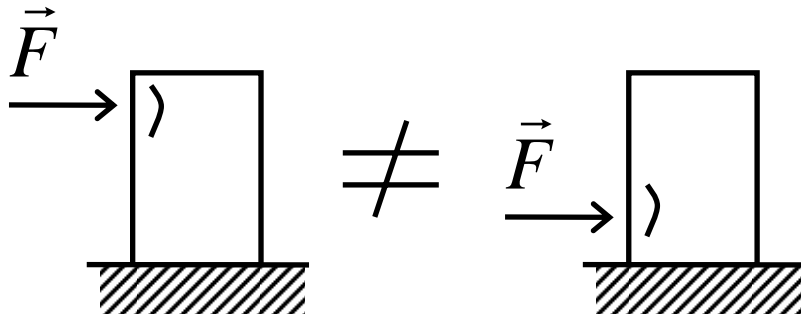


Chapter 2: Force systems

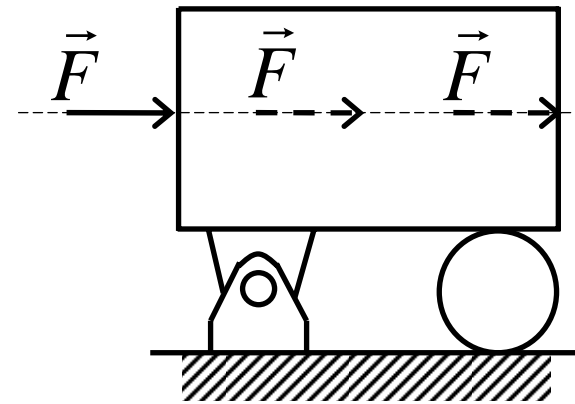
Force: vector quantity (magnitude and direction are important)

Unit: newton (N)



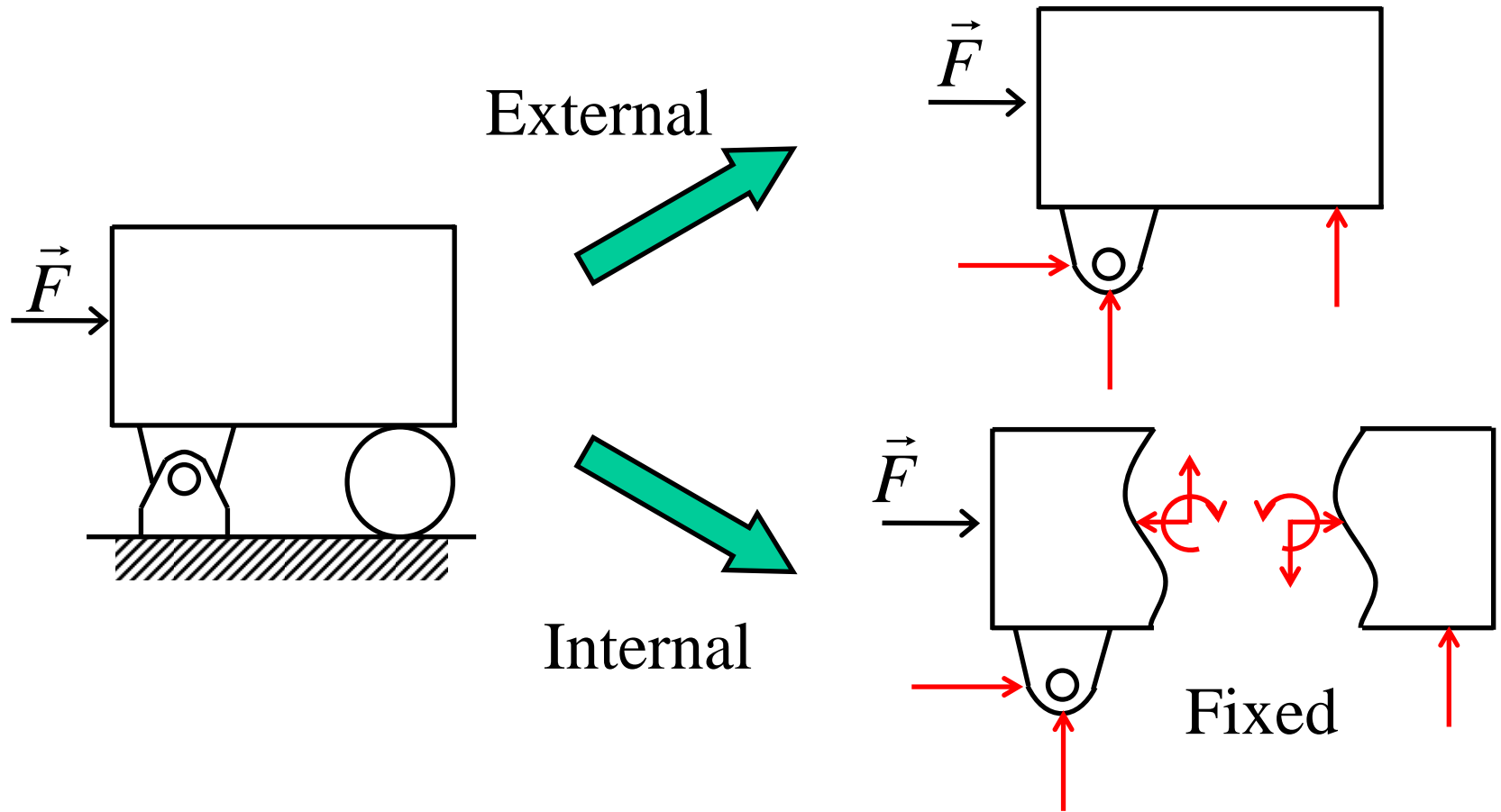
Deformable body: *point of action* is also important!
(fixed vector)

