SOLVED EXAMPLES

Ex.1 A boy standing on a weighing machine observes his weight as 200 N. When he suddenly jumpes upwards, his friend notices that the reading increased to 400 N. The acceleration by which the boy jumped will be-

(A) 9.8 m/s^2 (B) 29.4 m/s^2

(C) 4.9 m/s^2 (D) 14.7 m/s^2

Sol.(A) Force causing the acceleration

= 400 – 200 = 200N

mass of the boy = 200/9.8

hence acceleration $= F/m = \frac{200}{200} \times 9.8$

$= 9.8\ m/s^2$

Hence correct answer is (A)

Ex.2 A force of $(6\hat{i} + 8\hat{j})$ N acted on a body of mass 10 kg. The displacement after 10 sec, if it starts from rest, will be -

(A) 50 m along $\tan^{-1}$ 4/3 with x axis

(B) 70 m along $\tan^{-1}$ 3/4 with x axis

(C) 10 m along $\tan^{-1}$ 4/3 with x axis

(D) None

Sol.(A) Acceleration $= \frac{\vec{F}}{m} = \frac{6\hat{i}+8\hat{j}}{10}$ in the direction of force and displacement

$$\vec{S} = \vec{u}t + \frac{1}{2}\vec{a}t^2 = 0 + \frac{1}{2}\left(\frac{6\hat{i}+8\hat{j}}{10}\right)100$$

$$= 30\hat{i} + 40\hat{j}$$

So the displacement is 50 m along $\tan^{-1}\frac{4}{3}$ with x-axis

Hence correct answer is (A)

Ex.3 A boat of mass 1000 kg is moving with a velocity of 5 m/s. A person of mass 60 kg jumps into the boat. The velocity of the boat with the person will be -

(A) 4.71 m/s (B) 4.71 cm/s

(C) 47.1 m/s (D) 47.1 cm/s

Sol.(A) From the law of conservation of momentum

1000 × 5 + 0 = (1000 + 60) v

$$\Rightarrow v = \frac{1000 \times 5}{1060} = 4.71\ m/s$$

Hence correct answer is (A)

Ex.4 A disc of mass 10 gm is kept horizontally in air by firing bullets of mass 5 g each at the rate of 10/s. If the bullets rebound with same speed. The velocity with which the bullets are fired is -

(A) 49 cm/s (B) 98 cm/s

(C) 147 cm/s (D) 196 cm/s

Sol.(B) Weight of disc $= \frac{10}{1000}$ kg ,

Let speed of the bullet = v

So rate of change of momentum of the bullets

$$= \frac{2 \times 10 \times 5}{1000}$$

v = applied force on the disc

Now $\frac{2 \times 10 \times 5}{1000} \times v = \frac{10 \times g}{1000}$

$\Rightarrow v = 0.98\ m/s^2 = 98\ cm/s^2$

Hence correct answer is (B)

Ex.5 A fire man has to carry an injured person of mass 40 kg from the top of a building with the help of the rope which can withstand a load of 100 kg. The acceleration of the fireman if his mass is 80 kg, will be-

(A) 8.17 m/s^2 (B) 9.8 m/s^2

(C) 1.63 m/s^2 (D) 17.97 m/s^2

Sol.(C) Total mass = 80 + 40 = 120 kg

The rope cannot with stand this load so the fire man should slide down the rope with some acceleration

$\therefore$ The maximum tension = 100 × 9.8 N

m (g – a) = tension ,120 (9.8 – a) = 100 × 9.8

$\Rightarrow a = 1.63\ m/s^2$

Hence correct answer is (C)

Ex.6 A body of 0.02 kg falls from a height of 5 metre into a pile of sand. The body penetrates the sand a distance of 5 cm before stoping. What force has the sand exerted on the body ?

(A) 1.96 N (B) –19.6 N

(C) –0.196 N (D) 0.0196 N

Sol.(B) Suppose the velocity of the body at the instant when it reaches the pile of sand be v. Then $v^2 = 0 + 2\ (9.8) \times (5\ \text{metre}) = 98$

($\because v^2 = u^2 + 2as$)

$$a = -\frac{98}{2\times(0.05)} = -\ 980\ \text{m/sec}^2$$

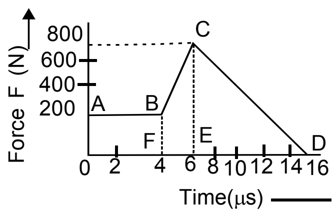
Now, retarding force

F = mass x acceleration

$= 0.02\ \text{kg} \times (-\ 980\ \text{m/sec}^2) = -19.6\ \text{N}$

Hence correct answer is (B)

Ex.7 The magnitude of the force (in Newtons) acting on a body varies with time t (in microseconds) as shown in fig. AB, BC, and CD are straight line segments. The magnitude of the total impulse of the force on the body from t = 4 μs to t = 16 μs is .... N-s.



