Name: Shreyas Srinivasa

ID Number: 012551187

19.

(a) Using $\vec{F}_{net} = \sum \vec{F}$

$= \vec{F}_1 + \vec{F}_2$

Substitute $(3.0\hat{i} + 6.0\hat{j})N$ for $\vec{F}_2$ and $(2.0\hat{i} + 4.0\hat{j})N$ for $\vec{F}_1$

$\vec{F}_{net} = (2.0\hat{i} + 4.0\hat{j})N + (3.0\hat{i} + 6.0\hat{j})N$

$= (5\hat{i} + 10\hat{j})N$

Hence, the resultant force acting on a rope is $(5\hat{i} + 10\hat{j})N$

(b) Using

$F_{net} = |\vec{F}_{net}|$

$= \sqrt{(F_{net})_x^2 + (F_{net})_y^2}$

Substitute 5N for $(F_{net})_x$ and 10 N for $(F_{net})_y$.

$F_{net} = \sqrt{(5.0N)^2 + (10.0N)^2} = \sqrt{25N + 100N}$

$= \sqrt{125}\ N = 5\sqrt{5}\ N$

~~Using~~

Hence the magnitude of the resultant force acting on a rope is ($F_{net} = 5\sqrt{5}\ N$)

Using $\theta = \tan^{-1}\left(\frac{(F_{net})_y}{(F_{net})_x}\right)$

Substitute 5N for $(F_{net})_x$ and 10N for $(F_{net})_y$

$\theta = \tan^{-1}\left(\frac{10.0}{5.0}\right) = \tan^{-1}(2.0) = 63.4°$

Hence, the angle measured from the positive x axis is 63.4°

29. Using
$F_{ma} = ma$

Substitute 2.10×10^3 kg for m and $-196\ m/s^2$ for a (negative sign denotes deceleration).

$F_{net} = (2.10 \times 10^3\ kg)(196\ m/s^2)$

$= 411.6 \times 10^3\ N$

$= 4.12 \times 10^5\ N$

Hence, the necessary force required to produce the deceleration of 196 m/s^2 is 4.11×10^5 N

31. Convert 1000 km/h into m/s

$$1000 \text{ km/h} = \left(1000 \frac{\text{km}}{\text{h}}\right)\left(\frac{1 \text{ km}\left(\frac{10^3 \text{ km}}{1 \text{ km}}\right)}{1 \text{ h}\left(\frac{3600 \text{ s}}{1 \text{ h}}\right)}\right)$$

$$= 277.78 \text{ m/s} \approx 278 \text{ m/s}$$

Substitute 0 m/s for v, 278 m/s for u and 1.10 s for t in $v = u + at$

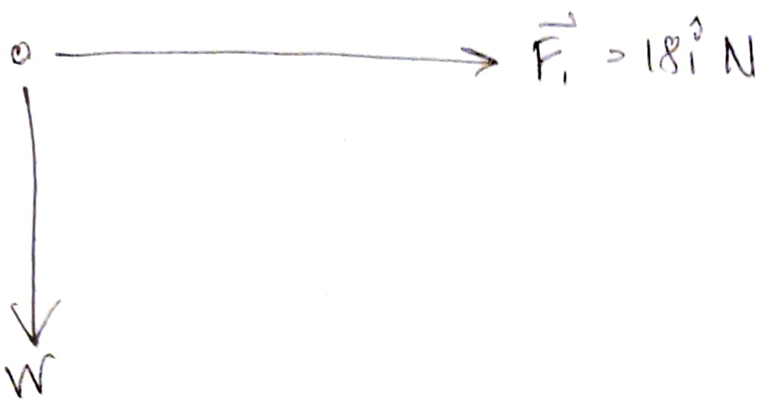
$$0 \text{ m/s} = 278 \text{ m/s} + a(1.10 \text{ s})$$

$$a = \frac{-278 \text{ m/s}}{1.10 \text{ s}} = -252.72 \text{ m/s} \approx -253 \text{ m/s}$$

