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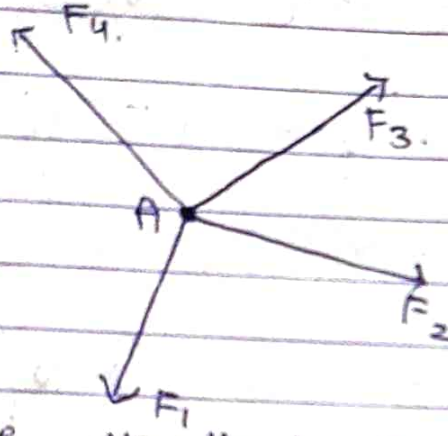
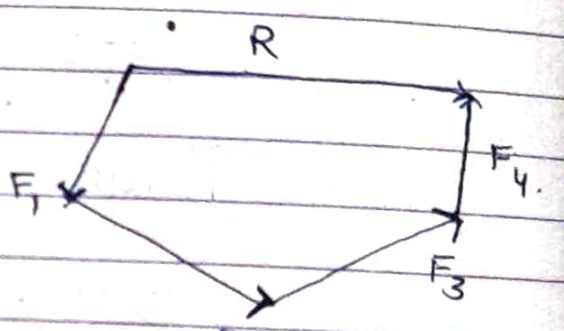
Unit-I.

Answer 1(a). It may be stated as "If a number of coplanar forces are acting at a point such that they can be represented in magnitude and direction by the sides of a polygon taken in an order, their resultant is represented in both magnitude and direction by the closing side of the polygon taken in the opposite order.

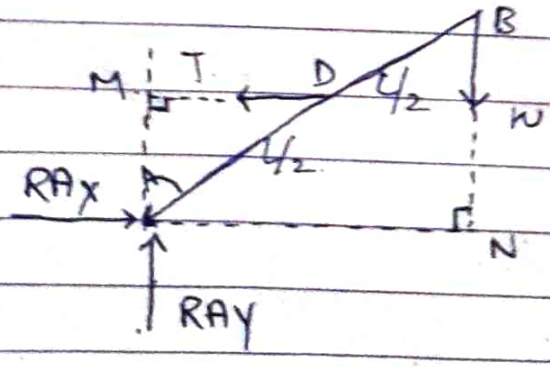




The resultant R does not depend upon the order in which the forces are chosen to draw polygon.

Answer (b) (c).

Consider the bar AB as a rigid body in equilibrium.



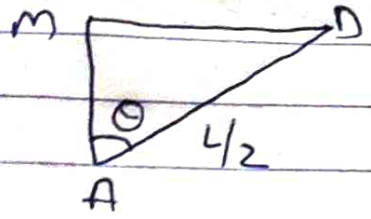
Taking moment about A —

$$+\circlearrowleft \quad \Sigma M_A = 0$$

$$R_{Ax} \times 0 + R_{Ay} \times 0 + W \times AN - T \times AM = 0$$

$$\Rightarrow W \times AN - T \times AM = 0 \quad \text{—— (1)}$$

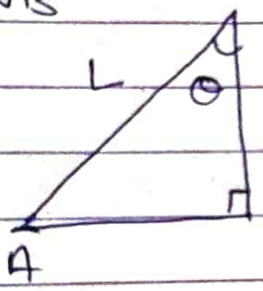
In ΔAMD



$$\cos\theta = \frac{AM}{AD}$$

$$AM = \frac{L}{2}\cos\theta$$

In ΔANB



$$\sin\theta = \frac{AN}{AB}$$

$$AN = L\sin\theta$$

Putting in eq° (1)

$$W \times L\sin\theta - T \times \frac{L}{2}\cos\theta = 0$$

$$T = 2W\tan\theta$$

Now, $\Sigma F_x = 0$

$$R_{Ax} - T = 0$$

$$R_{Ax} = 2W\tan\theta$$

$$\Sigma f_y = 0$$

$$R_{Ay} - W = 0$$

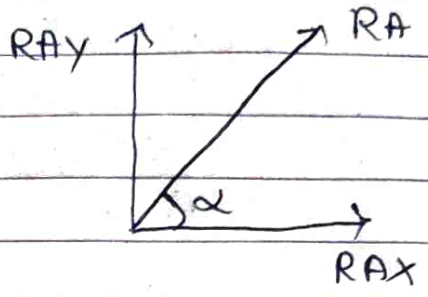
$$R_{Ay} = W$$

$$R_A = \sqrt{R_{Ax}^2 + R_{Ay}^2}$$

$$R_A = \sqrt{(2W\tan\theta)^2 + W^2}$$

$$\tan\alpha = \frac{\Sigma F_y}{\Sigma F_x}$$

$$= \frac{R_{Ay}}{R_{Ax}}$$



$$= \frac{W}{2W\tan\theta}$$

$$\tan\alpha = \frac{1}{2}\cot\theta$$

$$\alpha = \tan^{-1}\left(\frac{\cot\theta}{2}\right).$$

Answer(id)

When the wheel is about to roll over the block, it just lifts of the horizontal plane and loses contact at B. Therefore reaction at B becomes zero.

