

①

Given $\vec{a} = 2\hat{i} + \hat{j} + \hat{k}$ and $\vec{b} = -4\hat{i} - 2\hat{j} + 3\hat{k}$ are taken in order

$$\begin{aligned}\therefore \vec{c} &= -(\vec{a} + \vec{b}) \\ &= -[2\hat{i} + \hat{j} + \hat{k} + (-4\hat{i} - 2\hat{j} + 3\hat{k})] \\ &= -[-2\hat{i} - \hat{j} + 4\hat{k}]\end{aligned}$$

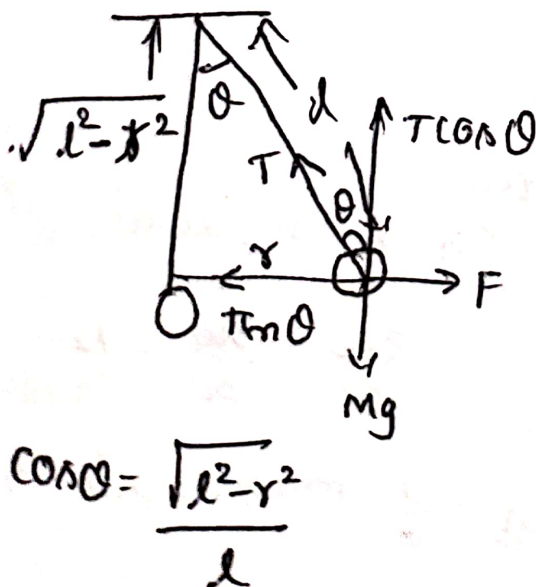
②

Given $\vec{a} = 2\hat{i} + \hat{j} - \hat{k}$; $\vec{b} = 3\hat{i} + 2\hat{j} + \hat{k}$ are represented on the adjacent sides of a triangle taken in order. Then the closing side = $-(\vec{a} + \vec{b})$

represent closing side is taken in reverse order,

$$\begin{aligned}\therefore \text{closing side} &= 2\hat{i} + \hat{j} - \hat{k} + 3\hat{i} + 2\hat{j} + \hat{k} \\ &= 5\hat{i} + 3\hat{j} =\end{aligned}$$

④



$$\begin{aligned}T \cos \theta &= Mg \Rightarrow T = \frac{Mg}{\cos \theta} \\ T \sin \theta &= F \\ \therefore \frac{T \sin \theta}{T \cos \theta} &= \frac{F}{Mg} \\ \tan \theta &= \frac{F}{Mg}\end{aligned}$$

$$\begin{aligned}T &= \frac{Mg}{\cos \theta} \\ &= \frac{Mg}{\frac{\sqrt{l^2 - r^2}}{l}} \\ T &= \frac{Mgl}{\sqrt{l^2 - r^2}}\end{aligned}$$

⑤

Given $|\vec{A}| = 12$; $|\vec{B}| = 5$; $|\vec{C}| = 13$.

$$\vec{C} = \vec{A} + \vec{B}$$

$$\Rightarrow C = \sqrt{A^2 + B^2 + 2AB \cos \theta}$$

$$\Rightarrow C^2 = A^2 + B^2 + 2AB \cos \theta$$

$$\Rightarrow 13^2 = 12^2 + 5^2 + 2(12)(5) \cos \theta$$

$$\Rightarrow 169 = 144 + 25 + 120 \cos \theta \Rightarrow 120 \cos \theta = 0$$

$$\Rightarrow \cos \theta = 0$$

$$\Rightarrow \theta = 90^\circ \text{ or } \frac{\pi}{2}$$

⑥

From triangle law of vector addition

The resultant must be zero if the sum of two vectors $\geq$ remaining vector

in all the options except D, the sum of two forces $\geq$ remaining force.

However for option D, $10 + 20 = 30 < 40$

Hence the resultant can not be zero for option D.

⑦

The minimum no. of ^{equal} forces required for resultant to be 0 is $\frac{360}{30} = \frac{360}{30} = 12$

Here 11 equal forces of magnitude 5N are there.
so remaining 1 more 5N required to make resultant 0.