Hence, the deceleration of the rocket sled before coming to rest is 253 m/s

37. Using $s = ut + \frac{1}{2}at^2$ and $F_{net} = ma$

Free body diagram of the particle is,



(a) Substitute 2.0 kg for m and 18 N for F_{net}

$$18 \text{ N} = (2.0 \text{ kg})a$$

$$a = \frac{18 \text{ kg} \cdot \text{m/s}^2}{2.0 \text{ kg}}$$

$$= 9 \text{ m/s}^2$$

Hence the acceleration of the body is 9 m/s^2

(b) Using $s = ut + \frac{1}{2}at^2$

Substitute 0 m/s for u, 9 m/s^2 for a and 9 m/s^2 for a,

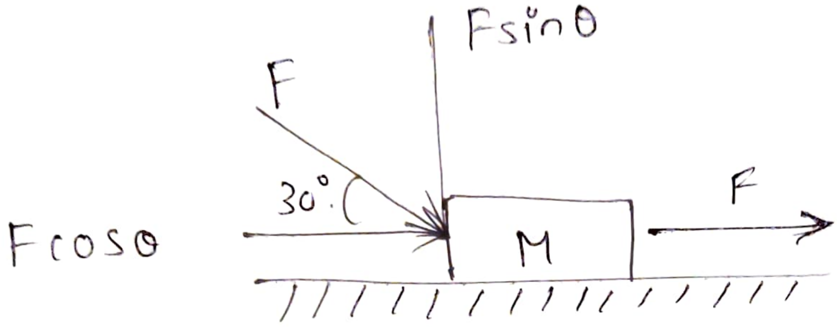
$$s = 0 \text{ m/s}^2 + \frac{1}{2}(9 \text{ m/s}^2)(5 \text{ s})^2$$