Free body diagram of the wheel is shown in fig. as the forces W and P pass through.

Applying the equation of equilibrium.

$\Sigma F_x = 0$: $P - R_A \sin\theta = 0$ or $R_A \sin\theta = P$ — (1)

$\Sigma F_y = 0$: $R_A \cos\theta - W = 0$ or $R_A \cos\theta = W$ — (11)

Dividing i by (ii)

$$\tan\theta = \frac{P}{W}.$$

In $\triangle ADE$

$$\tan\theta = \frac{DA}{DE}. \qquad DE = 2r - h.$$

$$\tan\theta = \frac{\sqrt{r^2 - (r-h)^2}}{(2r-h)}. \qquad DA = \sqrt{CA^2 - CD^2}$$

$$DA = \sqrt{r^2 - (r-h)^2}$$

$$= r\,\frac{\sqrt{2rh - h^2}}{(2r-h)}$$

$$\tan\theta = \frac{\sqrt{h}\sqrt{(2r-h)}}{\sqrt{2r-h}\sqrt{2r-h}} = \frac{\sqrt{h}}{\sqrt{2r-h}} = \frac{\sqrt{0.15}}{\sqrt{0.6-0.15}}$$

But, $\frac{P}{W} = \tan\theta$

$$P = W\tan\theta = 1000 \times 0.577$$

Therefore $P = 577\,N$ ans.

Unit - 2

(2) (a) Laws of static friction are :-

→ First Law :-

The limiting force of static friction (F_L) is directly proportional to the normal reaction (N) between the two surfaces in contact.

$$F_L \propto N$$

$$\therefore F_L = \mu_s N$$

where μ_s = constant called the coefficient of static friction.

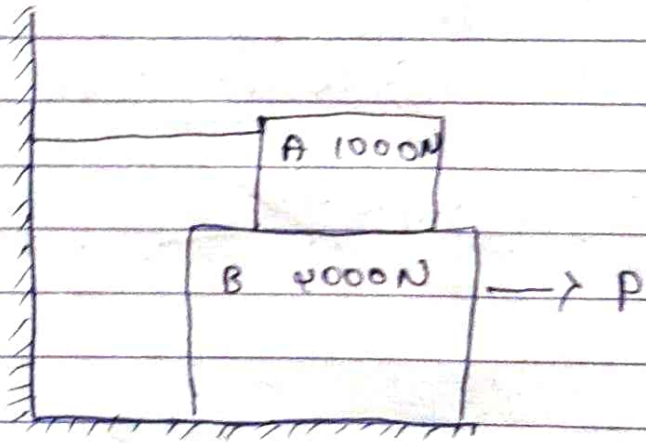
→ Second Law :-

The limiting force of friction is independent of the apparent area between the surfaces in contact, so long as the normal reaction remains the same.

→ Third Law :-

The limiting force of friction depends upon materials in contact and the nature of their surfaces.

Answer. (b)



Assume coefficient of friction.

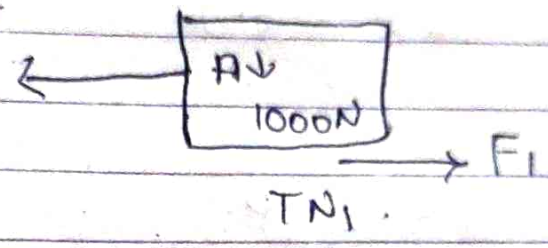
$\mu = 0.25$

$N_1 = 1000N$

$T = 250N$ $\quad f_1 = 250N$

F.B.D

for Block A



$f_1 = \mu N_1$

$f_1 = 0.25\ N_1$ $\quad = f = 250N$

$\Sigma f_y = \Rightarrow N_1 - 1000 = 0$

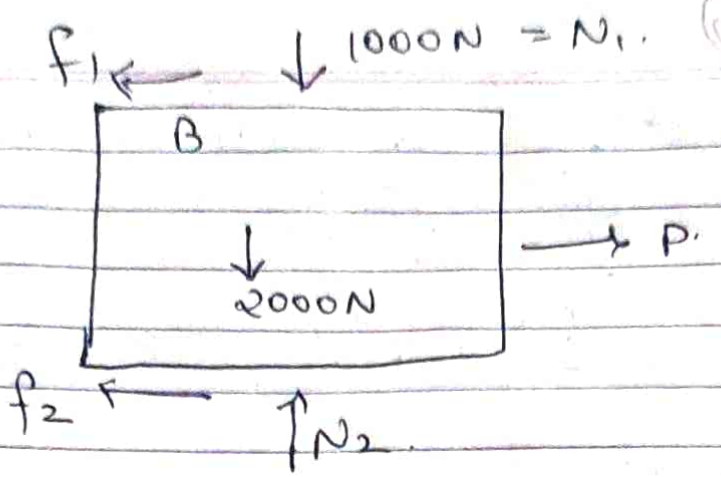
$N_1 = 1000$

$\Sigma f_x = \Rightarrow T - f_1 = 0$

$T - 250 = 0$

$T = 250N$

for Block B



$\Sigma f_y = 0 \Rightarrow N_2 = 3000N$.

