)]**

**Ans.**  $m = 350 \text{ kg}$ ,  $h = 1 \text{ m}$ ,  $g = 10 \text{ ms}^{-2}$

- (a) Work done =  $mgh = 350 \text{ kg} \times 1 \text{ m} \times 10 \text{ ms}^{-2} = \mathbf{3500 \text{ J}}$   
(b) The acting forces causes no displacement, so work done is zero.  
(c) In case of holding mass, their muscles are stretched, their blood is displaced to the straining muscles and it is in making these displacements that energy is lost. It is because of this loss of energy that they feel tired.

**Q.17.** (a) A ball of mass 0.5 kg slows down from a speed of 5 m/s to that of 3 m/s, calculate the change in kinetic energy of the ball.

- (b) Which would have greater effect on the kinetic energy of an object-doubling the mass or doubling the velocity? **[2011 (T-II)]**

**Ans.** (a)  $m = 0.5 \text{ kg}$ ,  $v_1 = 5 \text{ m/s}$ ,  $v_2 = 3 \text{ m/s}$

The change in kinetic energy =  $\frac{1}{2} m (v_1^2 - v_2^2) = \frac{1}{2} \times 0.5 (5^2 - 3^2) = \frac{1}{2} \times 0.5 \times 16 = \mathbf{4 \text{ J}}$

(b) Kinetic energy =  $\frac{1}{2} mv^2$

When mass is doubled, then new kinetic energy =  $\frac{1}{2} \times 2 mv^2 = 2 \times \frac{1}{2} mv^2$

When velocity is doubled, then effective kinetic energy =  $\frac{1}{2} m \times (2v)^2 = 4 \times \frac{1}{2} mv^2$

Thus, doubling the velocity would have greater effect on kinetic energy.

- Q.18.** (a) The potential energy of a freely falling object decreases progressively. Does this violate the law of conservation of energy? Why?  
 (b) An object is dropped from a height  $h$ . When is its  
 (i) potential energy maximum  
 (ii) kinetic energy maximum [2011 (T-II)]

- Ans.** (a) It does not violate the law of conservation of energy, because sum of potential energy and kinetic energy remains always the same.  
 (b) (i) At height  $h$  potential energy is maximum.  
 (ii) At the surface of ground the kinetic energy is maximum due to maximum velocity.

#### Other Important Questions

- Q.1.** Derive an expression for kinetic energy of a body moving with a uniform velocity ' $v$ ' and having a mass ' $m$ '.

- Ans.** Let there be a body of mass ' $m$ ' moving with a uniform velocity  $v$ . If the body be acted upon by a constant retardation, such that it comes to rest after covering a distance ' $s$ '.  
 In such a situation, the work done by the retarding force is equal to the kinetic energy of the body. Now, we know :

$$v^2 - u^2 = 2as \Rightarrow (0)^2 - (v)^2 = 2as \Rightarrow a = -\frac{v^2}{2s}$$

$$\therefore \text{Retardation} = - (a) = -\left(-\frac{v^2}{2s}\right) = \frac{v^2}{2s}$$

$$\therefore \text{Retarding force} = \text{Mass} \times \text{Retardation} = \frac{mv^2}{2s}$$

$$\therefore \text{Work done by retarding force} = \frac{mv^2}{2s} \times s = \frac{mv^2}{2}$$

$$\text{But work done by retarding force} = \text{K.E.} = \frac{mv^2}{2} = \frac{1}{2} mv^2$$

- Q.2.** Two bodies A and B of masses 4 kg and 16 kg respectively have the same kinetic energy. Calculate the ratio of their velocities.

**Ans.** For body A,  $K_A = \frac{1}{2} m_A v_A^2 = \frac{1}{2} \times 4 \times v_A^2 = 2 v_A^2$

For body B,  $K_B = \frac{1}{2} m_B v_B^2 = \frac{1}{2} \times 16 \times v_B^2 = 8 v_B^2$

But,  $K_A = K_B$  (Given)

$$\Rightarrow 2v_A^2 = 8v_B^2 \Rightarrow \frac{v_A^2}{v_B^2} = \frac{8}{2} = \frac{4}{1} \Rightarrow \frac{v_A}{v_B} = \frac{2}{1} \Rightarrow v_A : v_B = 2 : 1$$

**Q.3.** A motor pump of power 400 W operates for 2 minutes and 40 seconds and in doing so raises 200 kg of water to the top of a building. If  $g = 10 \text{ ms}^{-2}$ , calculate the height of the building.

**Ans.**  $p = 400 \text{ W}$ ,  $t = 2 \text{ min. and } 40 \text{ s} = 160 \text{ seconds}$ .

$$W = pt = 400 \times 160 = 64000 \text{ J}$$

$$m = 200 \text{ kg}, \quad g = 10 \text{ m/s}^2, \quad h = ?$$

$$W = mgh \Rightarrow h = \frac{W}{mg} = \frac{64000}{200 \times 10} = 32 \text{ m.}$$

**Q.4.** A truck and a car are running at the same speed. If the mass of the truck is 10 times that of the car, calculate the ratio of the kinetic energy of the truck with respect to the car.