Principle of Transmissibility



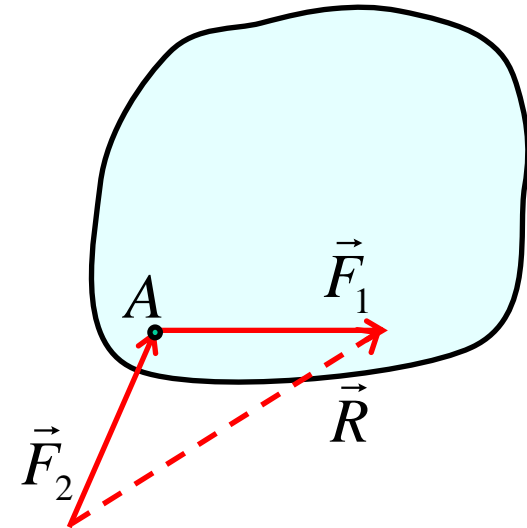
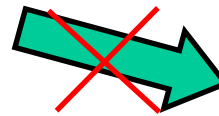
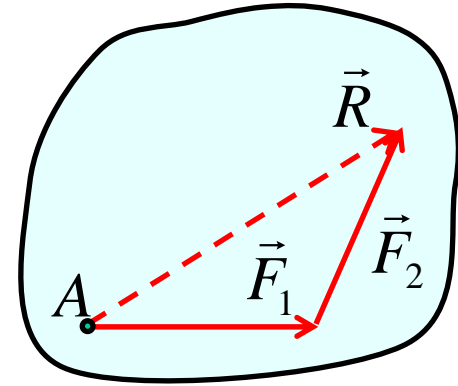
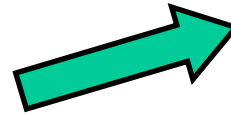
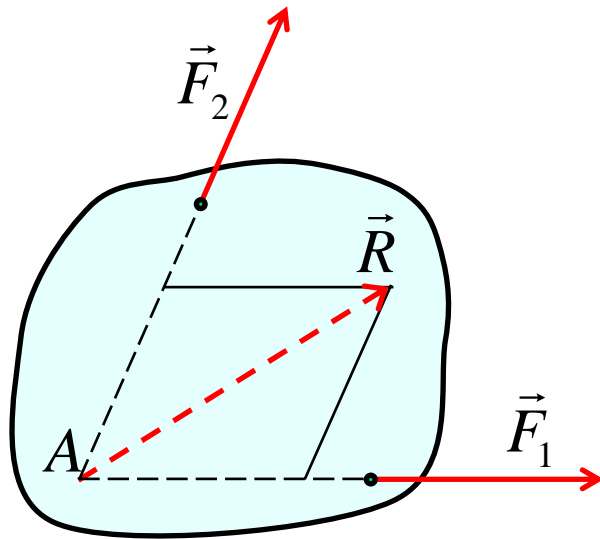
Rigid body: force acting at any point on the line of action brings the same effect
(sliding vector)

