Chapter No 04

Examples

(4.2)

(a) 1000 kg car at $\frac{1}{2}g$

(b) 200g apple at same rate.

Solution:-

(a) $a = \frac{1}{2}g = \frac{1}{2}(9.8ms^{-2})$

$\frac{1}{2}(9.8ms^{-2}) \approx 5ms^{-2}$

$\Sigma F = ma \approx (1000kg)(5ms^{-2})$

$\boxed{\Sigma F = 5000N}$

(b)

For the apple:-

$m = 200g = 0.2kg$

$\Sigma F = ma \approx (0.2)(5ms^{-2})$

$\boxed{\Sigma F = 1N}$

These are two net forces needed to accelerate the body of 1000kg & 200g.

(4.3)

From figure we assume the motion is along +x-axis

Initial velocity $= V_0 = 100 km/h$

$V_0 = 27.8 m/s$

Final velocity $= V = 0$

Distance travelled $= x - x_0 = 55m$

Solution:-

As we know:-

$$V^2 = V_0^2 + 2aS$$

$$V^2 = V_0^2 + 2a(x - x_0) \qquad \therefore S = (x - x_0)$$

$$a = \frac{V^2 - V_0^2}{2(x - x_0)}$$

$$a = \frac{0 - (27.8 ms^{-1})^2}{2(55m)}$$

$$\boxed{a = -7.0 ms^{-2}}$$

Then net force required is:-

$$\Sigma F = ma$$

$$= (1500kg)(-7.0)$$

$$= -1.1 \times 10^4 N$$

$$\boxed{\Sigma F = -1.1 \times 10^4 N}$$

⟹ The negative sign means that the force must be exerted in direction opposite to initial velocity"

(4.6)

$m = 10.0\,kg$

$weight_{Box} = ?$

$F = 40.0\,N$

Force exerted by each box = ?

(a) Determine weight of box & normal force exerted on it by the table.

weight of the box is $mg = (10.0\,kg)(9.8\,ms^{-2})$

weight of box = 98.0 N (This force act downward)

Net force on the box = $\Sigma F_y = F_N - mg$

⟹ (Negative sign indecates that mg acts in negative y direction)

$\Sigma F_y = ma_y$ & $a_y = 0$

By newton's 2nd Law: $\boxed{F = ma}$

$\Sigma F_y = ma_y$

$F_N - mg = 0$

So we have $\boxed{F_N = mg}$

⟹ Normal force exerted by table is 98.0N upward with magnitude equal to box weight.

(b) In this case another force is also involved which is the force of friend. Again determine normal force exerted by table on box.

weight of box is $mg = 98.0\,N$

net force $= \Sigma F_y = F_N - mg - 40.0\,N$

$$\Sigma F_y = F_N - mg - 40.0\,N = 0 \quad \left(\text{Because box remains at rest}\right)$$
$(a = 0)$

$$\Sigma F_y = F_N - 40.0\,N - mg = 0$$

For normal force:-

$$F_N = mg + 40.0\,N = 98.0\,N + 40.0\,N$$

$$\boxed{F_N = 138.0\,N}$$

(c) If your friend pulls the box upward with a force of 40.0 N, Then what will the normal force exerted on box by table?

Box's weight $= 98.0\,N$ (acts downward)

The net force again sets to zero in newton's 2nd law of motion because $(a=0)$ is

$$\sum F_y = F_N - mg + 40.0N = 0$$

So

$$F_N = mg - 40.0N$$
$$= 98.0N - 40.0N$$
$$\boxed{F_N = 58.0N}$$

4.7

Solution:-

The net ~~box~~ force on box is

$$\sum F_y = F_N - mg + F_P$$
$$\sum F_y = F_N - 98.0N + 100.0N$$

if we set this equal to zero.

$$F_N - 98.8N + 100.0N = 0$$

we would get $F_N = -2.0N$

Negative sign denotes F_N is downward,

$$\sum F_y = F_P - mg$$
$$= 100.0N - 98.0N$$
$$\boxed{\sum F_y = 2.0N}$$

at least we can say F_N

equal to zero.

$$\boxed{\sum F_y = 2N}$$

The net force is upward.

By applying newton's 2nd law of motion.

$$\sum F_y = ma_y$$

$$a_y = \frac{\sum F_y}{m}$$

$$a_y = \frac{2.0N}{10.0kg} = 0.20\, m/s^{+2}$$

$$\boxed{a_y = 0.20 ms^{-2}}$$

(4.8)

$m = 65kg$

weight $= ma = ?$

$a = 0.20$ (downward)

$v = 2.0 ms^{-1}$

Solution:-

(a)

Acceleration $= 0.20g$

From newton's 2nd law,

$$F = ma$$

Scanned with CamScanner

$\sum F = ma$

$mg - F_N = ma$

$mg - F_N = m(0.2mg)$

Now solve for F_N:-

$F_N = mg - 0.20mg$

$\boxed{F_N = 0.80mg}$ (acts upward)

weight = 65Kg

$F_N = mg$

$F_N = (65Kg)(9.8ms^{-2})$

$\boxed{F_N = 640N}$

But the Scale, needing to exert a force of only 0.80mg will give a reading of.