⑧

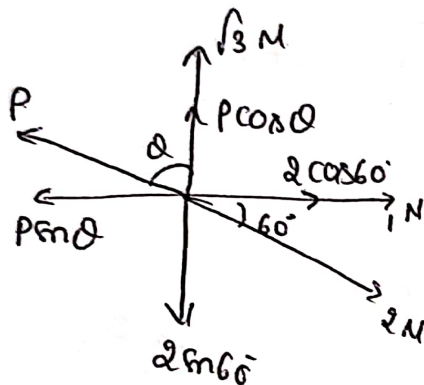
No. of forces are $N = 6$

If N forces are acting at point, the resultant is zero if the angle between the forces is $\frac{360}{N}$

$$\text{Here } \theta = \frac{360}{6} = 60^\circ$$

So the resultant is zero

⑨



under equilibrium

Net force along x-axis = 0

$$\begin{aligned} \text{i.e. } P \sin \theta &= 2 \cos 60^\circ + 1 \\ &= 2 \times \frac{1}{2} + 1 \\ P \sin \theta &= 2 \end{aligned}$$

Net force along y-axis = 0

$$\Rightarrow P \cos \theta + \sqrt{3} = 2 \sin 60^\circ$$

$$\Rightarrow P \cos \theta + \sqrt{3} = 2 \times \frac{\sqrt{3}}{2}$$

$$\Rightarrow P \cos \theta + \sqrt{3} = \sqrt{3}$$

$$\Rightarrow P \cos \theta = 0 \Rightarrow \theta = 90^\circ$$

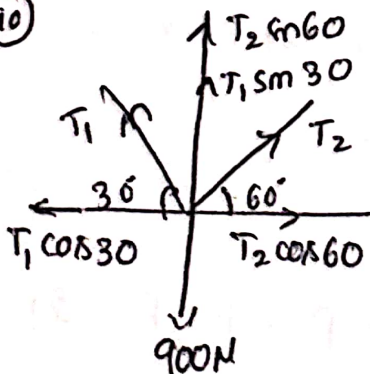
$\therefore$ we know that

$$P \sin \theta = 2$$

$$\Rightarrow P \sin 90^\circ = 2$$

$$\Rightarrow P = 2N$$

⑩



under equilibrium

Net force along x-axis = 0

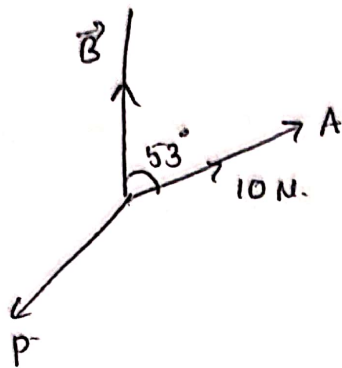
$$\Rightarrow T_1 \cos 30^\circ = T_2 \cos 60^\circ$$

$$\Rightarrow T_1 \frac{\sqrt{3}}{2} = T_2 \frac{1}{2}$$

$$\Rightarrow \frac{T_1}{T_2} = \frac{1}{\sqrt{3}}$$

Advanced level

①



Given

$$\cos 53 = \frac{3}{5}$$

we know that when the system is at equilibrium

$$\vec{A} + \vec{B} + \vec{P} = 0$$

$$\Rightarrow \vec{P} = -(\vec{A} + \vec{B})$$

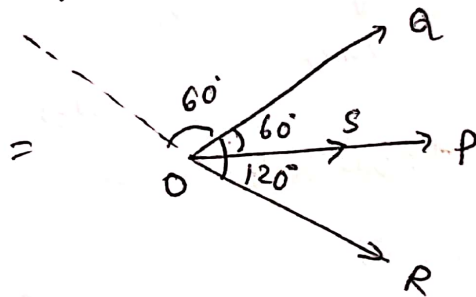
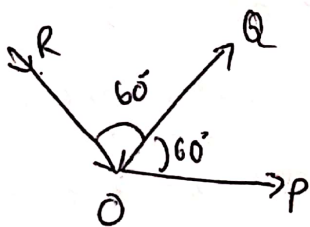
$$\Rightarrow |\vec{P}| = \sqrt{A^2 + B^2 + 2AB \cos \theta}$$