External and internal effects



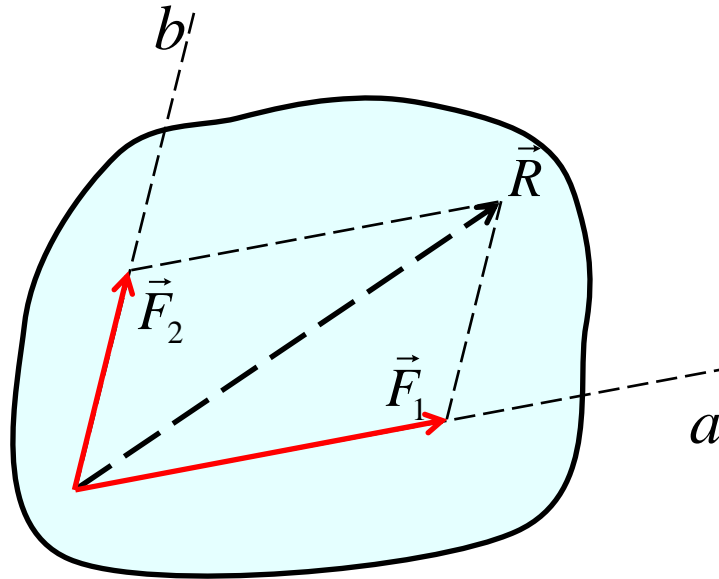
Depend on body in consideration

Concurrent forces



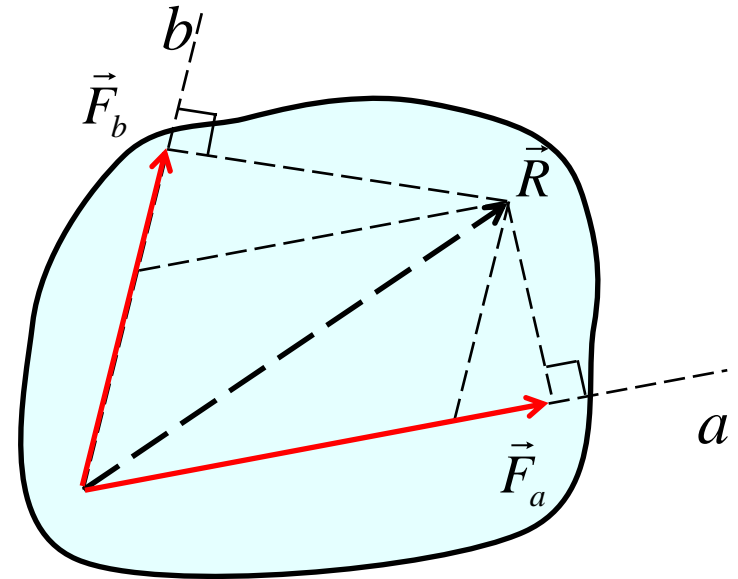
- **Concurrent forces:**
Forces that their line of action intersect at a point (point A)
- Their sum is called resultant R
- Line of action of resultant R must *pass* point A

Vector components and projections



\vec{F}_1, \vec{F}_2 = **vector components**
of \vec{R} (along axis a and b)

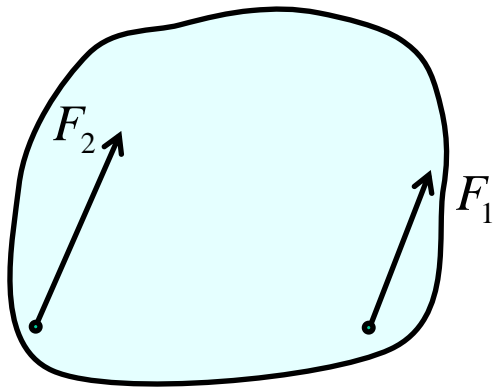
$$\vec{R} = \vec{F}_1 + \vec{F}_2$$



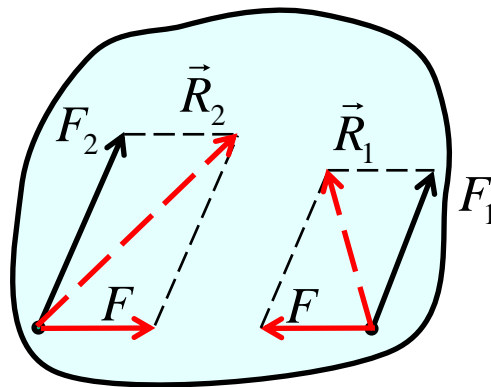
\vec{F}_a, \vec{F}_b = **orthogonal projection**
of \vec{R} (onto axis a and b)