$0.80m = 52Kg$

(b)

There is no acceleration i.e $a=0$

Newton's Second law:-

$F_N = mg$

The Scale reads her true mass of 65Kg. $\boxed{F_N = 640N}$

⟹ "The Scale in (a) may give a reading of 52kg (as a apparent mass), But her mass close not change as a result of acceleration, it says at 65kg."

(4.9)

$|F_A| = 40.0N$ $\theta_A = 45.0^\circ$

$|F_B| = 30.0N$ $\theta_B = 37.0^\circ$

$\vec{F_A}$ & $F_B = ?$

Solution:-

→ Here components of $\vec{F_A}$ are F_{Ax} & F_{Ay}.

$$F_{Ax} = F_A \cos\theta$$

$$F_{Ax} = F_A \cos 45.0^\circ = (40.0N)(0.707)$$

$$\boxed{F_{Ax} = 28.3N}$$

$$F_{Ay} = F_A \sin\theta$$

$$F_{Ay} = F_A \sin(45.0)$$

$$= (40.0)(0.707)$$

$$\boxed{F_{Ay} = 28.3N}$$

⟹ Now components of $\vec{F_B}$ are F_{Bx} & F_{By}.

$$F_{Bx} = + F_B \cos 37.0^\circ$$

$= (30.0N)(0.799)$

$$\boxed{F_{BX} = 24.0N}$$

$F_{By} = -F_B \cos 37.0^\circ$

$= -(30.0N)(0.799)$

$$\boxed{F_{By} = -18.1N}$$

F_{By} is negative because it is along negative y-axis.

Resultant Forces:-

$F_{RX} = F_{AX} + F_{BX}$

$= 28.3N + 24.0N$

$$\boxed{F_{RX} = 52.3N}$$

$F_{Ry} = F_{Ay} + F_{By}$

$= 28.3N - 18.1N$

$$\boxed{F_{Ry} = 10.2N}$$

Magnitude of Resultant Force:-

$F_R = \sqrt{F_{RX}^2 + F_{RY}^2}$

$F_R = \sqrt{(52.3)^2 + (10.2)^2}$

$$\boxed{F_R = 53.3N}$$

Angle:-

The angle θ which is make by $\vec{FR}$ with x-axis.

$$\tan\theta = \frac{F_{Ry}}{F_{Rx}}$$

$$= \frac{10.2N}{52.3N} = 0.195$$

$$\tan\theta = 0.195$$

$$\theta = \tan^{-1}(0.195)$$

$$\boxed{\theta = 11.0^\circ}$$

(4.11)

$m = 10.0 kg$

$a = ?$

$F_P = 40.0N$

$\theta_P = 30.0$

$|F_N| = ?$

Solution:-

(a) Find acceleration of the box:-

F_P = The force exerted by a person is given = $40.0 N$

Chose axis by resolve Vectors:-

$$F_{Px} = F_P \cos\theta$$

$$= (40.0N)(\cos 30.0^\circ)$$

$$\boxed{F_{Px} = 34.6N}$$

$$F_{Py} = F_P \sin\theta$$

$$= (40.0N)(\sin 30^\circ)$$

$$\boxed{F_{Py} = 20.0N}$$

In horizontal direction, $\vec{F_N}$ & mg have zero components. Thus horizontal component of net force is F_{Px}.

⟹ To determine x component of acceleration use newton's second law of motion

$$F_{Px} = ma_x$$

$$a_x = \frac{F_{Px}}{m} = \frac{34.6N}{10.0kg}$$

$$\boxed{a_x = 3.46ms^{-2}}$$

Acceleration of box is $3.46ms^{-2}$ to the right.

(b) Find F_N:-

Apply newton's second law of

motion to Vertical y direction, with upward as positive.

$\Sigma F_y = ma_y$

$F_N - mg + F_{Py} = ma_y$

$F_N - 98.0N + 20.0N = 0$ ∴ The box close not move Vertically $a_y = 0$

So:-

$F_N = 98.0N - 20.0N$

$\boxed{F_N = 78.0N}$

(4.12)

$m_A = 12.0\,kg$

$m_B = 10.0\,kg$

$F_P = 40.0N$

a of T = ?

(a) Find acceleration of each box:-

For box A

we apply $\Sigma F_x = ma_x$

According to given Condition:-

$\Sigma F_x = F_P - F_T = m_A a_A \longrightarrow (1)\ eq$

For box B

For box B only the horizontal

Force is F_T. So

$$\sum F_x = F_T = m_B a_B \longrightarrow (2) \text{ eV}$$

The boxes are connected and if they doesn't stretch then the two boxes have same acceleration.