$$= \sqrt{10^2 + 6^2 + 2 \times 10 \times 6 \times \frac{3}{5}}$$

$$= \sqrt{100 + 36 + 72} = \sqrt{208}$$

②

Given $|\vec{R}| = |\vec{Q}| = |\vec{P}| = F$



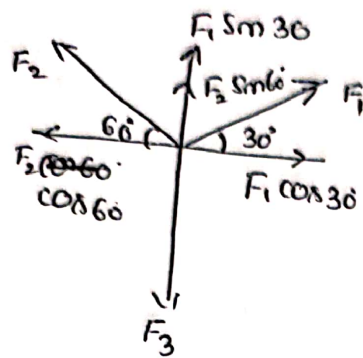
So the resultant^(S) of Q and R is along OP, we can find the resultant (S) by using Parallelogram law of vectors

$$S = \sqrt{R^2 + Q^2 + 2RQ \cos \theta} = \sqrt{F^2 + F^2 + 2FF \cos 120^\circ}$$

$$= \sqrt{2F^2 + 2F^2(-\frac{1}{2})} = \sqrt{2F^2 - F^2} = F$$

$\therefore$ Net force is along OP $= S + P = F + F = 2F$

④



Given $F_3 = 5\sqrt{3} \text{ N}$

$$\therefore F_2 = \sqrt{3} \times 5 = 5\sqrt{3}$$

under equilibrium

$$F_x = 0$$

$$\Rightarrow F_1 \cos 30 = F_2 \cos 60$$

$$\Rightarrow F_1 \frac{\sqrt{3}}{2} = F_2 \cdot \frac{1}{2}$$

$$\Rightarrow \sqrt{3} F_1 = F_2 \Rightarrow \sqrt{3} F_1 = 5\sqrt{3}$$

$$F_y = 0$$

$$F_1 \sin 30 + F_2 \sin 60 = F_3 \Rightarrow F_1 = 5 \text{ N}$$

$$F_1 \frac{1}{2} + \sqrt{3} F_1 \frac{\sqrt{3}}{2} = 5\sqrt{3}$$

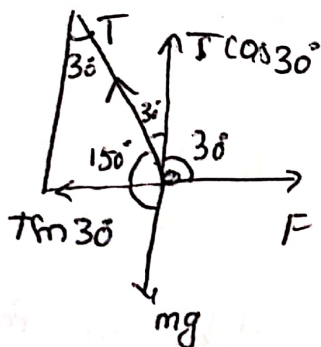
$$\Rightarrow \frac{F_1}{2} + \frac{3F_1}{2} = 5\sqrt{3}$$

$$\Rightarrow 2F_1 = 5\sqrt{3}$$

$$\Rightarrow F_1 = \frac{5\sqrt{3}}{2}$$

$$F_3 = 2 \times 5 = 10 \text{ N}$$

⑦, ⑧, ⑨



Given $m = 0.05 \text{ kg}$

$$T \sin 30 = F \quad ; \quad T \cos 30 = mg$$

$$\Rightarrow \frac{T \sin 30}{T \cos 30} = \frac{F}{mg} \Rightarrow \tan 30 = \frac{F}{mg}$$

$$\Rightarrow F = mg \tan 30 = 0.05 \times 10 \times \frac{1}{\sqrt{3}} = \frac{0.5}{\sqrt{3}}$$

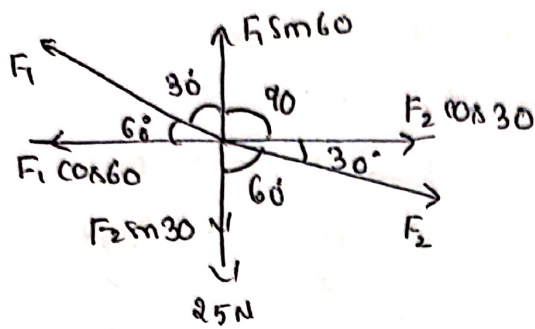
$$\Rightarrow F = 0.28$$

we know

$$T \sin 30 = F \Rightarrow T \left(\frac{1}{2} \right) = 0.28 \Rightarrow T = 0.56 \text{ N}$$

$$\frac{F}{T} = \frac{0.28}{0.56} = \frac{1}{2} = 0.5$$

(10)



