FRRE BODY DIAGRAM

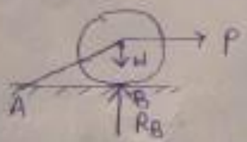
(23)

Free body Diagram :- To draw the free body diagram of a body we remove all the supports (like wall, floor, hinge or any other body) and replace them by the reactions which these supports exert on the body.

There are two types of forces that act on a body

1. External forces
2. Internal force

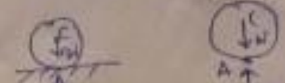
External forces :- these are forces which act on a body or a system of bodies from outside.



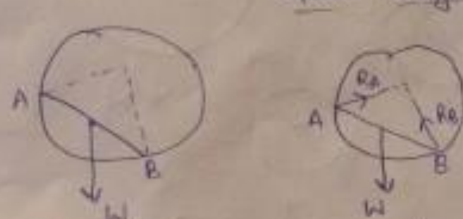
Internal forces :- are those forces which hold together the particles of a body and if, more than one body is involved, it may be the force that holds the two bodies together.

Types of Supports and Support reactions :-

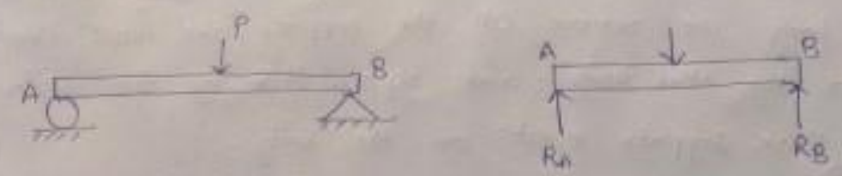
1. Frictionless Support



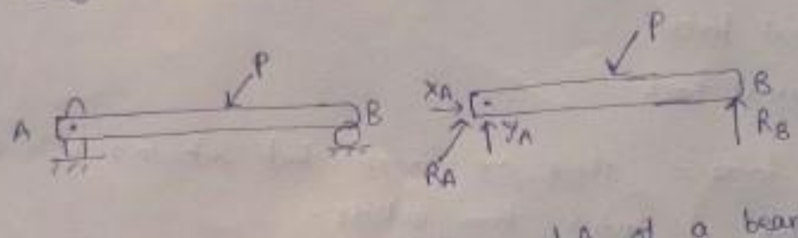
Sphere resting on a horizontal Plane



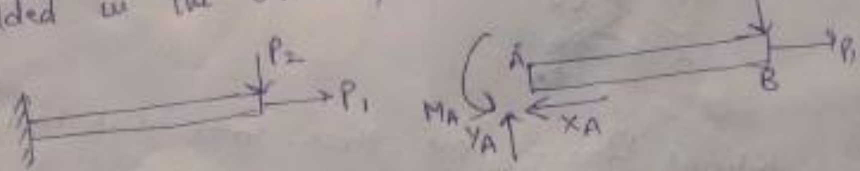
2. Roller and knife edge supports



