POWER

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Power

Power is defined as the rate at which work is done.

power is the work done in unit time.

If W is the work done in a time t, the average power is given by

$$Power = \frac{work}{time}$$

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

But work done is defined as the product of force and displacement.

$$W = FS$$

$$\therefore \quad P = \frac{FS}{t}$$

- But the velocity of the body is given by $v = \frac{S}{t}$

$$\therefore P = Fv$$

$$Power = Force \times velocity$$

Power can also be defined as the energy converted or transferred in unit time.

$$Power = \frac{energy}{time}$$

Power is a scalar quantity. The SI unit of power is joule/second or watt (W).

1 watt = 1 joule/second.

Other commonly used units are

1 kilowatt (kW) = 10^3 watt
1 megawatt (MW) = 10^6 watt
1 Horsepower (hp) = 746 watt

The energy consumption of electrical devices is expressed in kilowatt-hour (kWh).

Kilo watt-hour is not the unit of power, but it is a practical unit of electrical energy.

Problems

1. Calculate the work done in lifting a mass 5 Kg vertically through 8m.

Given m = 5 Kg, h = 8 m

W = force × vertical displacement = mgh = 5 × 9.8 × 8 = 392 J

2. A body of mass 5 kg initially at rest is subjected to a force of 20 N. What is the kinetic energy acquired by the body at the end of 10 s?

Given, m = 5 kg, F = 20 N, t = 10s, u = 0

$$F = ma$$

$$a = \frac{F}{m} = \frac{20}{5} = 4\ m/s^2$$

$$v = u + at = 0 + 4 \times 10 = 40\ m/s$$

$$K = \frac{1}{2}mv^2 = \frac{1}{2} \times 5 \times 40^2 = 4000\ \text{J}$$

3. A work 900 J is done when a force of 30 N is applied to a body. Calculate the distance through which the body moves.

Work done (W) = 900 J

Force (F) = 30 N

$W = F.S$

Distance covered, S = W/F

=900/30

= 30 m

4. The momentum of a body of mass 10 kg is 30 SI units. Calculate its kinetic energy.

Momentum, p =mv = 30 kgm/s.

Mass m = 10 kg

Velocity = p/m = 3m/s

Kinetic energy $K = \frac{1}{2} mv^2 = \frac{1}{2} \times 10 \times 3^2 = 45$ J

The relation $E = p^2/2m$ can also be used to get the result.

5. An engine develops 10 kW of power. How much time will it take to lift a mass of 200 kg to a height of 40 m?

Force acting on a body of mass 200 kg, F = mg = 200 x 9.8 = 1960 N

Work done W = F.S = 1960 x 40 = 78400 J

Power = 10 kW = 10000 W.

Power = work/time

Time taken = work/power = 78400/10000 = 7.84 s

6. An electric motor raises 200 kg of water to a tank at a height 30 m above ground level in a time of 3 minutes. If the efficiency of the pump is 87 %,what is the power of the motor (designed by the company/ manufacturer)?

Output energy of the pump = mgh = 200 x 9.8x 30 = 58,800 J

Time = 3 min = 3 x 60 = 180 s

Output power of the pump = energy /time = 58800/180 = 326.67 W

Efficiency = output power /input power = 87% = 87/100 =0.87

Input power = output power /0.87 = 326.67/0.87 = 375.48 W

Power of the motor = 375.48 W

7. A cricket ball of mass 0.3 kg is thrown vertically up with a velocity of 14.7 m/s. Calculate the K.E and P.E of the ball after one second.

8. An elephant lifts a body of mass 1000 kg through a vertical height of 3 m in 10 s. What is power?

- Answers

7.

Mass of the ball m = 0.3 kg

Initial velocity u = 14.7 m/s

$a = g = 9.8\ m/s^2; t = 1\ s$

The velocity after 1 s, $v = u + at = 14.7 - 9.8 \times 1 = 4.9\ m/s$

K.E after 1 s is $K = \frac{1}{2} mv^2 = \frac{1}{2} \times 0.3 \times (4.9)^2 = 3.6\ J$

Vertical displacement of the ball after 1 second is

$h = ut - \frac{1}{2} gt^2 = 14.7 \times 1 - \frac{1}{2} 9.8 \times 1 = 9.8\ m$

P.E after 1 s = mgh = 0.3 x 9.8 x 9.8 = 28.81 J

8. Work done = mgh= 1000 x 9.8 x 3 =29400 J

Power = work /time = 2940 W