$$\vec{R} \neq \vec{F}_a + \vec{F}_b$$

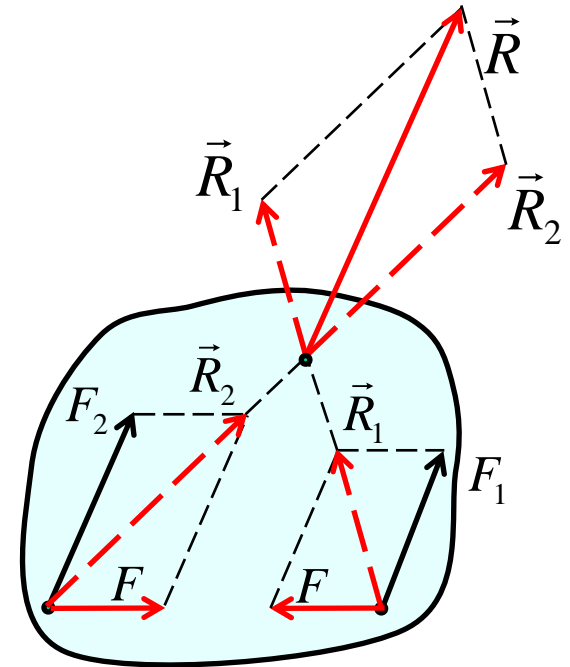
A special case of vector addition



\vec{F}_1 and \vec{F}_2 are parallel

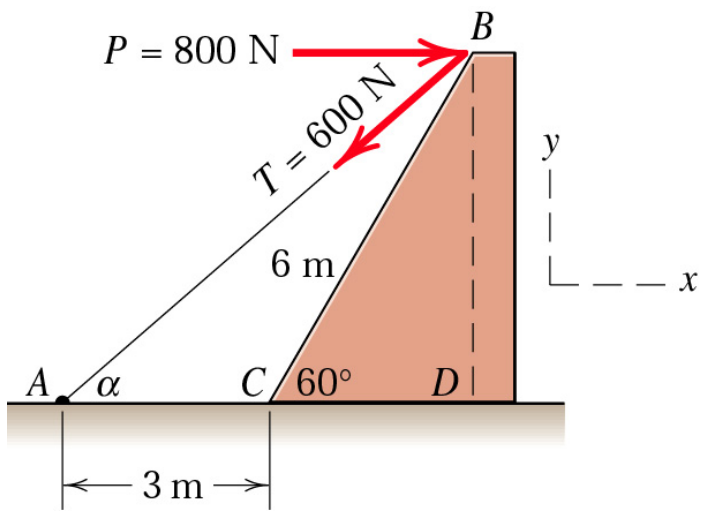


Add \vec{F} and $-\vec{F}$ to produce \vec{R}_1 and \vec{R}_2



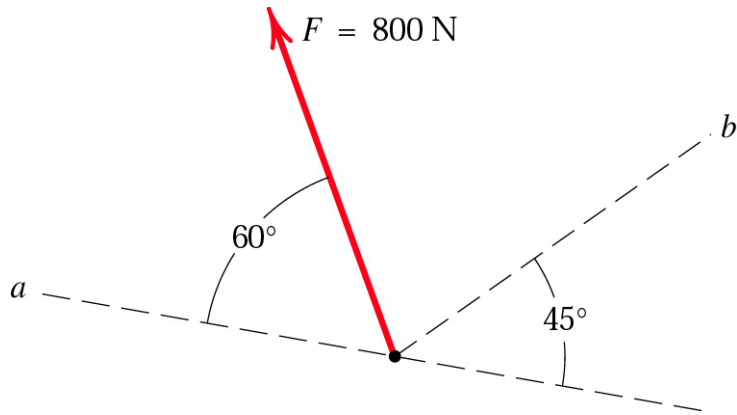
Magnitude, direction and line of action of \vec{R} can be known

Sample problem (1)