under equilibrium

$$F_x = 0$$

$$F_2 \cos 30 = F_1 \cos 60$$

$$\Rightarrow F_2 \frac{\sqrt{3}}{2} = F_1 \frac{1}{2}$$

$$\Rightarrow F_1 = \sqrt{3} F_2$$

$$F_y = 0$$

$$F_1 \sin 60 = F_2 \sin 30 + 25$$

$$\Rightarrow F_1 \frac{\sqrt{3}}{2} = F_2 \left(\frac{1}{2}\right) + 25$$

$$\Rightarrow (\sqrt{3}) F_2 \frac{\sqrt{3}}{2} = \frac{F_2}{2} + 25$$

$$\Rightarrow \frac{3 F_2}{2} - \frac{F_2}{2} = 25$$

$$\Rightarrow F_2 = 25 \text{ N}$$

$$\therefore F_1 = \sqrt{3} (25) = 25\sqrt{3} \text{ N}$$

Angle between 25 N and F_2 is 60° Angle between F_1 and $F_2 = 30^\circ + 90^\circ + 30^\circ = 150^\circ$ L Task
CUQ's

(5)

To keep a particle in equilibrium the net force acting on the body is zero.

$$(i.e) \vec{A} + \vec{B} + \vec{C} = 0$$

$$\Rightarrow \vec{C} = -(\vec{A} + \vec{B})$$

$$= -(\hat{i} + \hat{j} + \hat{k} + 2\hat{i} - \hat{j} + 3\hat{k})$$

$$= -(3\hat{i} + 4\hat{k})$$

⑥

The coordinates of A, B, C, D & E are (0,0) (0,2) (3,1) (2,5) & (1,0)

$$\text{Displacement} = E - A = (1-0, 0-0) \\ = (1, 0)$$

⑦

If N equal forces are acting at a point in equilibrium, their resultant is zero if the angle between successive forces is $\frac{360}{N}$: Given $\theta = 90^\circ$

$$N = \frac{360}{90} = 4.$$

Task See mains level

⑪

$$\text{Mass} = 100 \text{ kg} \\ l = 2 \text{ m.}$$

$$\theta = 60^\circ$$

$$\frac{F}{mg} = \tan \theta$$

$$\Rightarrow F = mg \tan \theta \\ = 100 \times 9.8 \tan 60^\circ \\ = 980 \sqrt{3} \text{ N}$$

⑫ Given $F_1 = 2\hat{i} + \hat{j} - \hat{k} \text{ N}$

$$F_2 = 2\hat{i} + 3\hat{j} - 3\hat{k}$$

$$F_3 = a(\hat{i} + \hat{j} - \hat{k})$$

under equilibrium $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = 0$

$$\Rightarrow 2\hat{i} + \hat{j} - \hat{k} + 2\hat{i} + 3\hat{j} - 3\hat{k} + a(\hat{i} + \hat{j} - \hat{k}) = 0$$

$$\Rightarrow 4\hat{i} + 4\hat{j} - 4\hat{k} + a\hat{i} + a\hat{j} - a\hat{k} = 0$$

$$\Rightarrow (4+a)\hat{i} + (4+a)\hat{j} - (4+a)\hat{k} = 0\hat{i} + 0\hat{j} + 0\hat{k}$$

$$a + 4 = 0$$

$$\Rightarrow a = -4$$

(14)

Given $m = 100 \text{ kg}$

$l = 2 \text{ m}$

$r = 50 \text{ cm}$

we know that $F = mg \sin \theta$

$$F = 100 \times 9.8 \times \frac{r}{\sqrt{l^2 - r^2}}$$

$$F = 980 \times \frac{50 \times 10^{-2}}{\sqrt{4 - \frac{1}{4}}}$$

$$\Rightarrow F = \frac{490}{\frac{\sqrt{15}}{2}} = \frac{2 \times 490}{\sqrt{15}} \approx 980 \text{ N}$$

(15)

we know that $T \propto \frac{1}{l}$

$$\Rightarrow \frac{T_1}{T_2} = \frac{l_2}{l_1} = \frac{3}{4}$$

(18)

No. of forces required to make resultant

$$\text{zero } N = \frac{360}{90} = \frac{360}{90} = 4$$

But Given 3 equal forces of magnitude 5 N

$\therefore$ one more force is required (ie) 5 N to make resultant 0.