$$= \frac{225}{2} \text{ m} = 112.5 \text{ m}$$

Hence the distance travelled by the particle in

5s of time is 112.5m

40. The free body diagram explains the motion of the block when the force is applied:



Using $F_{net} = F + F\cos\theta$

Substitute 30° for θ and 30 N for F

$F_{net} = 30\,N + (30\,N)\cos 30° = 55.98\,N$

Using $F_{net} = ma$

Substitute 10.0 kg for m and 55.98 N for F_{net}

$55.98\,N = (10\,kg)a$

$$a = \left(\frac{55.98\,N}{10\,kg}\right) = 5.598\,m/s^2$$

$a \approx 5.60\,m/s^2$

Therefore, the acceleration of the block is $5.60\,m/s^2$

51. (a) Using $F_{net} = ma$

Substitute 1100 kg for m and $2.4 \times 10^4 \ m/s^2$ for F_{net}

$$F_{net} = (1100.0 \ kg)(2.40 \times 10^4 \ m/s^2)$$

$$= 2.64 \times 10^7 \ kg \cdot m/s^2$$

$$= 2.64 \times 10^7 \ kg \cdot m/s^2.$$

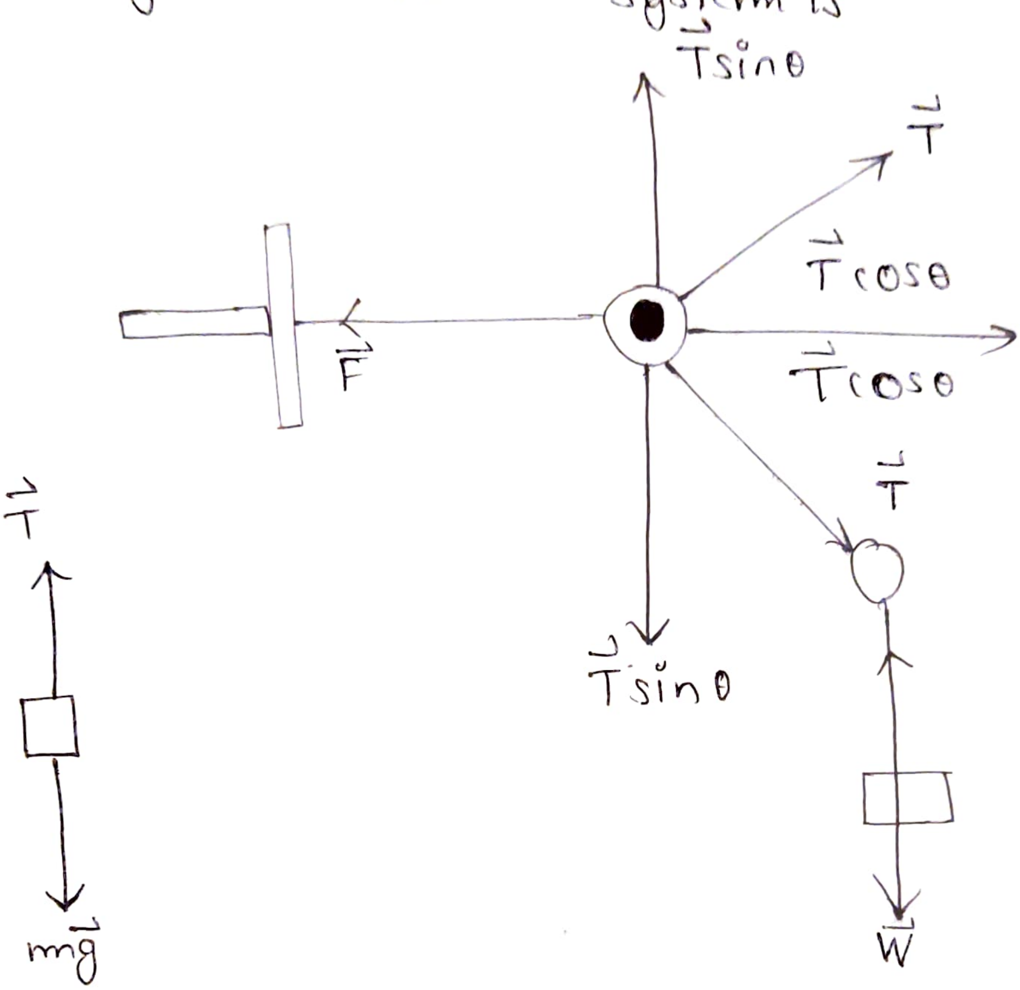
$$= 2.64 \times 10^7 \ N$$

Hence the net force exerted on the artillery shell is $2.64 \times 10^7 \ N$

(b) In accordance with the Newton's third law the force exerted on the ship by the artillery shell is equal to the force exerted on the shell but in opposite direction.

Hence the net force exerted on the ship is $2.64 \times 10^7 \ N$

55. Free body of the traction system is



(a) As per the F.B.D of the pulley closest to foot,

$$\vec{F} = \sum \vec{T}_x$$

$$= (\vec{T}\cos\theta\,\hat{i}\,N) + (\vec{T}\cos\theta\,\hat{i}\,N)$$

$$= 2\vec{T}\cos\theta\,\hat{i}\,N$$

Hence the force exerted on the foot in vector form is $2\vec{T}\cos\theta\,\hat{i}$ N.

In scalar form it can be expressed as

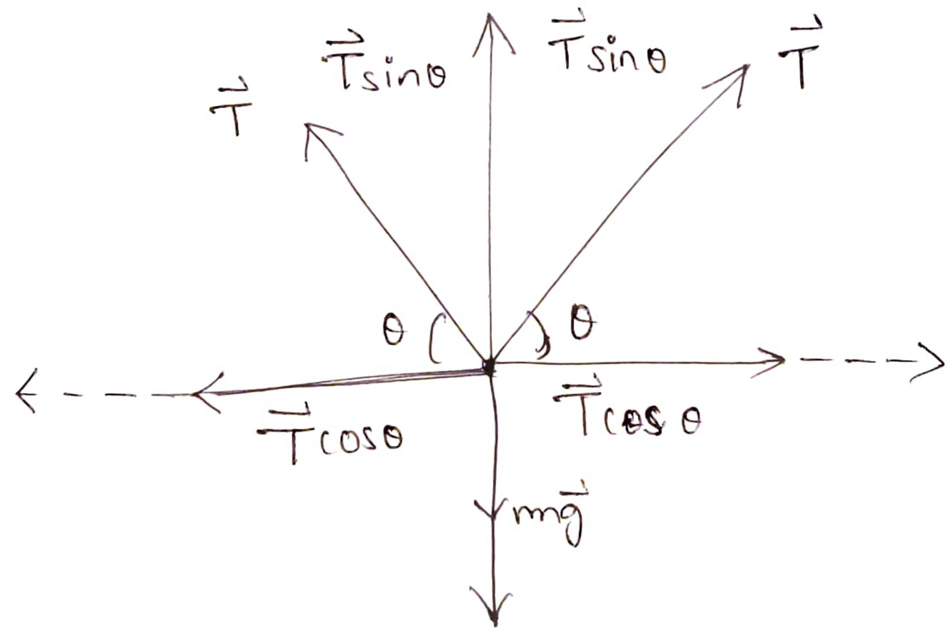
$F = 2T\cos\theta$ N.