3. Hinged Support :-

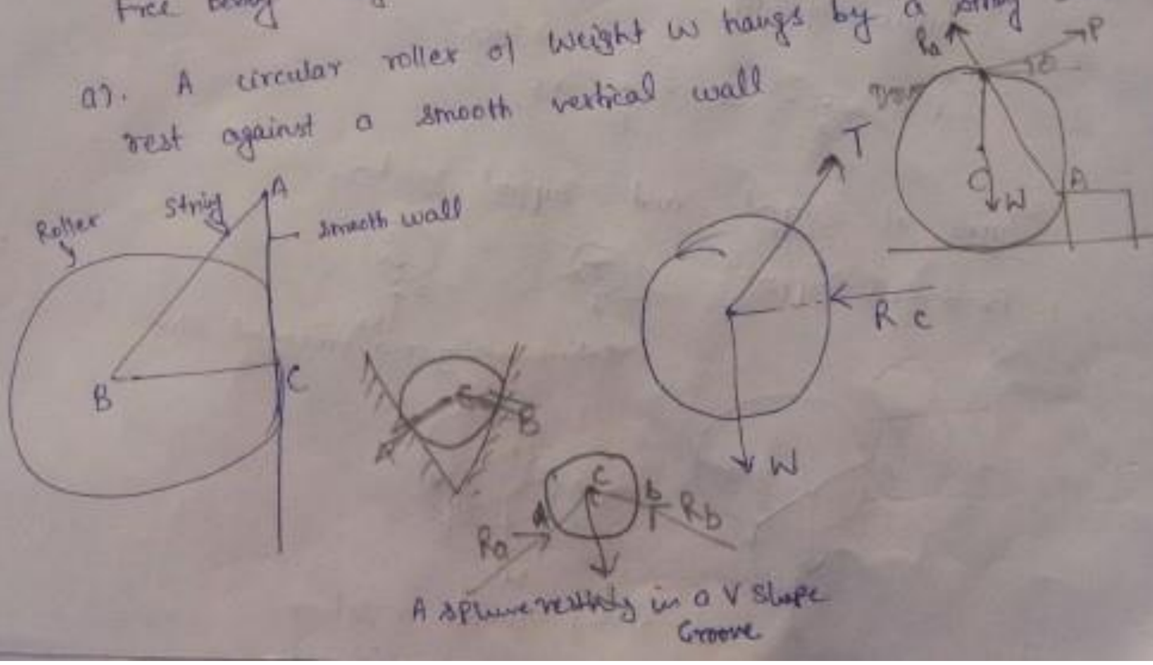


4. Built in Support :- if the end A of a beam AB is embedded in the concrete,

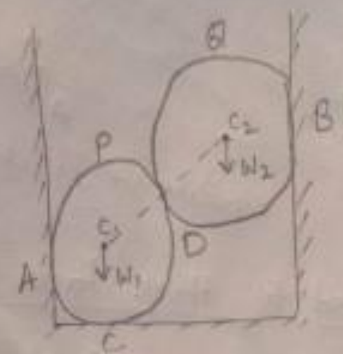


Few example of systems and mechanisms together with their Free body diagram.

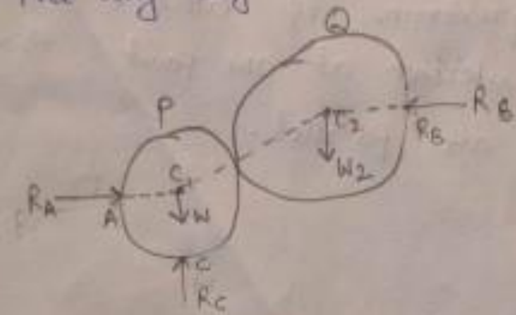
a). A circular roller of weight W hangs by a string and rest against a smooth vertical wall



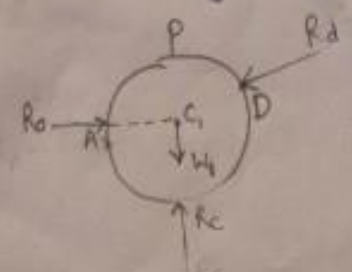
Two spheres P and Q placed in a vessel



Free body diagram of sphere P and Q



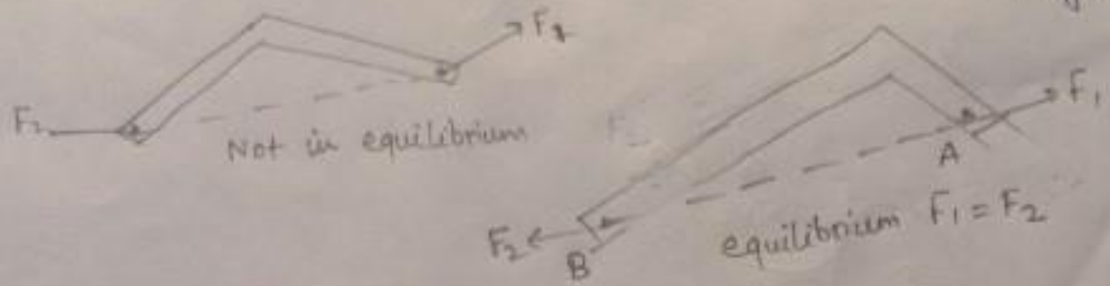
Free body diagram of sphere P



Free body diagram of sphere Q

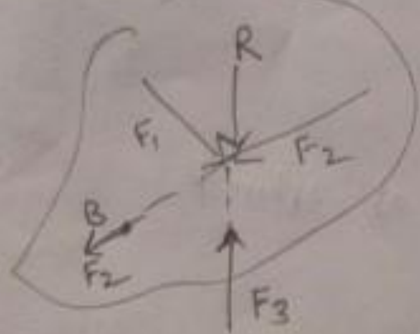
$$R_{d(Q)} = R_{d(P)} = R_D$$

Equilibrium of a body subjected to two forces (Two force body)



Equilibrium of a body subjected to three forces

When a body is acted upon by three coplanar forces it can be in equilibrium if either the lines of the three forces intersect at one point (that is concurrent) or they are parallel.



