Chapter 19

Dynamics

Exercise 19.1

1. Find the impulse of a force acting on a mass of 50 kg producing a change in velocity from 5 ms^{-1} to 15 ms^{-1}.

Sol^n: mass (m) = 50 kg

initial velocity (u) = 5 ms^{-1}

final velocity (v) = 15 ms^{-1}

$\therefore$ Impulse = mv - mu = $50 \times 15 - 50 \times 5 = 500$ kg ms^{-1}.

2. A girl on a bicycle, total mass 50 k, has a velocity of 1 m/s and paddling faster for 5 seconds, the velocity increases to 3 ms^{-1}. Find the average force exerted.

Sol^n: mass (m) = 50 kg

initial velocity (u) = 1 ms^{-1}

final velocity (v) = 3 ms^{-1}

time taken (t) = 5 seconds.

force exerted (F) = ?

$\therefore \quad F = \frac{mv - mu}{t} = \frac{m(v - u)}{t} = \frac{50(3 - 1)}{5} = \frac{100}{5} = 20$ N

3. A body of mass 50 kg falling from a certain height is brought to rest after striking the ground with a speed of 5 ms^{-1}. If the resistance force of the ground is 500 N, find the duration of contact.

Sol^n: mass of the body (m) = 50 kg

initial velocity (u) = 0

final velocity (v) = 5 ms^{-1}

force on the ground (F) = 500 N

duration of contact (t) = ?

Now, $F = \frac{mv - mu}{t}$

$\Rightarrow \quad t = \frac{m(v - u)}{F} = \frac{50(5 - 0)}{5} = \frac{250}{500} = 0.5$ sec

4. A cart is pushed on a frictionless smooth plane with an average force of 20 N for 5 seconds. If the cart with mass 50 kg is at rest in the beginning, find the velocity acquired by the cart.

Sol^n: average force (F) = 20 N

mass of the cart (m) = 50 kg

time taken (t) = 5 secs.

initial velocity (u) = 0

final velocity (v) = ?

Now, $F = \frac{mv - mu}{t}$

$\Rightarrow \quad v = \frac{Ft}{m} + u = \frac{20 \times 5}{50} + 0 = 2$ ms^{-1}.

5. a) A rocket expels gas at the rate of 0.5 kgs^{-1}. If the velocity of the gas expelled is 200 ms^{-1}, what is the force produced by the rocket?

Sol^n: rate of expelling $\left(\frac{m}{t}\right) = 0.5\ kgs^{-1}$

initial velocity (u) = 200 ms^{-1}

final velocity (v) = 0

force produced by the rocket (F) = ?

$\therefore \quad F = \frac{mv - mu}{t} = \frac{m}{t}(v - u) = 0.5(200 - 0) = 100\ N$

b) Sand allowed to fall vertically at a steady rate hits a horizontal floor with a speed 0.05 ms^{-1}. If the force exerted on the floor is 0.005 N, find the mass of sand falling per second.

Sol^n: initial velocity (u) = 0

final velocity (v) = 0.05 ms^{-1}

force exerted on the floor (F) = 0.005 N

mass of sand falling per second $\left(\frac{m}{t}\right)$ = ?

Now, $F = \frac{m}{t}(v - u)$

$\Rightarrow \quad 0.005 = \frac{m}{t}(0.05 - 0)$

$\Rightarrow \quad \frac{m}{t} = \frac{0.005}{0.05} = 0.1\ kg\ s^{-1}$

c) Suppose a rocket moving upwards in the air loses its mass as its fuel burns. If the velocity of the rocket is reduced from 210 ms^{-1} to 110 ms^{-1} by a force of 100 N due to earth, find the mass of fuel burnt per second.

Sol^n: initial velocity (u) = 210 ms^{-1}

final velocity (v) = 110 ms^{-1}

force exerted (F) = 100 N

mass of fuel brunt per second $\left(\frac{m}{t}\right)$ = ?

Now, $F = \frac{mv - mu}{t}$

$\Rightarrow \quad 100 = \frac{m}{t}(110 - 210)$

$\Rightarrow \quad \frac{m}{t} = -\frac{100}{100} = -1\ kgs^{-1}$

d) Suppose a steady mass of rain falls vertically on a flat roof at the rate of 0.5 kgs^{-1} and then comes to rest. If the force on the roof is 2.5 N, find the velocity of raindrops just before hitting the roof.

Sol^n: quantity of rain falling per second $\left(\frac{m}{t}\right) = 0.5\ kgs^{-1}$

force exerted on the roof (F) = 2.5 N

velocity before hitting the roof (u) = ?

velocity after hitting the roof (v) = 0

Now, $F = \frac{mv - mu}{t}$

$\Rightarrow \quad F = \frac{m}{t}(v - u) \qquad \Rightarrow 2.5 = 0.5(0 - u) \qquad \Rightarrow \quad u = -5 \text{ ms}^{-1}$

$\therefore \quad u = 5 \text{ ms}^{-1}$.