(b) As per the F.B.D of the figure at a point where weight is attached,

$$\vec{T} = \vec{W} = m\vec{g}$$

Hence the tension of the rope is $m\vec{g}$

63. Free body diagram of the bird is as,



Convert 26g into kg

$$26g = (26g)\left(\frac{10^{-3}\,kg}{1g}\right) = 0.026\,kg$$

Using $F = mg$

As F_y net $= 0$, therefore as per the free body diagram,

$$F_{y\,net} = F - 2T\sin\theta^{\circ}$$

$0 = mg - 2T\sin\theta^\circ$

$2T\sin\theta^\circ = mg$

$$T = \frac{mg}{2\sin\theta^\circ}$$

Hence the tension in the rope is $\frac{mg}{2\sin\theta^\circ}$

(b) Substitute 0.026 kg for m, $9.80\ m/s^2$ for g and 5° for θ in equation $T = \frac{mg}{2\sin\theta^\circ}$

$$T = \frac{(0.026\ kg)(9.81\ m/s^2)}{2\sin 5^\circ}$$

$$= \frac{(0.255\ kg\cdot m/s^2)}{0.174}$$

$= 1.46\ kg\cdot m/s^2 = 1.5\ N$

Hence the tension in the telephone line when $\theta^\circ = 5^\circ$ is 1.5 N

(c) Substitute 0.026 kg for m, $9.80\ m/s^2$ for g and 0.5° for θ in equation $T = \frac{mg}{2\sin\theta^\circ}$

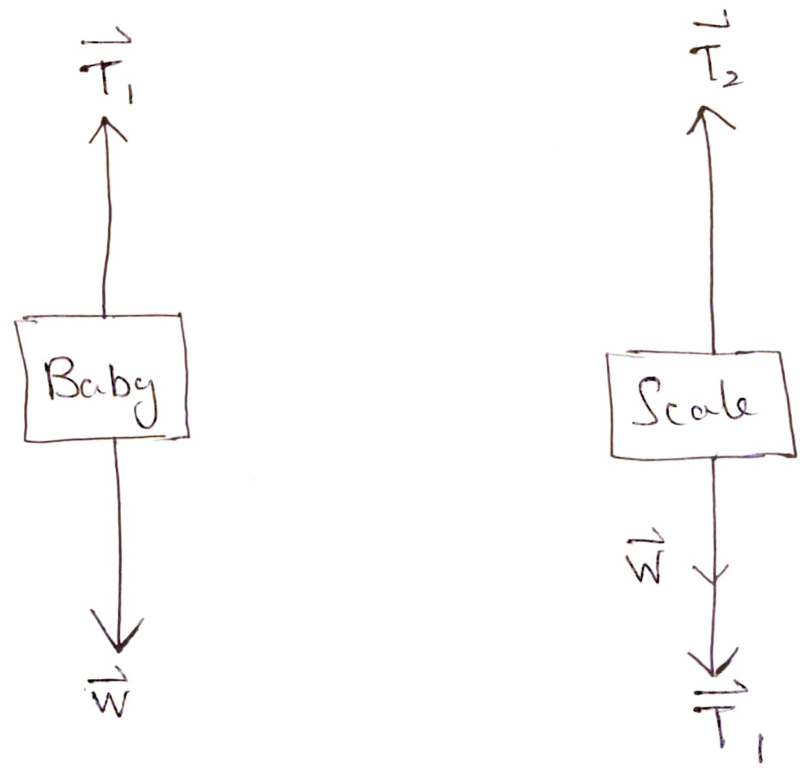
$$T = \frac{(0.026\ \text{kg})(9.81\ \text{m/s}^2)}{2 \sin 0.5^\circ}$$