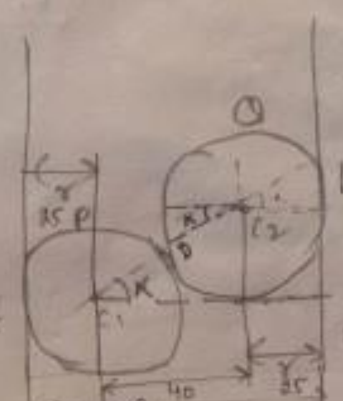
Numerical

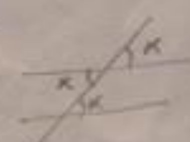
Two smooth spheres P, Q each of radius 25cm and weighing 500N, rest in a horizontal channel having vertical walls as shown in figure. If the distance b/w the walls is 90cm, make calculations for the pressure exerted on the wall and floor at point of contact A, B and C.

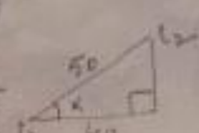
Solⁿ:- The following point need consideration

(i) The spheres are smooth and as such the pressures at various points of contact would be normal to the surface

(ii) at the point of contact b/w the two spheres, the reactions would act along the line joining their centres.







PBP
HHB

$$\cos\alpha = \frac{b-r-r}{2r}$$

$$\cos\alpha = \frac{90-25-25}{50} = \frac{40}{50} \quad \alpha = \cos^{-1}(0.8) \quad \boxed{\alpha = 36.87^\circ}$$

$\Sigma F_x = 0 \quad R_b - R_d\cos\alpha = 0$

$R_b = R_d\cos\alpha$

$\Sigma F_y = 0 \quad R_d\sin\alpha = 500$

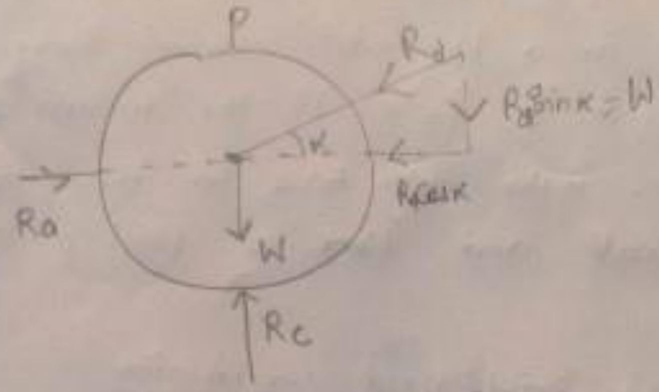
$R_d = \frac{500}{\sin\alpha} \Rightarrow R_d = \frac{500}{\sin 36.87}$

$\boxed{R_d = 833.33\,N}$

$R_b = R_d\cos\alpha$

$R_b = 833.33\cos 36.87$

$\boxed{R_b = 666.66\,N}$



$$\Sigma F_x = 0 \Rightarrow R_a - R_d \cos\alpha = 0$$

$$R_a = R \cos\alpha$$

$$\boxed{R_a = 666.67\,N}$$

$$\Sigma F_y = 0 \qquad R_d \sin\alpha + W - R_c = 0$$

$$500 + 500 = R_c$$

$$\boxed{R_c = 1000\,N}$$

A uniform wheel of 50 cm radius diameter and 1 kN weight rests against a rigid rectangular block of thickness 20 cm. Considering all surfaces smooth, determine: (Do this numerical after Moment [illegible])

(i) Least pull to be applied through the centre of wheel to just turn it over the corner of the block.

(ii) Reaction of the block.

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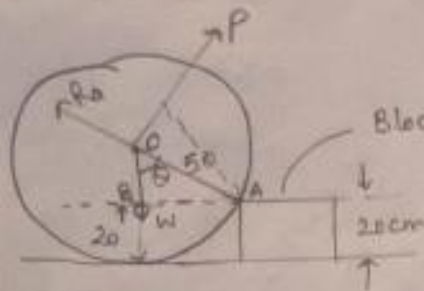
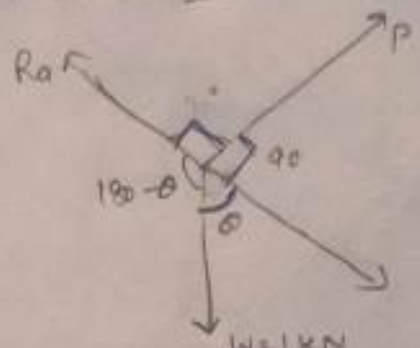
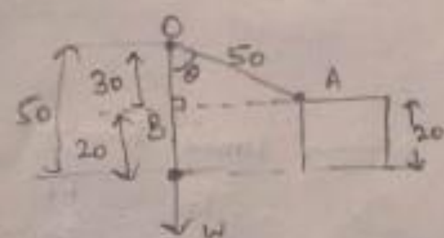
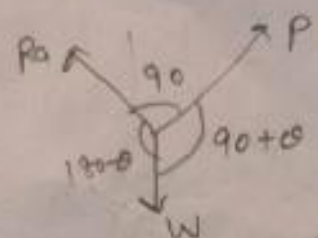