**Ans.** Let mass of car =  $m$ ;  $\therefore$  mass of truck =  $10m$

Let speed of truck and car be  $v$

$$\therefore \text{K.E. of car} = \frac{1}{2} mv^2$$

$$\text{K.E. of truck} = \frac{1}{2} \times 10mv^2$$

$$\therefore \text{K.E. of car} : \text{K.E. of truck} = \frac{1}{2} mv^2 : \frac{1}{2} \times 10mv^2 = 1 : 10$$

**Q.5.** A mass of 10 kg is dropped from a height of 50 cm. Find : (a) kinetic energy, and (b) velocity, just as it reaches the ground. Does the velocity depend on the mass of the particle? Explain.

**Ans.**  $m = 10 \text{ kg}$ ,  $h = 50 \text{ cm} = \frac{50}{100} \text{ m} = 0.5 \text{ m}$ ,  $u = 0$ ,  $g = 10 \text{ m/s}^2$

$$v^2 = u^2 + 2gh = 0^2 + 2 \times 10 \times 0.5 \Rightarrow v^2 = 10$$

$$\text{(a) Kinetic energy, } K = \frac{1}{2} mv^2 = \frac{1}{2} \times 10 \times 10 = 50 \text{ J.}$$

$$\text{(b) } v^2 = 10 \Rightarrow v = \sqrt{10} = 3.16 \text{ m/s}$$

**Q.6.** Write the energy change taking place when the heat of the sun evaporates water, till it starts raining.

**Ans.** Heat energy of sun  $\Rightarrow$  K.E. of water molecules [On absorbing heat energy of sun]

K.E. of water molecules  $\Rightarrow$  P.E. of water vapour [This leads to the formation of clouds]

P.E. of clouds  $\Rightarrow$  K.E. of rain water

**Q.7.** A force applied on a body of mass 4 kg for 5 second changes its velocity from  $10 \text{ ms}^{-1}$  to  $20 \text{ ms}^{-1}$ . Find the power required.

**Ans.**  $m = 4 \text{ kg}$ ,  $t = 5 \text{ s}$ ,  $u = 10 \text{ ms}^{-1}$ ,  $v = 20 \text{ ms}^{-1}$

$$\text{Work done} = \text{Change in K.E.} = \frac{1}{2} mv^2 - \frac{1}{2} mu^2 = \frac{1}{2} \times 4 \times 20^2 - \frac{1}{2} \times 4 \times 10^2 = 800 - 200 = 600 \text{ J}$$

$$\text{Power} = \frac{W}{t} = \frac{600 \text{ J}}{5 \text{ s}} = 120 \text{ W}$$

**Q.8.** (a) Define kinetic energy.

(b) A stone of mass 2 kg is falling from rest from the top of a steep hill. What will be its kinetic energy after 5s? ( $g = 10 \text{ ms}^{-2}$ )

**Ans.** (a) The energy possessed by an object on account of its motion is known as kinetic energy of that object.

(b) Initial velocity ( $u$ ) = 0; Final velocity ( $v$ ) = ?;  $v = 0 + 10 \times 5 = 50 \text{ ms}^{-1}$  ( $\because v = u + gt$ )

$$\therefore \text{K.E.} = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times 50 \times 50 \text{ J.} = \mathbf{2500 \text{ J.}}$$

**Q.9.** A child is pulling a toy car along a horizontal surface :

(a) Name the forces acting on the toy car.

(b) Which of these forces perform positive work?

(c) Which of these forces perform negative work? Justify your answer.

**Ans.** (a) Force of friction and applied force.

(b) **Applied force.** Applied force causes a displacement in its own direction, and hence, work done by the applied force is positive.

(c) **Force of friction.** Force of friction acts in the opposite direction of the applied force, i.e., opposite to the direction of displacement. Thus, work done by the force of friction is negative.

**Q.10.** What is meant by term power? A boy pulls a bucket of water of mass 10 kg from a 5 m deep well in 10 seconds. Calculate the power developed by the boy. ( $g = 10 \text{ ms}^{-2}$ ).

**Ans.** The rate of doing work is called power.

Mass of water ( $m$ ) = 10 kg; Displacement ( $D$ ) = 5 m

$\therefore$  Force exerted by the boy ( $F$ ) =  $mg = 10 \times 10 = 100 \text{ N}$ .

$\therefore$  Work done by the boy ( $W$ ) =  $F \times D = 100 \times 5 = 500 \text{ J}$

$\therefore$  time for doing work ( $t$ ) = 10 s

$$\therefore \text{Power of the boy } (p) = \frac{W}{t} = \frac{500 \text{ J}}{10 \text{ s}} = \mathbf{50 \text{ W.}}$$

**Q.11.** (a) The potential energy of a freely falling object decreases progressively. What happens to its (i) kinetic energy (ii) total mechanical energy? State the law on which your answer is based.