(19)

$$m = 40 \text{ kg}$$

$$\theta = 60^\circ$$

Horizontal force $F = mg \tan \theta$

$$= 10 \times 9.8 \tan 60^\circ$$

$$= 10 \times 9.8 \sqrt{3}$$

$$= 10\sqrt{3} \text{ kg wt}$$

(5)

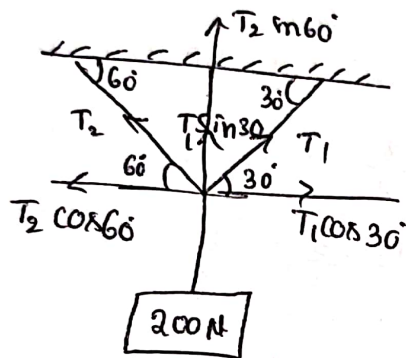
(20)

$$m = 2 \text{ kg} : \theta = 60^\circ$$

$$F = T \sin \theta$$

$$\Rightarrow \frac{F}{T} = \sin 60^\circ = \frac{\sqrt{3}}{2}$$

(21)



$$T_2 = \sqrt{3} T_1$$

$$= 100\sqrt{3} \text{ N.}$$

under equilibrium

$$F_x = 0 \Rightarrow T_1 \cos 30^\circ = T_2 \cos 60^\circ$$

$$\Rightarrow T_1 \frac{\sqrt{3}}{2} = T_2 \frac{1}{2}$$

$$\Rightarrow T_2 = \sqrt{3} T_1$$

$$F_y = 0 \Rightarrow T_1 \sin 30^\circ + T_2 \sin 60^\circ = 200$$

$$\Rightarrow T_1 \frac{1}{2} + T_2 \frac{\sqrt{3}}{2} = 200$$

$$\Rightarrow \frac{T_1}{2} + \sqrt{3} T_1 \frac{\sqrt{3}}{2} = 200$$

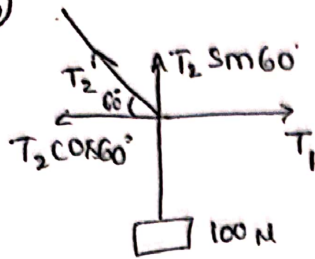
$$\Rightarrow 2 T_1 = 200 \Rightarrow T_1 = 100 \text{ N}$$

(22)

According to triangle law of vector addition
The resultant is zero if sum of two forces $\geq$ Remaining force.

From option (A) $3+7=10 < 11 \text{ N}$. so the set of $3 \text{ N}, 7 \text{ N}, 11 \text{ N}$ do not form zero resultant.

(23)

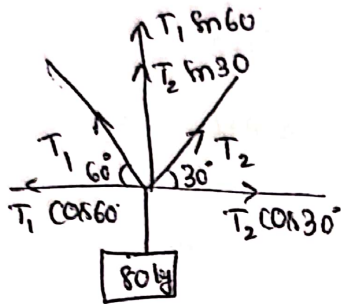


under equilibrium $T_2 \sin 60 = 100$
 $\Rightarrow T_2 \times \frac{\sqrt{3}}{2} = 100$
 $\Rightarrow T_2 = \frac{200}{\sqrt{3}} \text{ N}$

$$T_1 = T_2 \cos 60$$

$$= \frac{200}{\sqrt{3}} \times \frac{1}{2} = \frac{100}{\sqrt{3}} \text{ N}$$

(24)



under equilibrium $T_2 \cos 30 = T_1 \cos 60$
 $\Rightarrow T_2 \frac{\sqrt{3}}{2} = T_1 \frac{1}{2}$
 $\Rightarrow T_1 = \sqrt{3} T_2$

$$T_1 \sin 60 + T_2 \sin 30 = 80 \text{ g}$$

$$\Rightarrow T_1 \frac{\sqrt{3}}{2} + T_2 \frac{1}{2} = 800$$

$$\Rightarrow \sqrt{3} T_2 \frac{\sqrt{3}}{2} + \frac{T_2}{2} = 800 \Rightarrow 2T_2 = 800$$

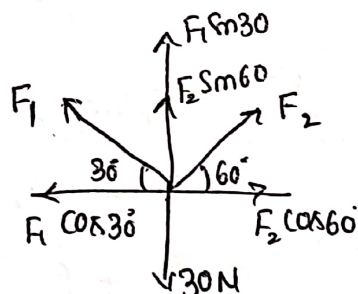
$$\Rightarrow T_2 = 400 \text{ N.}$$

$$= 40 \text{ kg wt}$$

$$T_1 = \sqrt{3} \times 40$$

$$= 40\sqrt{3} \text{ kg wt.}$$

(25), (26)