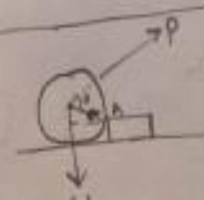




OAB

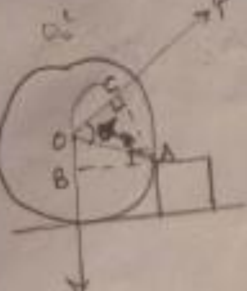
$$\cos\theta = \frac{OB}{OA} = \frac{50-20}{50} = \frac{30}{50} = 0.6$$

$$\boxed{\theta = 53.13^\circ}$$



Applying Lami's Theorem ⇒

$$\frac{W}{\sin 90} = \frac{Ra}{\sin(90+\theta)} = \frac{P}{\sin(180-\theta)}$$



$$Ra = \frac{W \sin 143.13^\circ}{\sin 90}, \qquad P = \frac{W \sin 126.87^\circ}{\sin 90^\circ}$$

$$Ra = 1 \times \sin 143.13^\circ \qquad P = 1 \times \sin 126.87^\circ$$

$$\boxed{Ra = 0.6\,\text{KN}} \qquad \boxed{P = 0.8\,\text{KN}}$$

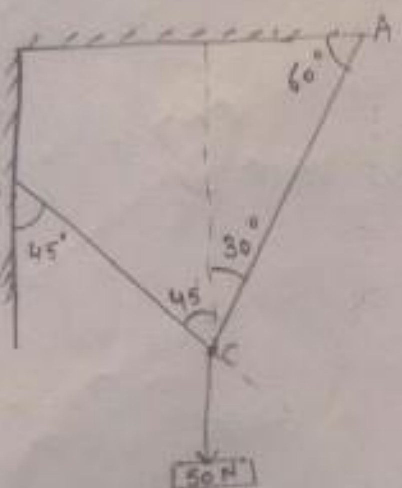
$\alpha = 90^\circ$ $\sin\alpha = 1$

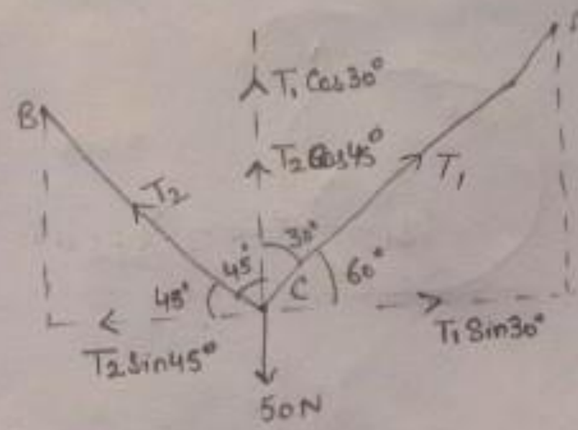
$\Sigma M_A = 0$ $\quad W \times AB = P \times AC$

$W \times AB = P \times OA \sin\alpha \Rightarrow P = \frac{W \times AB}{OA \sin\alpha} \Rightarrow P = \frac{x}{\sin\alpha}$ $\underline{P_{min}}$

A — heavy →

An electric light fixture weighing 50N hangs from point C by two strings AC and BC as shown in figure. The string AC is inclined at 60° to the horizontal and string BC is 45° to the vertical. Using Lami's theorem or otherwise determine the forces in the strings AC and BC.