(b) A household consumes 1 kWh of energy per day.

How much energy is this in joule?

**Ans.** (a) (i) Its kinetic energy increases due to gain in velocity.

(ii) Total mechanical energy remain constant.

Answer is based on the law of conservation of energy.

**It states :** The energy in a system can neither be created nor be destroyed. It may be transformed from one form to another form, but total energy of the system remains constant.

(b)  $1 \text{ kWh} = 3.6 \text{ MJ.} = \mathbf{3.6 \times 10^6 \text{ J.}}$

**Q.12.** A body of 5 kg initially at rest is subjected to a force of 20 N. Calculate the kinetic energy acquired by the body at the end of 10 seconds.

**Ans.** K.E. = ?; Force ( $F$ ) = 20 N; Mass of the body ( $m$ ) = 5 kg.; Time ( $t$ ) = 10 s;

Initial velocity ( $u$ ) = 0; Final velocity ( $v$ ) = ?

Applying,  $v = u + gt = 0 + 10 \times 10 = 100 \text{ ms}^{-1}$

$\therefore$  At the end of 10 second, K.E. =  $\frac{1}{2} mv^2 = \frac{1}{2} \times 5 \times 100 \times 100 = \mathbf{25,000 \text{ J}}$ .

**Q.13.** (a) State and define SI unit of power.

(b) A person carrying 10 bricks each of mass 2.5 kg. on his head moves to a height 20 metres in 50 seconds. Calculate power spent in carrying bricks of the person. ( $g = 10 \text{ m/s}^2$ )

**Ans.** (a) SI unit of power is watt (W).

Amount of work done by 1 J of energy in 1 second is called 1 watt.

(b) Total mass ( $m$ ) =  $10 \times 2.5 \text{ kg} = 25 \text{ kg}$ .

Displacement = 20 metres; Time ( $t$ ) = 50 s.; ( $g$ ) =  $10 \text{ ms}^{-2}$

Force exerted by person =  $mg = 25 \text{ kg} \times 10 \text{ ms}^{-2} = \mathbf{250 \text{ N}}$ .

Work done = force  $\times$  displacement =  $250 \text{ N} \times 20 \text{ m} = 5000 \text{ J}$

$\therefore$  Power =  $\frac{\text{Work done}}{\text{Time}} = \frac{5000 \text{ J}}{50 \text{ s}} = \mathbf{100 \text{ W}}$ .

**Q.14.** When an object is made to fall from a height, its kinetic energy is maximum just before it touches the ground. Does it justify the law of conservation of energy. If yes! how? If No, why not?

**Ans.** Yes, when an object falls from a height, its kinetic energy increases as its speed increases but its potential energy decreases in the same way. But total energy (K.E. + P.E.) remain same. When K.E. increases, P.E. decreases and vice-versa.

**Q.15.** Two women Shanti and Kamla each of mass 50 kg and 60 kg respectively climb up through a height of 10 m. Shanti takes 20 s while Kamla takes 40 s to reach. Calculate the difference in the power expended by Shanti and Kamla. (Assuming  $g = 10 \text{ ms}^{-2}$ )

**Ans.** Force exerted by Shanti =  $50 \text{ kg} \times 10 \text{ ms}^{-2} = 500 \text{ N}$

$\therefore$  Work done by Shanti =  $500 \text{ N} \times 10 \text{ m} = 5000 \text{ J}$

$\therefore$  Power expended by Shanti =  $\frac{5000 \text{ J}}{20 \text{ s}} = \mathbf{250 \text{ W}}$ .

Force exerted by Kamla =  $60 \text{ kg} \times 10 \text{ ms}^{-2} = 600 \text{ N}$

$\therefore$  Work done by Kamla =  $600 \text{ N} \times 10 \text{ m} = 6000 \text{ J}$

$\therefore$  Power expended by Kamla =  $\frac{6000 \text{ J}}{40 \text{ s}} = \mathbf{150 \text{ W}}$ .

Difference in the power expended by Shanti and Kamla =  $250 \text{ W} - 150 \text{ W} = \mathbf{100 \text{ W}}$ .

**Q.16.** (a) Define work and write its SI unit.

(b) State three conditions for which mechanical work is zero?

**Ans.** (a) See Pts 1 and 5 (concepts)

(b) (i) Work is not done when the displacement does not take place in the direction of applied force.

(ii) Work is not done when force is applied but no displacement takes place.

(iii) Work is not done as no force is applied and no displacement takes place.

**Q.17.** (a) Define SI unit of energy. How it is related to kilowatt-hour?

(b) Find the cost of using three bulbs each of 60 watt in 30 days if each bulb is used five hours daily, rate per unit is given as Rs. 3/-.

**Ans.** (a) Joule is the SI unit of energy

When a force of 1 N causes a displacement of 1 m, in its own direction, the work done or energy is said to be one joule.

