2017

Consider a drop of rain water having mass 1 g falling from a height of 1 km. It hits the ground with a speed of 50 m/s. Take g constant with a value 10 m/s^2. The work done by the (i) gravitational force and the (ii) resistive force of air is
(1) (i) – 10 J (ii) –8.25 J
(2) (i) 1.25 J (ii) –8.25 J
(3) (i) 100 J (ii) 8.75 J
(4) (i) 10 J (ii) –8.75 J

Work done by gravity is mgh,

To find the work done by resistive force as we don't have value of resistive force. We will use work energy theorem to find it. We subtract final value of kinetic energy, from the work done by gravitational energy to get the work done by resistive force

Work done by gravity $mgh = \frac{1}{1000} \times 10 \times 1000 = 10\text{ J}$

Final kinetic energy $\frac{1}{2}mv^2 = \frac{1}{2} \times \frac{1}{1000} \times 50 \times 50 = \frac{25}{20} = 1.25\text{ J}$

Work done by resistive force = 10 J – 1.75 J = 8.75 J

2016

A bullet of mass 10g moving horizontally with a velocity of 400 m/s strikes a wooden block of mass 2 kg which is suspended by a light inextensible string of length 5 m. As a result, the centre of gravity of the block is found to rise a vertical distance of 10 cm. The speed of the bullet after it emerges out horizontally from the block will be :-
(1) 120 m/s (2) 160 m/s (3) 100 m/s (4) 80 m/s

First we find the velocity of Block after the collision

$$\frac{1}{2}Mv^2 = MgH \Rightarrow v = \sqrt{2gH} = \sqrt{2 \times 10 \times \frac{10}{100}} = 1.41$$

Now we use this formula for finding the velocity of bullet using conservation of mass

$$\frac{10}{1000} \times 400 = 2v + \frac{10}{1000}v_1$$

$$4 = 2 \times 1.41 + \frac{10}{1000}v_1 \Rightarrow 1.21 \times 100 = v_1$$

Two identical balls A and B having velocities of 0.5 m/s and –0.3 m/s respectively collide elastically in one dimension. The velocities of B and A after the collision respectively will be :-
(1) –0.3 m/s and 0.5 m/s (2) 0.3 m/s and 0.5 m/s (3) –0.5 m/s and 0.3 m/s (4) 0.5 m/s and –0.3 m/s

The velocity of identical bodies interchange after elastic collision
Velocity interchange after elastic collision of identical bodies

A particle moves from a point (–2i + 5j) to (4j + 3k) when a force of (4i + 3j) N is applied. How much work has been done by the force ?
(1) 5 J (2) 2 J (3) 8 J (4) 11 J

Work done is DOT product of force and displacement

$$W = \vec{F}.\vec{r} = \vec{F}.(\vec{r}_2 - \vec{r}_1) = (4\hat{i} + 3\hat{j}).(2\hat{i} - \hat{j}) = 8 - 3 = 5J$$

2016

A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion ? **[2016]**
(a) 0.1 m/s^2 (b) 0.15 m/s^2 (c) 0.18 m/s^2 (d) 0.2 m/s^2

We can use $v^2 = u^2 + 2as$ to find 'a' after we find the final velocity using conservation of energy.

$$\frac{1}{2}mv^2 = E \Rightarrow \frac{1}{2} \times \frac{10}{1000} \times v^2 = 8 \times 10^{-4} \Rightarrow v^2 = 0.16 \Rightarrow v = 0.4\ m/s$$

$$v^2 = 2as \Rightarrow 0.16 = 2a \times 2 \times 2\pi \times \frac{6.4}{100} \Rightarrow a = 0.10\,m/s^2$$

OTHER METHOD

Force multiplied by displacement is equal to energy

Energy = Work = Force × Displacement = ma × s = $\frac{10}{1000} \times a \times 2\pi \times \frac{6.4}{100} \times 2 = 8 \times 10^{-4} J \Rightarrow a = 0.1 m/s^2$

A body of mass 1 kg begins to move under the action of a time dependent force F = (2ti+3t²j) N, where i and j are unit vectors along x and y axis. What power will be developed by the force at the time t? **[2016]**
(a) $(2t^2 + 3t^3)$W (b) $(2t^2 + 4t^4)$W (c) $(2t^3 + 3t^4)$ W (d) $(2t^3 + 3t^5)$W

$$P = F.v$$

$$F = ma = 1 \times \frac{dv}{dt} = 2t\hat{i} + 3t^2\hat{j} \Rightarrow v = t^2\hat{i} + t^3\hat{j}$$

$$P = (2t\hat{i} + 3t^2\hat{j}).(t^2\hat{i} + t^3\hat{j}) = 2t^3 + 3t^5$$

To revise WORK POWER and ENERGY we take a tour of this chapter.