$$= \frac{(0.255\ \text{kg} \cdot \text{m/s}^2)}{0.0174}$$

$$= 14.6\ \text{kg} \cdot \text{m/s}^2 = 15\ \text{N}$$

Hence the tension in the telephone line when $\theta = 0.5^\circ$ is 15 N

65. Free body diagram of the baby and scale is as follows,



(a) Using $w = mg$

Substitute 55N for w and $9.80\ m/s^2$ for g

$$m = \frac{w}{g} = \frac{55\ N}{9.80\ m/s^2} = 5.6\ kg$$

Hence the mass of the baby and his bucket is 5.6 kg

(b) As per the F.B.D of the baby,

$T_1 = w$

Substitute 55 N for w,

$T_1 = 55\ N$

Hence the tension in the string which attaches baby with scale is 55 N

(c) Using $w = mg$

Substitute 0.5 kg for m and $9.80\ m/s^2$ for g

$w = (0.5\ kg)(9.8\ m/s^2)$

$= 4.9\ kg \cdot m/s^2$

$= 4.9\ N$

As per the F.B.D at scale

$T_2 - T_1 = w$

Substitute 55 N for T_1 and 4.9 N for w,

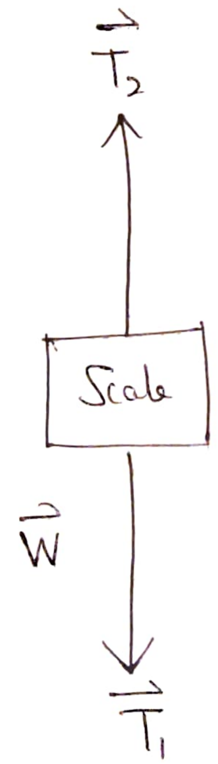
$$T_2 - (55\text{ N}) = (4.9\text{ N})$$

$$T_2 = (59.9\text{ N})$$

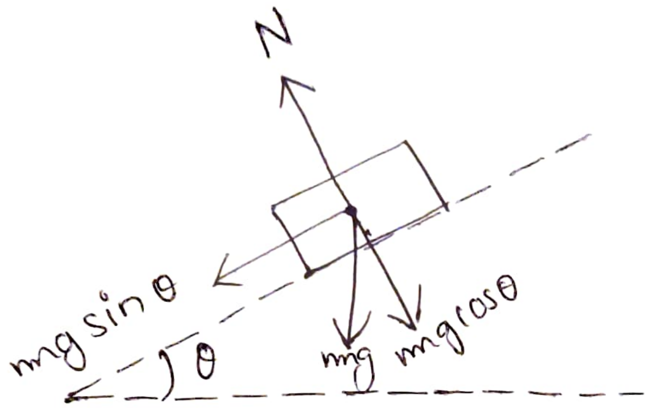
$$= 60\text{ N}$$

Hence the tension in the string which attaches ceiling and the scale is 60 N

(d) The systems of interest are given as along with the F.B.D



67. Free body diagram of the block is as



(a) From free body diagram,

$$(F_{net})_x = mg\sin\theta$$

From Newton's second law.

$$a_x = \frac{F_{net\,x}}{m}$$

Substitute $mg\sin 30°$ for $(F_{net})_x$ and $30°$ for θ

$$a_x = \frac{m\vec{g}\sin 30°}{m} = g\sin 30°$$

Substitute $9.8\ m/s^2$ for g

$$a_x = (9.8\ m/s^2)\sin 30°$$
$$= 4.9\ m/s^2$$

Hence, the acceleration of the block down the ramp is $4.9\ m/s^2$

From F.B.D,

$N = mg\cos\theta$

Substitute 2.0 kg for m, $9.8\ m/s^2$ for g and $30°$ for θ.