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

- (b) Power of three bulbs =  $60 \text{ W} \times 3 = 180 \text{ W} = 0.18 \text{ kW}$ ; Time = 5 hours  
 $\therefore$  Energy consumed in 5 hours daily =  $0.18 \text{ kW} \times 5 \text{ h} = 0.9 \text{ kWh}$ .  
 $\therefore$  Energy consumed in 30 days =  $0.9 \text{ kWh} \times 30 = 27 \text{ kWh} = 27 \text{ unit}$   
 $\therefore$  Cost of energy consumed =  $27 \text{ unit} \times \text{Rs } 3 \text{ per unit} = \text{Rs. } 81$

**Q.18.** A man weighing 75 kg climbs upto a vertical height of 15 m in 150 s, while a boy weighing 40 kg climbs upto the same height in 120 s.

- (a) Calculate the ratio of their powers.  
 (b) Who has gained more energy and why? ( $g = 10 \text{ m/s}^2$ )

**Ans.** (a) Force exerted by man =  $75 \text{ kg} \times 10 \text{ ms}^{-2} = 750 \text{ N}$   
 Work done by man =  $750 \text{ N} \times 15 \text{ m} = 11250 \text{ J}$

$$\text{Power exerted by man} = \frac{11250 \text{ J}}{150 \text{ s}} = 75 \text{ W.}$$

Force exerted by boy =  $40 \text{ kg} \times 10 \text{ ms}^{-2} = 400 \text{ N}$   
 Work done by boy =  $400 \text{ N} \times 15 \text{ m} = 6000 \text{ J}$ .

$$\text{Power exerted by boy} = \frac{6000 \text{ J}}{120 \text{ s}} = 50 \text{ W.}$$

$$\frac{\text{Power of man}}{\text{Power of boy}} = \frac{75 \text{ W}}{50 \text{ W}} = \frac{3}{2} \text{ or Power of man : Power of boy} = 3 : 2$$

- (b) Man has gained more energy due to its more weight.

#### D. Long Answer Questions

(5 Marks)

##### Previous Years' Questions

- Q.1.** (i) State the law of conservation of energy.  
 (ii) Define mechanical energy.  
 (iii) Calculate the energy in kWh consumed in 10 hours by four devices of power 500 W each. **[2011 (T-II)]**

**Ans.** (i) Law of conservation of energy : The energy in a system can neither be created nor destroyed. It may be transformed from one form to another, but total energy of the system remains constant.

- (ii) The energy possessed by a body due to a displacement caused in it by the application of a force, is called mechanical energy.

(iii) Energy = Power  $\times$  Time =  $4 \times 500 \text{ W} \times 10 \text{ h} = \frac{4 \times 500 \times 10}{1000} \text{ kWh} = 20 \text{ kWh}$ .

- Q.2.** (a) Give the mathematical relation between power, force and velocity.  
 (b) Can a body have energy, without having momentum? If yes, why?  
 (c) A car of mass 2000 kg is lifted upto a distance of 30 m by a crane in 1 minute. A second crane does the same job in a 2 minutes. What is the power applied by each crane? Do the cranes consume the same or different amount of fuel? **[2011 (T-II)]**

**Ans.** (a) Power = Force  $\times$  Velocity

- (b) Yes, a body can have energy without having momentum when a stone lying on a roof a building then its momentum is zero but energy is stored in the form of potential energy in the stone.
- (c) In case of Ist crane,

$$\text{Power} = \frac{mgh}{t} = \frac{2000 \text{ kg} \times 10 \text{ m/s}^2 \times 30 \text{ m}}{60 \text{ s}} = 10,000 \text{ W} = \mathbf{10 \text{ kW}}.$$

In case of IInd crane,

$$\text{Power} = \frac{mgh}{t} = \frac{2000 \text{ kg} \times 10 \text{ m/s}^2 \times 30 \text{ m}}{120 \text{ s}} = 5,000 \text{ W} = \mathbf{5 \text{ kW}}.$$

The cranes consume different amount of fuels due to unequal time taken for doing the same job.

**Q.3.** (a) Define work. State two factors on which the magnitude of work depends.

- (b) A car and a truck have the same speed of 30 m/s. If their masses are in the ratio 1 : 3; find the ratio of kinetic energy. [2011 (T-II)]

**Ans.** (a) Work is said to be done only when the point of application of force moves in the direction of the applied force.

Mathematically, work = Force  $\times$  Displacement.

Two factors on which work depends :

- (i) Magnitude of applied force
  - (ii) Displacement in the direction of force.
- (b) Consider the masses of car and truck are  $m$  and  $3m$ . Then

$$\text{Kinetic energy of the car} = \frac{1}{2} mv^2 = \frac{1}{2} m \times (30)^2 = 450 m.$$

$$\text{Kinetic energy of the truck} = \frac{1}{2} mv^2 = \frac{1}{2} \times 3m \times (30)^2 = 1350 m.$$

The ratio of their kinetic energies =  $450 m : 1350 m = 1 : 3$

**Q.4.** What do you mean by work? Give an example of negative work done. What is the work to be done to increase the velocity of a car from 18 km/hr to 90 km/hr if the mass of the car is 2000 kg?