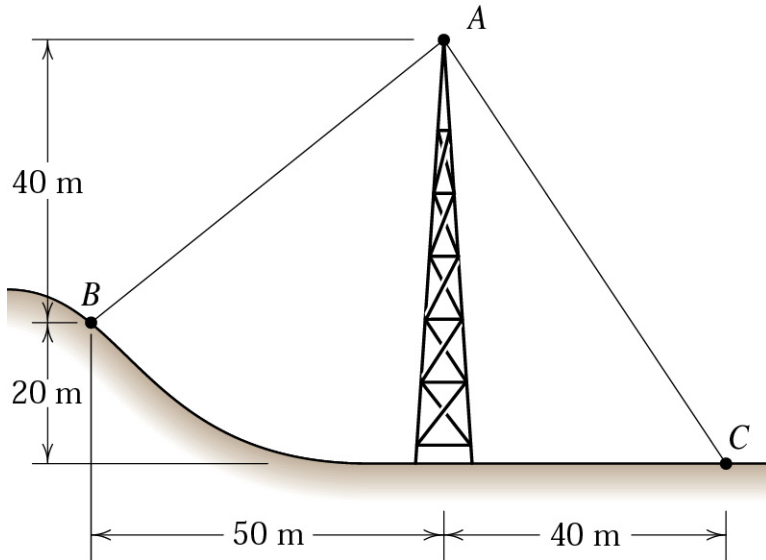
Combine the two forces **P** and **T**, which act on the fixed structure at **B**, into a single equivalent force **R**.

Sample problem (2)



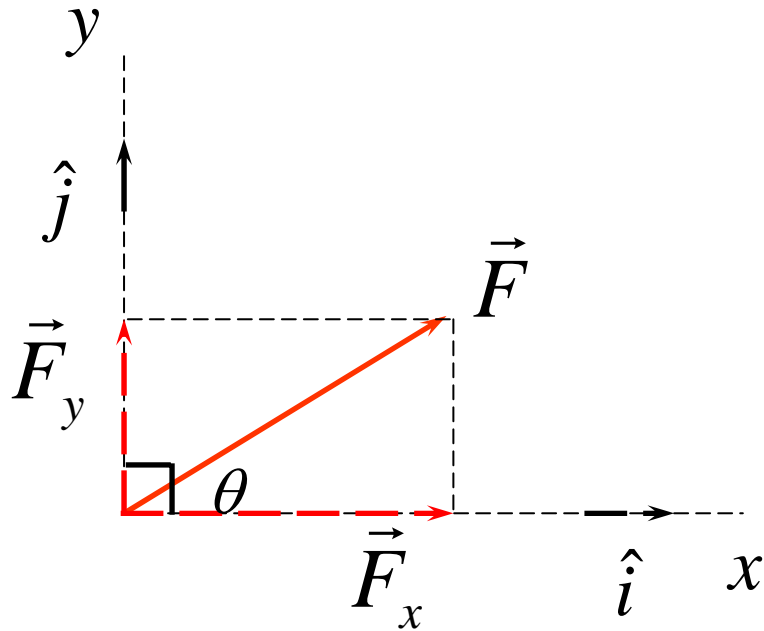
Determine the components of the 800-N force \mathbf{F} along the oblique axes a and b . Also, determine the projections of \mathbf{F} onto the a - and b - axes

Sample problem (3)



The tension in cable AC is 8 kN. Determine the required tension T in cable AB such that the net effect of the two cable tension is a downward force at point A . Determine the magnitude R of this downward force.