under equilibrium

$$F_1 \cos 30 = F_2 \cos 60$$

$$\Rightarrow F_1 \frac{\sqrt{3}}{2} = F_2 \frac{1}{2}$$

$$\Rightarrow F_2 = \sqrt{3} F_1$$

$$F_1 \sin 30 + F_2 \sin 60 = 30$$

$$\Rightarrow F_1 \frac{1}{2} + F_2 \frac{\sqrt{3}}{2} = 30$$

$$\Rightarrow \frac{F_1}{2} + \sqrt{3} F_1 \frac{\sqrt{3}}{2} = 30$$

$$\Rightarrow \frac{F_1}{2} + \frac{3F_1}{2} = 30$$

$$\Rightarrow 2F_1 = 30 \Rightarrow F_1 = 15 \text{ N}$$

$$\therefore F_2 = \sqrt{3} \times 15 = 15\sqrt{3} \text{ N}$$

27

When three forces acting on a body can be represented as sides of triangle taken in order, then the net force acting on the body is zero

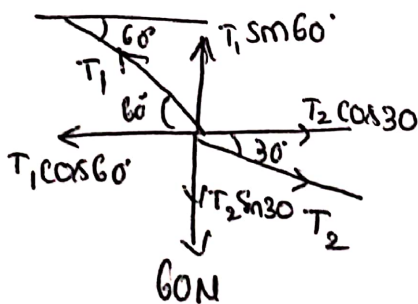
$\therefore$ Acceleration = 0

28

F is the resultant of $20\text{N} + 20\text{N}$ here $\theta = 120^\circ$

$$\begin{aligned} F &= \sqrt{(20)^2 + (20)^2 + 2(20)(20)\cos 120^\circ} \\ &= \sqrt{(20)^2 + (20)^2 + 2(20)^2\left(-\frac{1}{2}\right)} \\ &= \sqrt{(20)^2 + (20)^2 - (20)^2} = \sqrt{(20)^2} = 20\text{N} = \underline{2\text{N}} \end{aligned}$$

29



under equilibrium

$$T_1 \cos 60^\circ = T_2 \cos 30^\circ$$

$$\Rightarrow T_1 \frac{1}{2} = T_2 \frac{\sqrt{3}}{2}$$

$$\Rightarrow T_1 = \sqrt{3} T_2$$

$$T_1 \sin 60^\circ = T_2 \sin 30^\circ + 60$$

$$\Rightarrow T_1 \frac{\sqrt{3}}{2} = T_2 \left(\frac{1}{2}\right) + 60$$

$$\Rightarrow \sqrt{3} T_2 \frac{\sqrt{3}}{2} = \frac{T_2}{2} + 60$$

$$\Rightarrow \frac{3T_2}{2} = \frac{T_2}{2} + 60 \Rightarrow T_2 = 60\text{N}$$

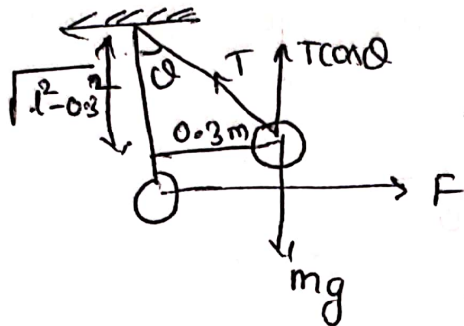
$$\text{Given } T_2 = 15\text{P}$$

$$\Rightarrow 60 = 15\text{P}$$

$$\Rightarrow \text{P} = 4$$

30

$$l = 0.5 \text{ m}$$



$$\sin \theta = \frac{0.3}{l}$$

$$T \cos \theta = mg$$
$$\Rightarrow T \frac{\sqrt{l^2 - 0.3^2}}{l} = 8$$

$$\Rightarrow T \frac{\sqrt{(0.5)^2 - (0.3)^2}}{(0.5)} = 8$$

$$\Rightarrow T \times \frac{\sqrt{(0.4)^2}}{0.5} = 8$$

$$\Rightarrow T \times \frac{4}{5} = 8$$

$$\Rightarrow \frac{T}{5} = 2$$

$$\Rightarrow T = 10 \text{ N}$$

(b) $F = T \sin \theta$

$$= 10 \times \frac{0.3}{0.5}$$

$$F = 10 \times \frac{3}{5} = 6 \text{ N}$$

(c) $T \times F = 10 \times 6 = 60$

(d) $\frac{T}{F} = \frac{10}{6} = 1.66$