(A) 5×10^{-4} N.s (B) 5×10^{-3} N.s

(C) 5×10^{-5} N.s (D) 5×10^{-2} N.s

Sol.(B) Impulse = F . t = Area under F-t curve from 4 μs to 16 μs = Area under BCDFB

= Area of trapizium BCEF + area of ΔCDE

$= \frac{1}{2}(200+800)\ (2\times10^{-6}) + \frac{1}{2}\times10 \times 10^{-6} \times 800$

$= 10 \times 10^{-4} + 40 \times 10^{-4}\ \text{N–s} = 50 \times 10^{-4}$

$= 5.0 \times 10^{-3}$ N-s

Hence correct answer is (B)

Ex.8 The total mass of an elevator with a 80 kg man in it is 1000 kg. This elevator moving upward with a speed of 8 m/sec, is brought to rest over a distance of 16m. The tension T in the cables supporting the elevator and the force exerted on the man by the elevator floor will respectively be-

(A) 7800 N, 624 N (B) 624 N, 7800 N

(C) 78 N, 624 N (D) 624 N, 78 N

Sol.(A) (a) The elevator having an initial upward speed of 8 m/sec is brought to rest within a distance of 16 m

Hence, $0 = (8)^2 + 2a\ (16)$ ($\because v^2 = u^2 + 2as$),

$$a = -\frac{8\times8}{2\times16} = -\ 2\ \text{m/sec}^2$$

Resultant upward force on elevator = T – mg.

According to Newton's law.

T – mg = ma

or T = mg + ma = m (g + a)

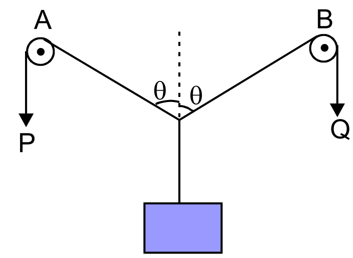
= 1000 (9.8 – 2) = 7800 N

(b) Let P be the upward force exerted on the man by the elevator floor. If m' be the mass of the man, then, weight of the man acting downward = m' g , Upward force on the man = P – m'g

According to Newton's law. P–m' g = m' a or P = m' (a + g) = (– 2 + 9.8) = 624 N

Hence correct answer is (A)

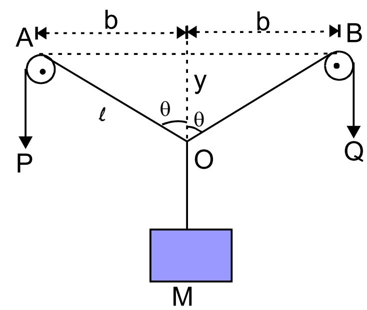
Ex.9 In the arrangement shown in fig the ends P and Q of an unstretchable string move downwards with uniform speed U. Pulleys A and B are fixed. Mass M moves upwards with a speed-



(A) 2U cos θ (B) U cos θ

(C) 2U/cos θ (D) U/cos θ

Sol.(D) As P and Q move down, the length ℓ decreases at the rate of U m/s



From figure, $\ell^2 = b^2 + y^2$

Differentiating with respect to time

$$2\ell\frac{d\ell}{dt} = 2y\frac{dy}{dt} \quad (\because \text{ b is constant})$$

$$\therefore \frac{dy}{dt} = \frac{\ell}{y}\cdot\frac{d\ell}{dt} = \frac{1}{\cos\theta}\cdot\frac{d\ell}{dt} = \frac{U}{\cos\theta}$$

Hence correct answer is (D)

Ex.10 An engine of mass 5×10^4 kg pulls a coach of mass 4×10^4 kg. Suppose that there is a resistance of 1 N per 100 kg acting on both coach and engine, and that the driving force of engine is 4500 N. The acceleration of the engine and tension in the coupling will respectively be-

(A) 0.04 m/s^2, 2000 N (B) 0.4 m/s^2, 200 N

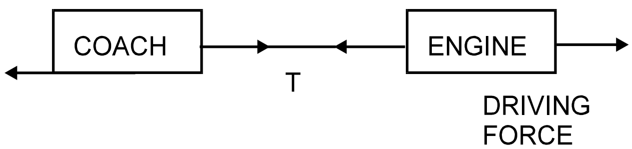
(C) 0.4 m/s^2, 20 N (D) 4 m/s^2, 200 N

Sol.(A) The engine, coach, coupling and resistance are, shown in fig

Driving force = 4500 N

Opposing force (Resistance)

$$= \frac{(5+4)10^4}{100} = 900 \text{ N}$$



Resultant force = 4500 – 900 = 3600 N

Mass of engine and coach = 9×10^4 kg

According to Newton's law, F = ma

$\therefore$ $3600 = 9 \times 10^4$ a

or a = (3600) / (9×10^4) = 0.04 m/sec^2

So acceleration of the train = 0.04 m/sec^2

Now considering the equilibrium of the coach only, we have

$(T - R) = 4 \times 10^4 \times 0.04$ ($\because$ F = ma)

or $T - \frac{4 \times 10^4}{100} = 4 \times 10^4 \times 0.04$,

$T = 4 \times 10^4 \times 0.04 + 4 \times 10^2$

= 1600 + 400 = 2000 N

Hence correct answer is (A)