[2011 (T-II)]

**Ans.** Work is said to be done only when the point of application of force moves in the direction of the applied force.

Mathematically, work = Force  $\times$  Displacement. It is a scalar quantity and its SI unit is joule (J).

Work done by the force of friction is negative, because this force is acting opposite to the direction of displacement.

$$u = 18 \text{ km/h} = 18 \times \frac{5}{18} \text{ m/s} = 5 \text{ m/s}, v = 90 \text{ km/h} = 90 \times \frac{5}{18} \text{ m/s} = 25 \text{ m/s}; m = 2000 \text{ kg}.$$

$$\text{Here, work done} = \text{change in kinetic energy of the car} = \frac{1}{2} mv^2 - \frac{1}{2} mu^2 = \frac{1}{2} m (v^2 - u^2)$$

$$= \frac{1}{2} \times 2000 \text{ kg} (25^2 - 5^2) \text{ m}^2/\text{s}^2 = 1000 \text{ kg} \times 600 \text{ m}^2/\text{s}^2 = 600000 \text{ J} = \mathbf{600 \text{ kJ}}$$

- Q.5.** (a) A body of mass 15 kg possesses kinetic energy of 18.75 kJ. Find the velocity.  
 (b) An electric bulb of 100 W is used for 4 hrs a day. Calculate the energy consumed by it in a day in Joules and kilowatt hour unit. [2011 (T-II)]

**Ans.** (a)  $m = 15 \text{ kg}$ ,  $\text{K.E.} = 18.75 \text{ kJ} = 18.75 \times 1000 \text{ J} = 18,750 \text{ J}$

$$\text{K.E.} = \frac{1}{2} mv^2 \Rightarrow v^2 = \frac{2 \text{ K.E.}}{m}$$

$$\therefore v = \sqrt{\frac{2 \text{ K.E.}}{m}} = \sqrt{\frac{2 \times 18750 \text{ J}}{15 \text{ kg}}} = \sqrt{2500} \text{ m/s} = \mathbf{50 \text{ m/s}}$$

(b)  $p = 100 \text{ W}$ ,  $t = 4 \text{ h}$ ,

$$\text{Thus, energy consumed} = p t = 100 \text{ W} \times 4 \text{ h} = \frac{400}{1000} \text{ kWh} = \mathbf{0.4 \text{ kWh}}$$

Now,  $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$

$$\Rightarrow 0.4 \text{ kWh} = 0.4 \times 3.6 \times 10^6 \text{ J} = \mathbf{1.44 \times 10^6 \text{ J}}$$

- Q.6.** An object of mass 10 kg is made to fall freely from a height of 10 m. Complete the table :

[2011 (T-II)]

Height of object (m)	PE (J)	KE (J)	Mechanical Energy (J)
10			
8			
5			
Just above ground			

Hence state the law of conservation of energy.

**Ans.** (a)  $m = 10 \text{ kg}$ ,  $h = 10 \text{ m}$ ,  $g = 10 \text{ m/s}^2$

At height of 10 m,

$$\text{PE} = mgh = 10 \text{ kg} \times 10 \text{ m/s}^2 \times 10 \text{ m} = 1000 \text{ J}$$

$$\text{KE} = \frac{1}{2} mv^2 = \frac{1}{2} \times 10 \text{ kg} \times 0 = 0 \quad (\because v = 0)$$

$$\text{Mechanical energy} = \text{PE} + \text{KE} = 1000 \text{ J} + 0 = 1000 \text{ J}$$

At height of 8 m

$$\text{PE} = mgh = 10 \text{ kg} \times 10 \text{ m/s}^2 \times 8 \text{ m} = 800 \text{ J}$$

Now,  $h' = 10 \text{ m} - 8 \text{ m} = 2 \text{ m}$  (In case of downward motion)

$$v^2 = u^2 + 2gh' = 0^2 + 2 \times 10 \times 2 = 40 \text{ m}^2/\text{s}^2$$

$$\text{KE} = \frac{1}{2} mv^2 = \frac{1}{2} \times 10 \text{ kg} \times 40 \text{ m}^2/\text{s}^2 = 200 \text{ J}$$

$$\text{Mechanical energy} = \text{PE} + \text{KE} = 800 \text{ J} + 200 \text{ J} = 1000 \text{ J}$$

At height of 5 m,

$$\text{PE} = mgh = 10 \text{ kg} \times 10 \text{ m/s}^2 \times 5 \text{ m} = 500 \text{ J}$$

$$h'' = 10 \text{ m} - 5 \text{ m} = 5 \text{ m}$$

$$v^2 = u^2 + 2gh = 0^2 + 2 \times 10 \times 5 = 100 \text{ m}^2/\text{s}^2$$

$$\text{KE} = \frac{1}{2} mv^2 = \frac{1}{2} \times 10 \text{ kg} \times 100 \text{ m}^2/\text{s}^2 = 500 \text{ J}$$

$$\text{Mechanical energy} = \text{PE} + \text{KE} = 500 \text{ J} + 500 \text{ J} = 1000 \text{ J}$$