$\Sigma f_x = 0$

$\Rightarrow f_1 + f_2 = P$.

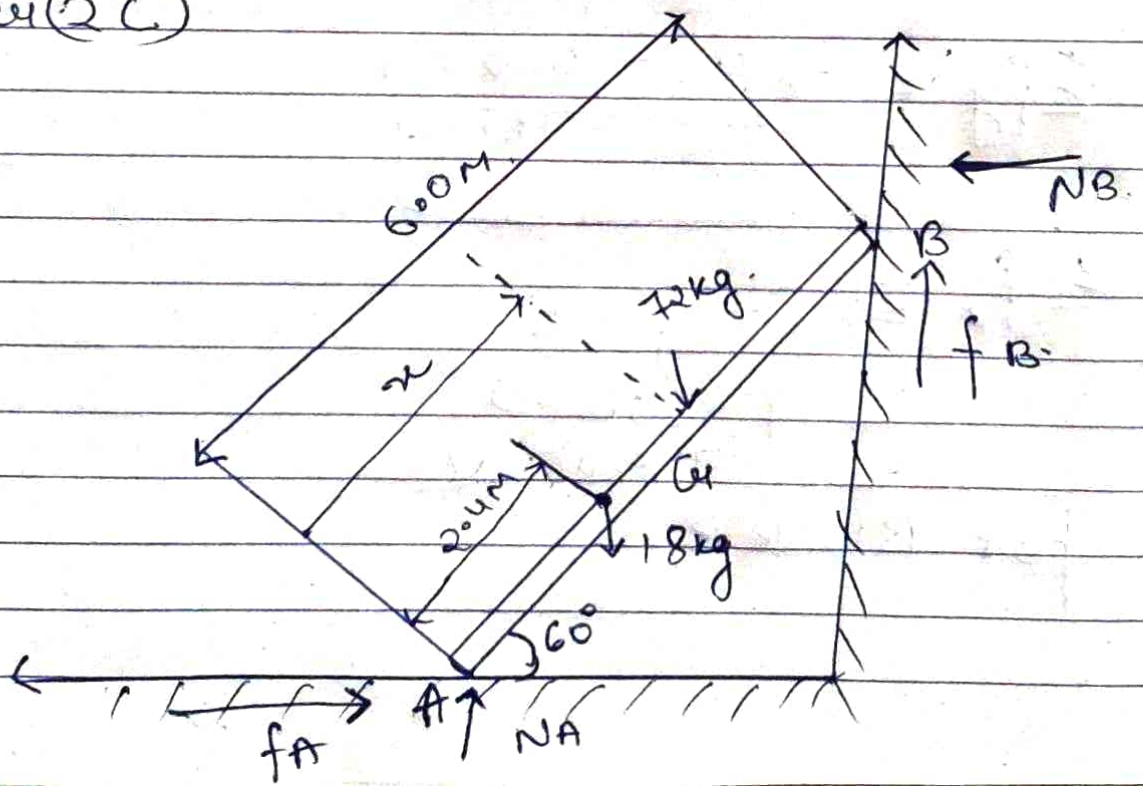
$250 + (0.25 \times N_2) = P$.

$250 + (0.25 \times 3000) = P$.

$250 + 750 = P$

$P = 1000N$

Answer (2 C.)



Coefficient of friction

$\mu = \tan\phi$

$\mu = \tan 15^\circ$.

Amount of friction at contact surfaces.

$f_A = \mu N_A = N_A \tan 15^\circ$

$f_B = \mu N_B = N_B \tan 15^\circ$

$\Sigma F_V = 0$.

$N_A + f_B = 18 + 72$

$N_A = 90 - f_B$

$N_A = 90 - N_B \tan 15^\circ$

$\Sigma F_H = 0$.

$f_A = N_B$

$N_A \tan 15^\circ = N_B$

$(90 - N_B \tan 15^\circ) \tan 15^\circ = N_B$

$90 \tan 15^\circ - N_B \tan 215^\circ = N_B$

$90 \tan 15^\circ = N_B + N_B \tan 215^\circ$

$N_B (1 + \tan 215^\circ) = 90 \tan 15^\circ$.

$N_B = 90 \tan 15^\circ / 1 + \tan 215^\circ$.

$N_B = 22.5$ kg.

$f_B = 22.5 \tan 18^\circ$

$f_B = 6.03 \text{ kg}$

$\Sigma M_A = 0$

$N_B (6 \sin 60^\circ) + f_B (6 \cos 60^\circ) = 18 (2.4 \cos 60^\circ) + 72 (x \cos$

$\Rightarrow N_B (6 \tan 60^\circ) + 6 f_B = 18 (2.4) + 72x$

$\Rightarrow 6 (22.5) \tan 60^\circ + 6 (6.03) = 43.2 + 72x$

$72x = 226.81$

$\boxed{x = 3.15 \text{ M}}$ Answer

Unit - 3

Answer 3(9).