Applying Lami's Theorem

$$\frac{T_1}{\sin 135°} = \frac{T_2}{\sin 150°} = \frac{50}{\sin 75°}$$

$$T_1 = \frac{50 \sin 135°}{\sin 75°}, \quad T_2 = \frac{50 \sin 150°}{\sin 75°}$$

$$\boxed{T_1 = 36.594\text{N}} \quad \boxed{T_2 = 25.88\text{N}}$$

Alternatively

Since the light fixture is in equilibrium $\Sigma f_x = 0$ and $\Sigma f_y = 0$

Horizontally

$$T_1 \sin 30 - T_2 \sin 45 = 0$$

$$T_1 \sin 30 = T_2 \sin 45$$

$$\frac{T_1}{T_2} = \frac{\sin 45}{\sin 30}$$

Vertically

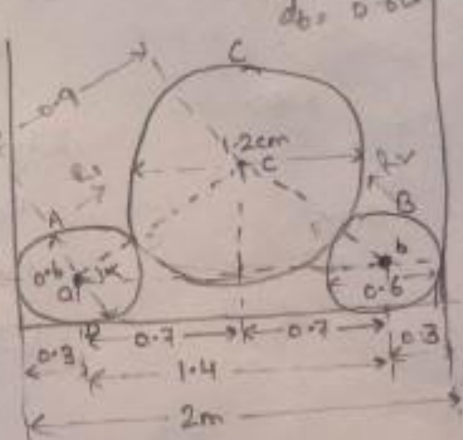
$$T_1 \cos 30 + T_2 \cos 45° - 50 = 0$$

Can also find out T_1 and T_2 respectively

Numerical

Refer to the system of cylinders arranged as depicted in fig. The cylinders A and B weigh 1000N each and the weight of cylinder C is 2000N. Determine the forces exerted at the contact points.

$d_C = 1.2cm$
$d_a = 0.6cm$
$d_b = 0.6cm$

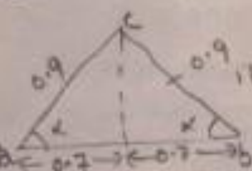


Sol^n:-

$ab = 2 - 0.3 - 0.3 \Rightarrow ab = 1.4$

$ac = 0.3 + 0.6 = 0.9$

PBP
HHB

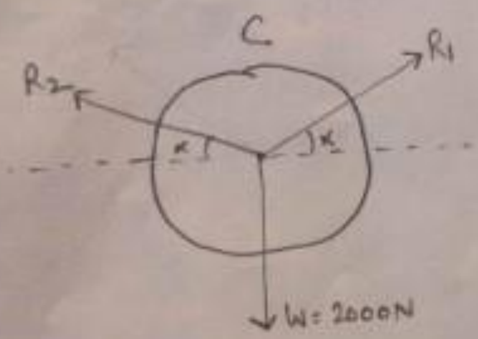


isoscels triangle
if two side equals

$$\cos\alpha = \frac{0.7}{0.9} \Rightarrow \alpha = 38.94^\circ$$

FBD Sphere C

R_1 - Reaction of A on C
R_2 - Reaction of B on C



Applying Lami's Theorem:-

$$\frac{R_1}{\sin(90+\alpha)} = \frac{R_2}{\sin(90+\alpha)} = \frac{2000}{\sin(180-2\alpha)}$$

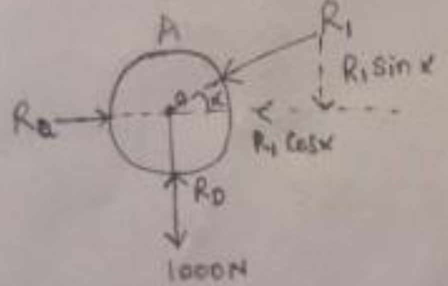
$$R_1 = \frac{2000\sin(90+\alpha)}{\sin(180-2\alpha)}, \quad R_2 = \frac{2000\sin(90+\alpha)}{\sin 2\alpha}$$

$$R_1 = \frac{2000\sin(90+\alpha)}{\sin 2\alpha}, \quad R_2 = \frac{2000\sin(90+\alpha)}{\sin 2\alpha}$$

$$\boxed{R_1 = R_2}$$

$$R_1 = \frac{2000 \sin(90 + 38.94^\circ)}{\sin(2 \times 38.94^\circ)} \Rightarrow \boxed{R_1 = 1590.87\ N}$$

Considering the free body diagram of cylinder A



$\Sigma F_x = 0$

$R_1 \cos\alpha = R_a \Rightarrow R_a = 1590.87 \cos 38.94$

$\boxed{R_a = 1237.38\ N}$

$\Sigma F_y = 0$

$R_D - R_1 \sin\alpha - 1000 = 0$

$R_D - 1590.87 \sin 38.94 - 1000 = 0$

$\boxed{R_D = 1999.87\ N}$