For just above the ground,  $h = 0$

$$\text{So, PE} = mg \times h = mg \times 0 = 0$$

Now,  $u = 0$ ,  $h = 10 \text{ m}$ ,  $g = 10 \text{ m/s}^2$

$$v^2 = u^2 + 2gh = 0^2 + 2 \times 10 \times 10 = 200 \text{ m}^2/\text{s}^2$$

$$\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 10 \times 200 = 1000 \text{ J}$$

$$\text{Mechanical energy} = \text{PE} + \text{KE} = 0 \text{ J} + 1000 \text{ J} = 1000 \text{ J}$$

Height of object (m)	PE (J)	KE (J)	Mechanical Energy (J)
10	1000	0	1000
8	800	200	1000
5	500	500	1000
Just above ground	0	1000	1000

Thus sum of energy of this system is constant. It can neither be created nor destroyed. It can only change its form. Which is the law of conservation of energy.

- Q.7.** (a) When 1 Joule of work is said to be done?  
 (b) The kinetic energy of an object of mass  $m$  moving with a velocity of 5 m/s is 25 J. What will be its kinetic energy if its velocity is doubled?  
 (c) An electric oven is rated 2500 W. How many units of electrical energy does it use in 4 hours? **[2011 (T-II)]**

**Ans.** (a) When a force of 1 newton causes a displacement of 1 m in its own direction, the work done is said to be one joule.

(b)  $v = 5 \text{ m/s}$ ,  $\text{KE} = 25 \text{ J}$

$$\text{KE} = \frac{1}{2}mv^2 \Rightarrow m = \frac{2\text{KE}}{v^2} = \frac{2 \times 25 \text{ J}}{(5 \text{ m/s})^2} = 2 \text{ kg}$$

Now, velocity =  $2 \times 5 \text{ m/s} = 10 \text{ m/s}$ ,

$$\text{Then new KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \text{ kg} \times (10 \text{ m/s})^2 = \mathbf{100 \text{ J}}$$

(c)  $p = 2500 \text{ W}$ ,  $t = 4 \text{ h}$

$$\text{Energy consumed} = p t = 2500 \text{ W} \times 4 \text{ h} = \frac{10000}{1000} \text{ kWh} = 10 \text{ kWh} = \mathbf{10 \text{ units}}$$

( $\because 1 \text{ kWh} = 1 \text{ unit}$ )

### Other Important Questions

- Q.1.** (i) About how many kg of boiled potatoes would you have to eat to supply energy for half hour of swimming. Assume that your body utilises only 20% of the energy stored in potatoes. Energy content of potatoes is  $3.7 \times 10^6 \text{ J/kg}$  and the energy used in swimming is 25.6 kJ/minute. (ii) A rocket of  $3 \times 10^6 \text{ kg}$  mass takes off from a launching pad and acquires a vertical velocity of  $1 \text{ km/s}^{-1}$  at an altitude of 25 km. Calculate (a) Potential energy (b) Kinetic energy. [Take the value of  $g = 10 \text{ ms}^{-2}$ ]

**Ans.** (i) Energy used in  $\frac{1}{2}$  hour (30 minutes) of swimming =  $25.6 \times 30 \text{ kJ} = 768 \text{ kJ} = 768 \times 10^3 \text{ J}$

The amount of potatoes needed for the required energy

$$= \frac{768 \times 10^3}{3.7 \times 10^6} \text{ kg} \times \frac{100}{20} = \mathbf{1.037 \text{ kg}}$$

(ii)  $m = 3 \times 10^6 \text{ kg}$ ,  $v = 1 \text{ km/s} = 1000 \text{ m/s}$   
 $h = 25 \text{ km} = 25 \times 1000 \text{ m}$ ,  $g = 10 \text{ m/s}^2$

(a) P.E. =  $mgh = 3 \times 10^6 \times 10 \times 25 \times 1000 = 75 \times 10^{10} \text{ J} = \mathbf{7.5 \times 10^{11} \text{ J}}$

(b) K.E. =  $\frac{1}{2} mv^2 = \frac{1}{2} \times 3 \times 10^6 \times (1000)^2 = \mathbf{1.5 \times 10^{12} \text{ J}}$

**Q.2.** (i) Distinguish between work, energy and power. State the SI units for each of these quantities.

(ii) A dog of mass 16 kg is running at a constant speed of  $12 \text{ ms}^{-1}$ . Calculate the kinetic energy of the dog.

**Ans.** (i) **Work :** When a force acting on a body causes displacement in the direction of force, work is said to be done.

$$\text{Workdone} = \text{Force} \times \text{displacement}$$

Work is scalar quantity and its unit in SI system is joule (J).

