Work, Energy and Power

CHAPTER 6

TRY YOURSELF

ANSWERS

1. Work done by a force depends upon
(i) magnitude of the force
(ii) magnitude of displacement of the body
(iii) angle between the force and displacement.

2. 1 erg = 10^{-7} J

3. Work done is a scalar quantity because it can be expressed as the dot product of force and displacement.

4. $\vec{F} = (3\hat{i} + 3\hat{j} + 2\hat{k})$ and $\vec{s} = (2\hat{i} + 5\hat{j} - 3\hat{k})$

$W = (3\hat{i} + 3\hat{j} + 2\hat{k}) \cdot (2\hat{i} + 5\hat{j} - 3\hat{k}) = 6(\hat{i} \cdot \hat{i}) + 15(\hat{j} \cdot \hat{j}) - 6(\hat{k} \cdot \hat{k})$

$= 6 + 15 - 6 = 15$ J

5. A weight lifter holding a 100 kg mass steadily on his shoulder for 20 second does zero work or no work on the load during this time because displacement, $\vec{s} = 0$.

6. No, if a body has momentum, it must be in motion and consequently possess kinetic energy.

7. The energy possessed by a body by virtue of its motion is called its kinetic energy. For example, the kinetic energy of air is used to run windmills.

8. Here, m = 8 kg, F = 32 N and t = 10 s

Acceleration, $a = \frac{F}{m} = \frac{32}{8} = 4$ m s^{-2}

$\therefore$ $v = u + at = 0 + 4 \times 10 = 40$ m s^{-1}

The kinetic energy acquired by the body,

$$K = \frac{1}{2}mv^2 = \frac{1}{2} \times 8 \times (40)^2 = 6400 \text{ J}$$

9. Here, m = 0.5 kg
When $x = 0$, $v_1 = 0$
When x = 2 m, v_2 = 20 m s^{-1}

W = change in K.E. = $\frac{1}{2}mv_2^2 - \frac{1}{2}mv_1^2$

$$W = \frac{1}{2}m(v_2^2 - v_1^2) = \frac{1}{2} \times 0.5[(20)^2 - 0]$$

$$= \frac{1}{2} \times \frac{1}{2} \times 400 = 100 \text{ J}$$

10. Potential energy is the energy stored in a body or a system by virtue of its position in a field of force or by its configuration.
Gravitational potential energy, elastic potential energy and electrostatic potential energy are some common types of potential energy.

11. Here, m = 0.2 kg, u = 9.8 m s^{-1}
$a = -g = -9.8$ m s^{-2}, t = 1 s

Using, $s = ut + \frac{1}{2}at^2$

$s = 9.8 \times 1 - \frac{1}{2} \times 9.8 \times (1)^2 = 4.9$ m

$\therefore$ Potential energy = mgh = 0.2 × 9.8 × 4.9 = 9.604 J

12. A flying bird possesses both potential and kinetic energy. It has potential energy due to its position above the ground level and has kinetic energy due to its motion.

13. Total energy *i.e.*, kinetic energy + potential energy will remain constant.

14. Potential energy stored in a spring is

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

where x is the extension (or compression) in the spring.
Let k N m^{-1} be spring constant of the spring.
As per question,

$$U = \frac{1}{2}k(1 \times 10^{-3} \text{ m})^2 = 1 \text{ J} \quad \text{...(i)}$$

It is further compressed by 1 mm. Then

$$U' = \frac{1}{2}k(2 \times 10^{-3} \text{ m})^2 \quad \text{...(ii)}$$

Divide eqn. (ii) by eqn. (i), we get

$$\frac{U'}{U} = 4 \quad \text{or} \quad U' = 4U$$

$\therefore$ Work done, $W = U' - U = 4U - U = 3U = 3 \times 1$ J = 3 J

15. The energy required to break one bond in DNA is 10^{-20} J.

16. Mechanical energy (Kinetic energy + potential energy), heat energy, electrical energy, chemical energy and nuclear energy.

17. (i) The spring force is position dependent as is clear by Hooke's law, $F_s = -kx$. Thus, work done by the spring force depends on initial and final positions.
(ii) Work done by the spring force in a cyclic process is zero.

18. The instantaneous power is defined as the limiting value of the average power as time interval approaches zero.

$$P = \lim_{\Delta t \to 0} \frac{\Delta W}{\Delta t} = \frac{dW}{dt}$$

19. Here, m = 150 kg, h = 10 m, t = 2 min = 120 s

$\therefore$ Power, $P = \frac{W}{t} = \frac{mgh}{t} = \frac{150 \times 10 \times 10}{120} = 125$ W

20. Kilowatt hour (kWh) is the commercial unit of electrical energy.
One kilowatt hour is the electrical energy consumed by an appliance of 1000 watt in 1 hour.

1 kWh = 1 kW × 1 h = 1000 W × 1 h
= 1000 J s^{-1} × 3600 s = 3.6 × 10^6 J

21. If a is the uniform acceleration of the body, then

$$v = 0 + at \text{ or } a = \frac{v}{t}$$

The velocity of the body at any instant T,

$$v' = \frac{v}{t} \times T$$

Instantaneous power, $P = Fv' = mav'$

$$= m \times \frac{v}{t} \times \frac{v}{t} \times T = \frac{mv^2 T}{t^2}$$

22. (i) Linear momentum is conserved.
(ii) Total energy is conserved.
(iii) Kinetic energy is conserved.
(iv) Forces involved must be conservative forces.

23. Loss of kinetic energy in a perfectly inelastic collision is

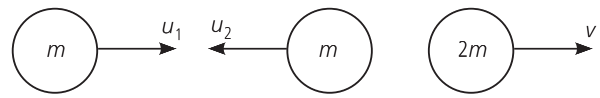
$$\Delta K = \frac{1}{2} \frac{m_1 m_2}{(m_1 + m_2)} (u_1 - u_2)^2$$

Here, $m_1 = m_2 = M$

$$\therefore \quad \Delta K = \frac{1}{2} \frac{M \times M}{(M + M)} (u_1 - u_2)^2 = \frac{M}{4} (u_1 - u_2)^2$$

24. Yes, it is possible. In Rutherford's scattering experiment, an alpha particle speeding towards nucleus of an atom gets deflected by the electrostatic force of repulsion without actual physical contact with the nucleus. So the alpha particle is said to have undergone collision with the nucleus.

25.



Before collision After collision

Here, $m = 0.5$ kg, $u_1 = 2$ m s^{-1} and $u_2 = 1$ m s^{-1}

According to conservation of linear momentum,

$$mu_1 + mu_2 = (2m)v$$

or $$v = \frac{u_1 + u_2}{2} = 1.5 \text{ m s}^{-1}$$