CH # 4 MOTION AND FORCE

Some important formulae:

i) F = ma ii) $m_1U_1+m_2U_2 = mv_1 + m_2V_2$

iii) $a = \left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$

4.1: Determine the acceleration of a car of mass 900Kg, when a net force of 2700N acts on it.

GIVEN:
Mass of car = m = 900Kg
Force = F = 2700N

REQUIRED:
Acceleration = a = ?

SOLUTION:
F = ma

$$a = \frac{F}{m}$$

$$a = \frac{2700}{900}$$

a = 3m/s^2

4.2: A car of mass 1000Kg travelling at 72Km/h is uniformly brought to rest over a distance of 40m. Find (a) the average acceleration (b) The average breaking force.

GIVEN:
Mass of car = m = 900Kg
Initial velocity= Vi = 72Km/h = 72 x 1000/3600= 20m/s
Final velocity = Vf = 0
Distance covered = S = 40m

REQUIRED:
Average acceleration = ?
Breaking force = F = ?

SOLUTION:
(a) 2aS = $Vf^2 – Vi^2$

$$a = \frac{Vf^2 - Vi^2}{2S}$$

$$a = \frac{(0)^2 - (20)^2}{2(40)}$$

a = –5m/s^2

(b) F = ma
F = 1000(–5)
F = –5000N

4.3: A bullet of mass 50g travelling with a speed of 15m/s penetrate into a bag of sand and is uniformly brought to rest in 0.05sec. Find (a) How for the bullet will penetrate into the back of sand. (b) The average force exerted by the sand.

GIVEN:
Mass of bullet = m = 50g = 50/1000 = 0.05Kg
Initial velocity= Vi = 15m/s
Final velocity = Vf = 0m/s
Time taken = t = 0.05sec

REQUIRED:
Acceleration = a = ?
Average force = F = ?

SOLUTION:

$$(a)\ a = \frac{Vf - Vi}{t}$$

$$a = \frac{0 - 15}{0.05}$$

a = –300m/s^2

(b) F = ma
F = 0.05(–300)
F = –15N

4.4: A force of 120N acts on a stationary body for 4sec and the body acquires a velocity of 36m/s. Calculate the mass of the body.

GIVEN:
Force = F = 120N
Initial velocity= Vi = 0m/s
Final velocity = Vf = 36m/s
Time taken = t = 4sec

REQUIRED:
Mass of body = m = ?

SOLUTION:

First we find acceleration,

$$a = \frac{Vf - Vi}{t}$$

$$a = \frac{36 - 0}{4}$$

a = –9m/s^2

Now,

F = ma

$$m = \frac{F}{a}$$

$$m = \frac{120}{9}$$

m = 13.3Kg

4.5: A gun of mass 20kg fires a bullet of mass 50g with a velocity of 200m/s. Calculate the velocity of the recoil of the gun.

GIVEN:

Before firing:

Mass of gun = m_1 = 20Kg

Mass of bullet = m_2 = 50g = 50/1000 = 0.05Kg

Velocity of gun before firing = U_1 = 0m/s

Velocity of bullet after firing = U_2 = 0m/s

After firing:

Mass of gun = m_1 = 20Kg

Mass of bullet = m_2 = 50g = 50/1000 = 0.05Kg

Velocity of gun After firing = V_1 = ?

REQUIRED:

Velocity of bullet after firing = V_2 = 200m/s

SOLUTION:

According to law of conservation of momentum,

Total momentum before firing = Total momentum after firing

$$m_1U_1 + m_2U_2 = m_1V_1 + m_2V_2$$

$$(20)(0) + (0.05)(0) = (20)V_1 + (0.05)(200)$$

$$0 = 20V_1 + 10$$

$$-10 = 20V_1$$

$$V_1 = -\frac{10}{20}$$

$$V_1 = -0.5 \text{ m/s}$$

Negative sign shows that recoil of the gun moves in opposite direction to the bullet.

4.6: An empty truck weighs 400N. Its engine can produce a maximum acceleration of 1m/s^2. If the truck is loaded with 2000N, find the maximum acceleration the engine can produce.

GIVEN:

Empty truck:

Weight of empty truck = W_1 = 4000N

Mass of empty truck = m_1 = 4000/10 = 400Kg

Acceleration of empty truck = a_1 = 1m/s^2

Loaded truck:

Weight loaded in truck = 2000N

Mass loaded in truck = 2000/10 = 200Kg

Weight of loaded truck = W_2 = 4000 + 2000 = 6000N

Mass of loaded truck = m_2 = 6000/10 = 600Kg

REQUIRED:

Acceleration of loaded truck = a_2 = ?

SOLUTION:

According to Newton's 2nd law of motion the dragging force will be,

$$F_1 = m_1a_1$$

$$F_1 = 400 \times 1$$

$$F_1 = 400N$$

And

$$F_2 = m_2a_2$$

$$F_2 = 600 \times a_2$$

$$F_2 = 600a_2$$

According to Newton's third law of motion,

$$F_2 = -F_1$$

$$600a_2 = -400$$

$$a_2 = -\frac{400}{600}$$

$$a_2 = -0.66\text{m/s}^2$$

Negative sign shows that when truck is loaded its acceleration is decreases.

4.7: Two bodies A and B are attached to the end of a string which passes over a pulley, so that they hang vertically. If the mass of the body B is 4Kg; find the mass of body A which moves up with an acceleration of 0.5m/s^2 (Take g = 10m/s^2)

GIVEN:

Mass of body B = m_1 = 4Kg (Body B moves downward)

Acceleration = a = 0.5m/s^2

Value of g = g = 10m/s^2

REQUIRED:

Mass of body B = m_2 = ?

SOLUTION:

$$a = \frac{(m_1 - m_2)g}{(m_1 + m_2)}$$

$$0.5 = \frac{(4 - m_2)10}{(4 + m_2)}$$

$$\frac{0.5}{10} = \frac{(4 - m_2)}{(4 + m_2)}$$

$$0.05 = \frac{(4 - m_2)}{(4 + m_2)}$$

$0.05(4 + m_2) = (4 - m_2)$

$0.2 + 0.05m_2 = 4 - m_2$

$0.05m_2 + m_2 = 4 - 0.2$

$1.05m_2 = 3.8$

$$m_2 = \frac{3.8}{1.05}$$

$m_2 = 3.62Kg$

Mass of body B is 3.62Kg which is less than mass of body A that why body B moves upward.

4.8: A rectangular metal block of mass 4Kg rests on the top of the metal surface. The coefficient of friction between the box and metal surface is 0.2. What force parallel to the surface needed to move the block.

GIVEN:

Mass of metal block = m = 4Kg

Weight of metal block = W = 4 x 10 = 40N

Coefficient of friction between metal block and surface = μ = 0.2

REQUIRED:

Parallel force need to move the block = F = ?

SOLUTION:

F = μR

Since Weight(W) = Normal reaction(R)

F = μW

F = (0.2)(40)

F = 8N