Rectangular components



$\vec{F}_x, \vec{F}_y =$ vector components of \vec{F}

$F_x, F_y =$ scalar components of \vec{F}

$$\vec{F} = \vec{F}_x + \vec{F}_y$$

$$F = F_x \hat{i} + F_y \hat{j}$$

$$F_x = F \cos(\theta)$$

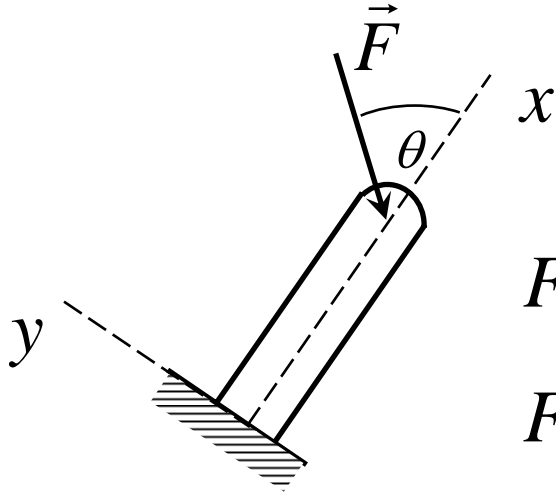
$$F_y = F \sin(\theta)$$

$$F = \sqrt{F_x^2 + F_y^2}$$

$$\theta = \tan^{-1}(F_y / F_x)$$

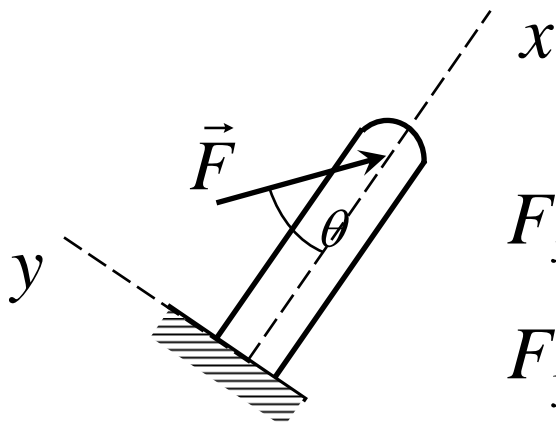
Reference axis

Reference axis: assignment based on convenience



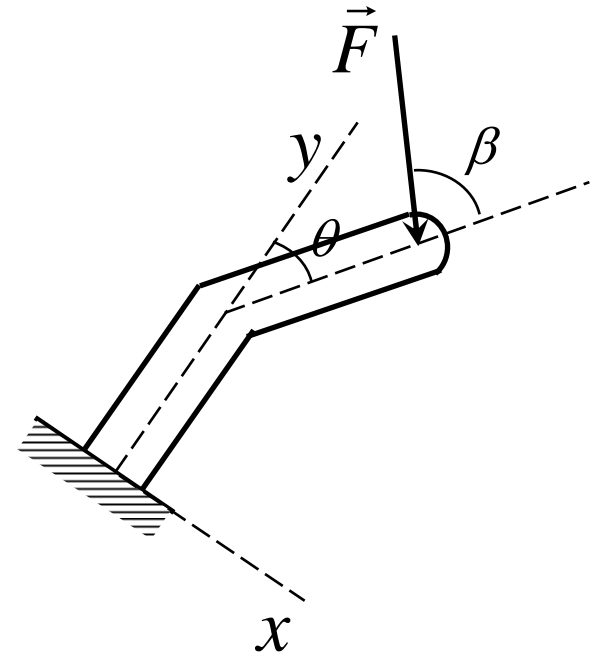
$$F_x = -F \cos \theta$$

$$F_y = -F \sin \theta$$



$$F_x = F \cos \theta$$

$$F_y = -F \sin \theta$$



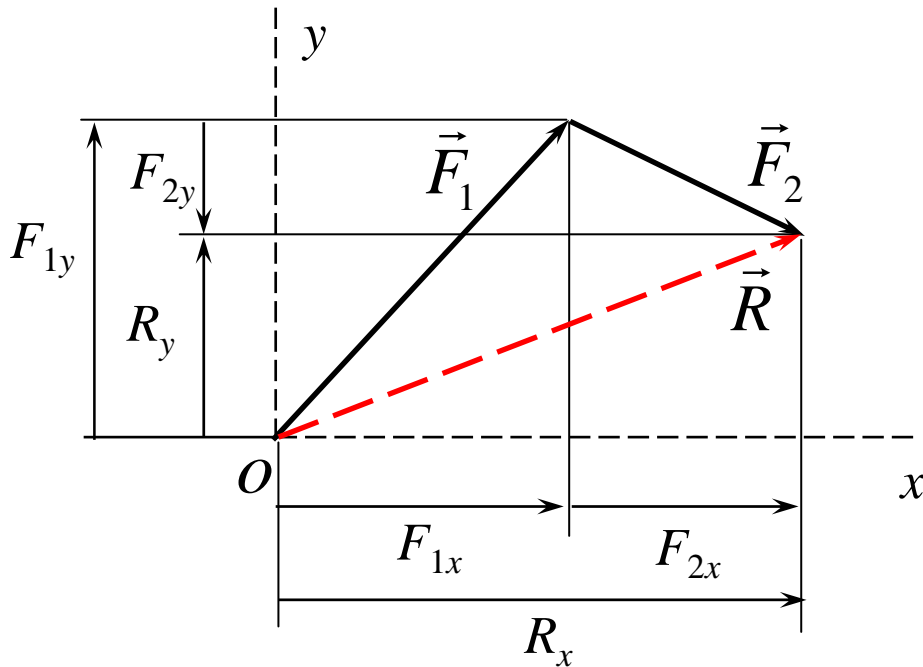
$$F_x = F \sin(\beta - \theta)$$

$$F_y = -F \cos(\beta - \theta)$$

Vector summation

$$\vec{R} = \vec{F}_1 + \vec{F}_2 = (F_{1x}\hat{i} + F_{1y}\hat{j}) + (F_{2x}\hat{i} + F_{2y}\hat{j})$$