**Energy :** Energy of a body is defined as its ability of doing work. The amount of work done by a body is the measure of its energy. The unit of energy in SI system is joule (J). Energy is a scalar quantity.

**Power :** Power is defined as the rate of doing work.

$$\text{Thus, power} = \frac{\text{Work done}}{\text{Time taken}} \Rightarrow p = \frac{W}{t}$$

Power is a scalar quantity. Its unit in SI system is watt.

(ii)  $m = 16 \text{ kg}$ ,  $v = 12 \text{ m/s}$

$$\text{K.E.} = \frac{1}{2} mv^2 = \frac{1}{2} \times 16 \times (12)^2 = 8 \times 144 = \mathbf{1152 \text{ J}}$$

**Q.3.** (i) A body has a mass  $m$  and velocity  $v$ . If the mass is increased four times and velocity is decreased two times, calculate the ratio of the kinetic energies in the above cases.

(ii) Why does a truck moving at  $18 \text{ kmh}^{-1}$  cause far more serious accident than a cycle moving at the same speed ?

(iii) What kind of energy transformation takes place when a sparkle is lighted?

**Ans.** (i) Initially, kinetic energy,  $K_1 = \frac{1}{2} mv^2$  ... (i)

Now mass is increased four times, *i.e.*,  $4m$  and velocity is decreased two times, *i.e.*,  $\frac{v}{2}$

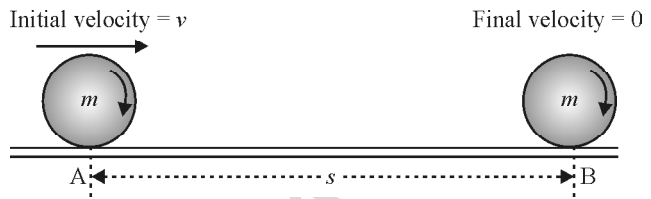
$$\text{Then, kinetic energy, } K_2 = \frac{1}{2} \times 4m \times \left(\frac{v}{2}\right)^2 = 2m \times \frac{v^2}{4} = \frac{1}{2} mv^2$$

$$\text{Thus, } K_1 : K_2 = \frac{1}{2} mv^2 : \frac{1}{2} mv^2 = 1 : 1$$

- (ii) We know that mass of a truck is greater than the mass of a cycle. Thus having same velocity, kinetic energy of the truck is greater than that of the cycle. So, the truck moving at 18 km/h cause far more serious accident than a cycle moving at the same speed.
- (iii) When a sparkle is lighted, then chemical energy is converted into heat and light energy.

- Q.4.** (a) Derive the formula of kinetic energy of an object of mass ' $m$ ' moving with a uniform velocity ' $v$ '.
- (b) A force acting on a 20 kg mass changes its velocity from  $5 \text{ ms}^{-1}$  to  $2 \text{ ms}^{-1}$ . Calculate the work done by the force.

- Ans.** (a) Consider a body of mass  $m$  at A, such that its initial velocity is  $v$ . Let the body roll on the floor, such that it **stops** after covering a distance  $s$ .



As the body stops, there must be some retarding force acting on the body. If we could calculate the retarding force and then multiply it with the distance covered by the body, we get the measure of work done in stopping the body. This measure of work will be numerically equal to the kinetic energy of the body at A.

Applying,  $(v)^2 - (u)^2 = 2as \Rightarrow (0)^2 - (v)^2 = 2as$  (Final velocity is zero)

$$\text{or } a = -\frac{v^2}{2s}$$

$$\therefore \text{Retardation of the body} = -(a) = -\left(\frac{-v^2}{2s}\right) = \frac{v^2}{2s}$$

$$\therefore \text{Retarding force acting on the body} = \text{Mass} \times \text{Retardation} = m \times \frac{v^2}{2s}$$

$$\therefore \text{Work done by the retarding force in stopping the body} = \text{Retarding force} \times \text{Distance}$$

$$= \frac{mv^2}{2s} \times s = \frac{mv^2}{2}$$

But, work done by the retarding force in stopping the body = kinetic energy of the body at A.

$$\therefore \text{Kinetic energy of the body} = \frac{mv^2}{2} \text{ or } \mathbf{K.E.} = \frac{1}{2}mv^2.$$

(b) Work done by the force when velocity is  $5 \text{ ms}^{-1} = \frac{1}{2}mv^2 = \frac{1}{2} \times 20 \text{ kg} \times (5 \text{ ms}^{-1})^2 = 250 \text{ J}$

Work done by the force when velocity is  $2 \text{ ms}^{-1} = \frac{1}{2}mv^2 = \frac{1}{2} \times 20 \text{ kg} \times (2 \text{ ms}^{-1})^2 = 40 \text{ J}$

$$\therefore \text{Resultant work done by the force} = 250 \text{ J} - 40 \text{ J} = \mathbf{210 \text{ J}}$$

- Q.5.** (a) State the law of conservation of energy.
- (b) Illustrate the law of conservation of energy by discussing the energy changes which occur when we draw a pendulum bob to one side and allow it to oscillate.