$N = (2.0\ kg)(9.8\ m/s^2)(\cos 30°)$

$= 17\ kg \cdot m/s^2 = 17\ N$

Hence, the force exerted by the ramp on the block is 17 N

(b) Using Σ

$F - mg\sin\theta = 0$ from F.B.D

Substitute 2.0 kg for m, $30°$ for θ and $9.8\ m/s^2$ for g

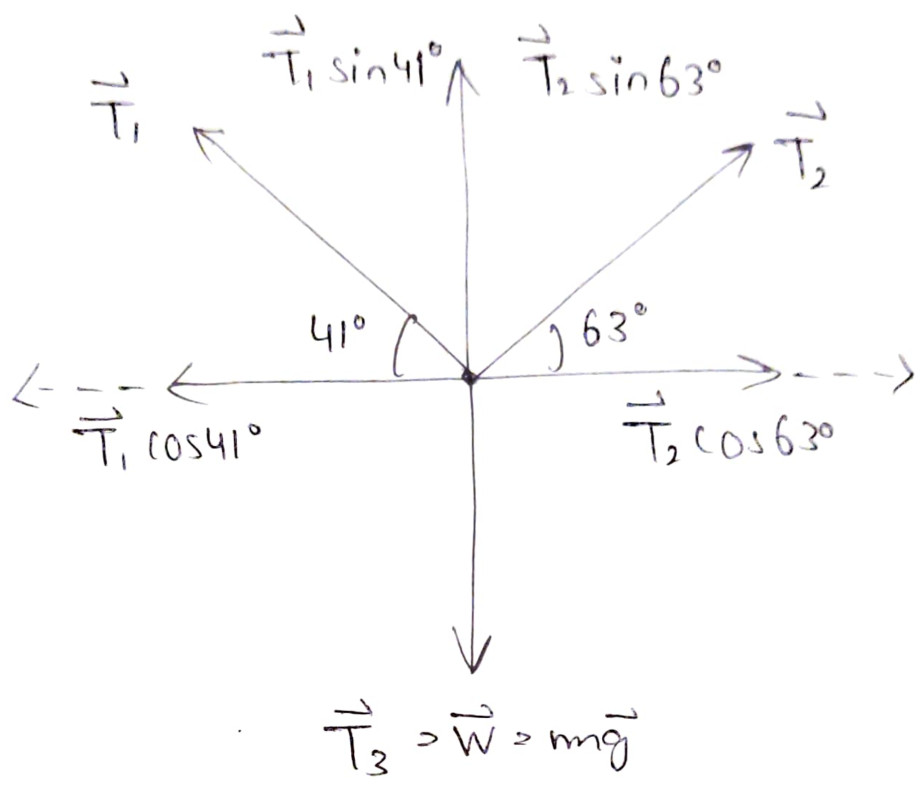
$F - mg\sin\theta = 0$

$F = (2.0\ kg)(9.8\ m/s^2)\sin 30°$

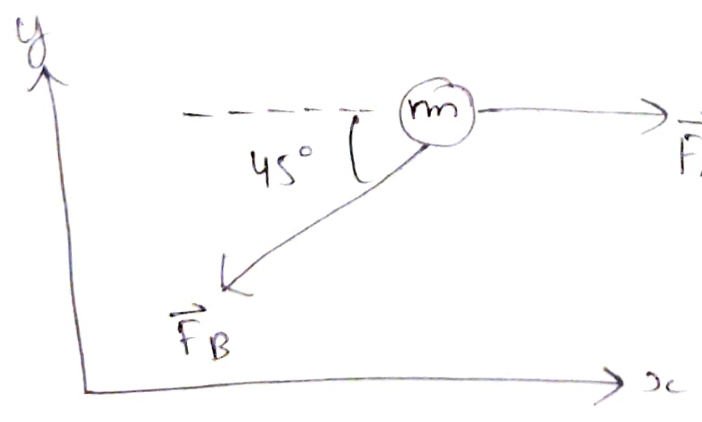
$= 9.8\ N$

Hence, the force required to push the block with constant velocity is 9.8 N

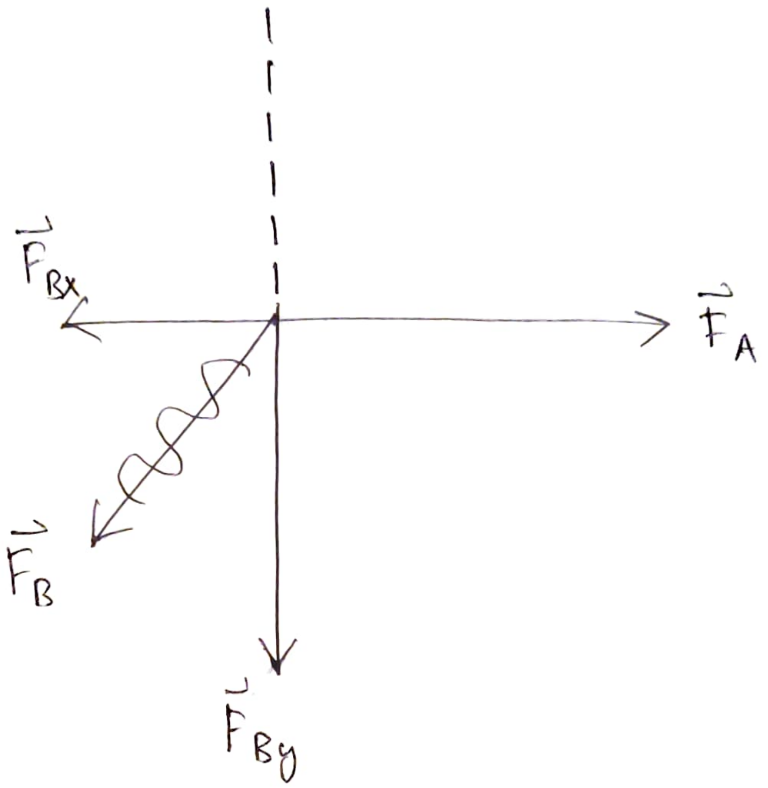
7). The free body diagram of the figure is,