Thus:-

$$a = a_A = a_B$$

we are given $m_A = 10.0\,kg$ & $m_B = 12.0\,kg$

⟹ By adding above equations:-

$$(m_A a_A + m_B a_B) = F_P - F_T + F_T$$

$$m_A a + m_B a = F_P$$

$$a(m_A + m_B) = F_P$$

$$a = \frac{F_P}{m_A + m_B} = \frac{40.0\,N}{22.0\,kg}$$

$$\boxed{a = 1.82\,ms^{-2}}$$

(b) Find Tension:-

$$F_T = m_B a_B$$

$$= (12.0\,Kg)(1.82\,ms^{-2})$$

$$\boxed{F_T = 21.8\,N}$$

Thus F_T is less than F_P ($40.0\,N$), as we expect, since F_T acts accelerate only m_B.

(4.13)

$m_c = 1000 Kg$

$m_E = 1150 Kg$

a & $F_t = ?$

Solution:-

(a) Acceleration of elevator:-

Newton's 2nd law:-

$$\Sigma F = ma$$

Here mass of an elevator $= m_E$

mass of Counter weight $= m_c$

So By the Condition:-

$a_c = a$ (because m_c accelerate upward)

$a_E = -a$ (because m_E accelerated downward)

Hence

$$F_T - m_E g = m_E a_E = -m_E a \longrightarrow (i)$$

$$F_T - m_c g = m_c a_c = m_c a \longrightarrow (ii)$$

By Subtract first eq from Second eq:-

$$(F_T - m_c g) - (F_T - m_E g) = m_c a - (-m_E a)$$

$$\cancel{F_T} - m_c g - \cancel{F_T} + m_E g = m_c a + m_E a$$

$$(m_E - m_c) g = (m_E + m_c) a$$

$$a = \frac{m_E - m_c}{m_E + m_c} g$$

$a = \frac{1150\,kg - 1000\,kg}{1150\,kg + 1000\,kg} g$

$a = 0.070\,g$

$\boxed{a = 0.68\,ms^{-2}}$

(b) Tension in the Cable:-

$\Sigma F = ma$

from (i) eq $F_T - m_E g = -m_E a$

$F_T = -m_E a + m_E g$

$F_T = (g - a) m_E$

$F_T = (9.80\,ms^{-2} - 0.68\,ms^{-2})\,1150\,kg$

$\boxed{F_T = 10,500\,N}$

from (ii) eq $F_T - m_c g = m_c a$

$F_T = m_c a + m_c g$

$F_T = m_c (a + g)$

$\boxed{F_T = 10,500\,N}$

"Hence we observe that the calculation given F_T between 9800N & 11,300N"

4.15

$a = 1.20\,ms^{-2}$

$V = 90\,Kmh^{-1}$

$\theta = ?$

(a) Find Angle:-

$a = 1.20\,ms^{-2}$

From newton's 2nd law of motion:-

$$F = ma$$

$$F_T \sin\theta = ma \longrightarrow \text{(i) eq}$$

for horizontal components, wherese the vertical component gives.

$$0 = F_T \cos\theta - mg$$

$$mg = F_T \cos\theta \longrightarrow \text{(ii) eq}$$

Divides these two equations, we obtained.

$$\frac{F_T \sin\theta}{F_T \cos\theta} = \frac{ma}{mg}$$

$$\tan\theta = a/g \qquad \therefore \tan\theta = \frac{\sin\theta}{\cos\theta}$$

$$\tan\theta = \frac{1.20\,ms^{-2}}{9.80\,ms^{-2}}$$

$$\tan\theta = 0.122$$

$$\theta = \tan^{-1}(0.122)$$

$$\boxed{\theta = 7.0^\circ}$$

(b) When the car moves constant velocity:- $V = 90\,Kmh^{-1}$

As velocity is constant

So $a = 0$

$\tan\theta = a/g$

$\tan\theta = 0$

$\Rightarrow$ Hence pendulum hangs vertically.

$$\boxed{\theta = 0^\circ}$$

(4.16)

mass = m

F_N & $a = ?$

Solution:-

(a) There is no motion in the y direction, So $a_y = 0$

By applying newton's 2nd law

$F_y = ma_y$

$F_N = mg\cos\theta = 0$

where F_N & y component of gravity $(mg\cos\theta)$ are all forces acting on the box in the y direction

Thus normal force is:-

$\boxed{F_N = mg \cos\theta}$

(b)

In the x direction the only force acting is the x components of $\vec{mg}$ which we see from diagram is

$mg = \sin\theta$

$F_x = ma_x$

$\cancel{m}g \sin\theta = \cancel{m}a$

$\boxed{a = g \sin\theta}$

(c)

For

$\theta = 30°$, $\cos\theta = 0.866°$ & $\sin\theta = 0.500$

$F_N = 0.866mg = 85N$

&

$a = 0.500g = 4.9ms^{-2}$

$\boxed{a = 4.9ms^{-2}}$