(c) Why does a saw become warm when it is used to cut a log of wood?

**Ans.** (a) The energy in a system can neither be created nor be destroyed. It may be transformed from one form to another form, but total energy of the system remains constant.

(b) Consider an undisturbed simple pendulum, in its mean position **A**.

When the pendulum is pulled to position **C**, it gains height. Thus, at position **C**, it has :

- (i) Maximum potential energy.
- (ii) Zero kinetic energy, as the pendulum is held by hand in position **C**.

When the pendulum is released from position **C**, it moves towards position **A**. In doing so, its **velocity increases**. Due to the increase in velocity, its **kinetic energy increases**, at the expense of potential energy. At position **A**, it has :

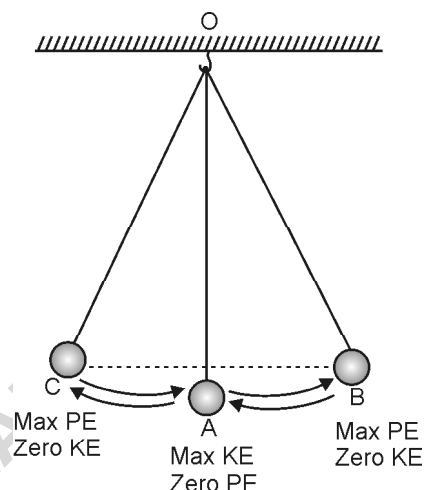
- (i) Maximum kinetic energy.
- (ii) Zero potential energy, as it is at its lowest position.

When the pendulum swings from **A** to **B**, it again **gain height**, and hence, its **potential energy increases**. However, due to gain in height, its velocity decreases, and hence, the kinetic energy decreases. At position **B**, it has :

- (i) Maximum potential energy.
- (ii) Zero kinetic energy, as pendulum comes to rest at **B** for a moment, before swinging back to position **A**.

From the above example, it is clear, that in the system of pendulum and earth, the energy is conserved. It is the potential energy, which changes into the kinetic energy and vice-versa.

(c) The saw become warm because biochemical energy of the man changes into mechanical energy of saw. The mechanical energy of saw changes into heat energy.



## II. FORMATIVE ASSESSMENT

### A. Group Activity

To find the average work done and power developed by a group of students.

**Materials Required :** 50 bricks (used for building construction), a stop watch, a table, a measuring tape.

**Procedure :**

1. Place all the bricks close to the table, which is at least 70 cm in height or more.
2. Measure the height of the table with the help of a measuring tape and record it. Convert the height into metres from centimetres.

3. Ask one of the students to place bricks one by one on the table, as quickly as possible and start the stop watch.
4. When the stop watch records 100 s, ask the boy to stop placing the bricks.
5. Count the number of bricks. Assuming each brick is 5 kg, find the total mass of bricks raised in 100 s.
6. Calculate the work done by the boy from the expression :  
 Work done = mass of brick  $\times$  acceleration due to gravity  $\times$  height of the table.  
 For example, if the number of bricks raised is 23 and height of the table is 85 cm and 'g' is  $10 \text{ ms}^{-2}$ , then,
 
$$\begin{aligned} \text{Work done} &= 23 \times 5 \text{ kg} \times 10 \text{ ms}^{-2} \times \frac{85}{100} \text{ m} \\ &= 115 \text{ kg} \times 10 \text{ ms}^{-2} \times 0.85 \text{ m} = 977.5 \text{ J} \end{aligned}$$
7. In order to calculate power, divide work done by time, which is 100 s in the present case.  

$$\therefore \text{Power} = \frac{\text{Work done}}{\text{time}} = \frac{977.5 \text{ J}}{100 \text{ s}} = 9.77 \text{ W}$$
8. Repeat the activity with the other boys. There should be 10 or more boys in the group. In each case find, the work done and power.
9. Add all the work done and divide it with the number of boys. You will get the average work done by the group.
10. Add all the powers and divide it with the number of boys. You will get the average power of the group.

### B. Charts and Models

1. Prepare a pictorial chart showing five examples of a body having only
  - (i) kinetic energy
  - (ii) potential energy
  - (iii) both kinetic and potential energy
2. Make a model of a windmill connected to a small dynamo and producing electric current. For strong wind you can use a blower.

### C. Class Room Discussions

**Discuss in class how and what type of energy conversions take place.**

- (i) A coin on rubbing on a wooden desk gets hot.
- (ii) A microphone and a loudspeaker in unison produce loud sound.
- (iii) Energy of coal produces electricity.
- (iv) Fast running water can be used to produce electricity.
- (v) Dry cells in a battery produce light energy.
- (vi) The food which we consume helps us to do various activities.

### D. Visits

Visit the nearest power generating station. It may be a hydropower station, a thermopower station or a wind supported power station. Make a detailed report on how electric energy is produced.