8). The schematic diagram:-



The free body diagram of the particle is as,



Resolve the force $\vec{F}_A$ along horizontal and vertical components,

$$\vec{F}_{Ax} = \vec{F}_A \hat{i} \text{ N}$$

$$\vec{F}_{Ay} = 0\hat{j} \text{ N}$$

$$\vec{F}_A = \vec{F}_{Ax} + \vec{F}_{Ay}$$

Substitute $\vec{F}_A \hat{i}$ N for $\vec{F}_{Ax}$ and $0\hat{j}$ N for $\vec{F}_{Ay}$

$$\vec{F}_A = \vec{F}_A \hat{i} + 0\hat{j} \text{ N}$$

$$= (\vec{F}_A \hat{i} + 0\hat{j}) \text{ N}$$

Hence the force $\vec{F}_A$ is $(\vec{F}_A \hat{i} + 0\hat{j})$ N

Resolve $\vec{F}_B$ along its components

$\vec{F}_{Bx} = -\vec{F}_B \cos 45° \hat{i}$ N

Substitute $2\vec{F}_B$ for $\vec{F}_B$ in above equation and solve,

$\vec{F}_{Bx} = -2\vec{F}_A \left(1/\sqrt{2} \right)\hat{i}$ N $= -\sqrt{2}\, F_A \hat{i}$ N

$\vec{F}_{By} = -\vec{F}_B \sin 45° \hat{j}$ N

Substitute $2\vec{F}_B$ for $\vec{F}_B$ in above equation and solve,

$\vec{F}_{By} = -2\vec{F}_A \left(1/\sqrt{2} \right)\hat{j}$ N $= -\sqrt{2}\, \vec{F}_A \hat{j}$ N

$\vec{F}_B = \vec{F}_{Bx} + \vec{F}_{By}$

Substitute $-\sqrt{2}\, F_A \hat{i}$ N for $\vec{F}_{Bx}$ and $-\sqrt{2}\, \vec{F}_A \hat{j}$ N for $\vec{F}_{By}$ in the above eq.

$\vec{F}_B = -\sqrt{2}\, \vec{F}_A \hat{i}$ N $- \sqrt{2}\, \vec{F}_A \hat{j}$ N

$= -\sqrt{2} \left(\vec{F}_A \hat{i} + \vec{F}_A \hat{j} \right)$ N

$$\vec{F}_{net} = \sum \vec{F} = \vec{F}_A + \vec{F}_B$$

Substitute $(\vec{F}_A\hat{i} + 0\hat{j})N$ for $\vec{F}_A$, $-\sqrt{2}(\vec{F}_A\hat{i} + \vec{F}_A\hat{j})N$ for $\vec{F}_B$

$$\vec{F}_{net} = (\vec{F}_A\hat{i} + 0\hat{j})N + (-\sqrt{2}(\vec{F}_A\hat{i} + \vec{F}_A\hat{j})N)$$

$$= (\vec{F}_A\hat{i} - \sqrt{2}\vec{F}_A\hat{i})N + (0\hat{j} - \sqrt{2}\vec{F}_A\hat{j})N$$

$$= (-0.414\hat{i})N + (-1.414\hat{j})N$$

$$= (-0.414\hat{i} - 1.414\hat{j})N$$

Hence the resultant force acting on the particle is $(-0.414\hat{i} - 1.414\hat{j})N$

$$\theta = \tan^{-1}\left(\frac{(F_{net})_y}{(F_{net})_x}\right)$$

Substitute $-0.414N$ for $(F_{net})_x$ and $-1.414N$ for $(F_{net})_y$

$$\theta = \tan^{-1}\left(\frac{-1.41}{-0.41}\right) = 180^\circ + \arctan\left(\frac{1.41}{0.41}\right)$$

$$= 254^\circ$$

Hence the direction of accelaration of the particle is 254°