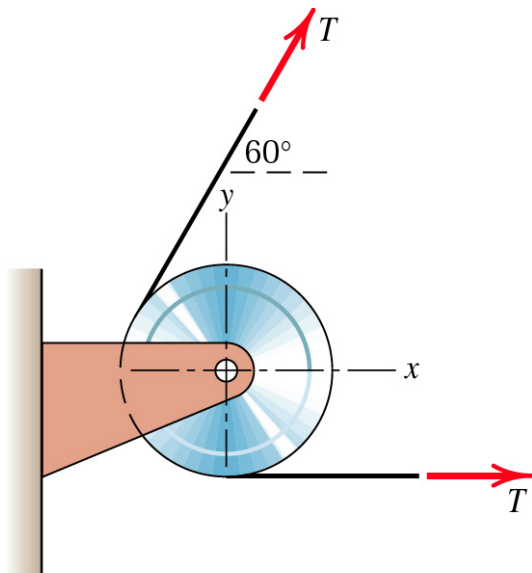
$$R_x\hat{i} + R_y\hat{j} = (F_{1x} + F_{2x})\hat{i} + (F_{1y} + F_{2y})\hat{j}$$



$$R_x = F_{1x} + F_{2x} = \sum F_x$$

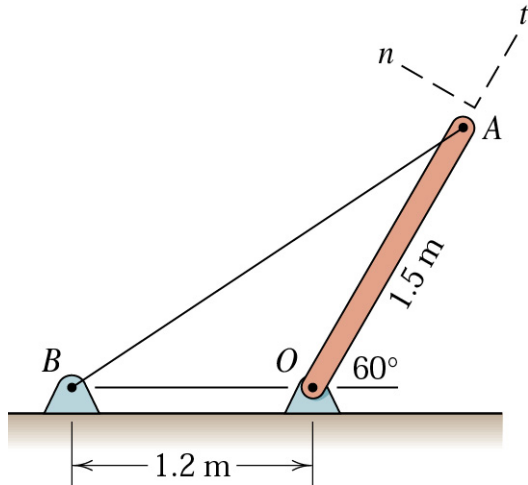
$$R_y = F_{1y} + F_{2y} = \sum F_y$$

Sample problem (4)



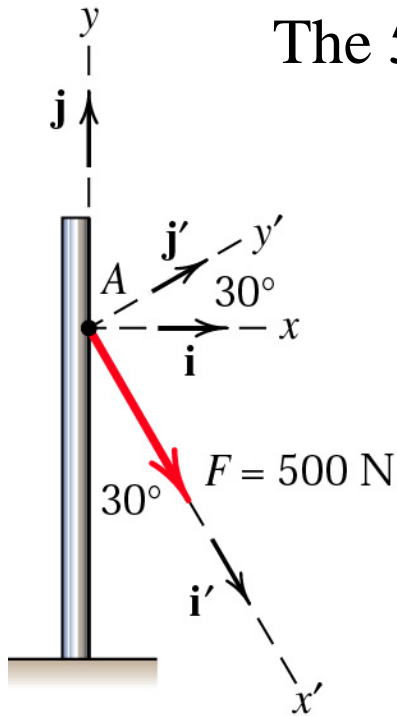
If the equal tensions T in the pulley cable are 400 N, express in vector notation the force \mathbf{R} exerted on the pulley by the two tensions. Determine the magnitude of \mathbf{R} .

Sample problem (5)



If the cable tension is 750 N , determine the n - and t -components of this force acting on point A of the bar.

Sample problem (6)



The 500-N force \mathbf{F} is applied to the vertical pole as shown.

- (1) Write \mathbf{F} in terms of the unit vector \mathbf{i} and \mathbf{j} and identify both its vector and scalar components.
- (2) Determine the scalar components of the force vector \mathbf{F} along the x' - and y' - axes.
- (3) Determine the scalar components of \mathbf{F} along the x - and y - axes.