

MCH2011 STATICS & STRENGTH OF MATERIALS

Force Systems

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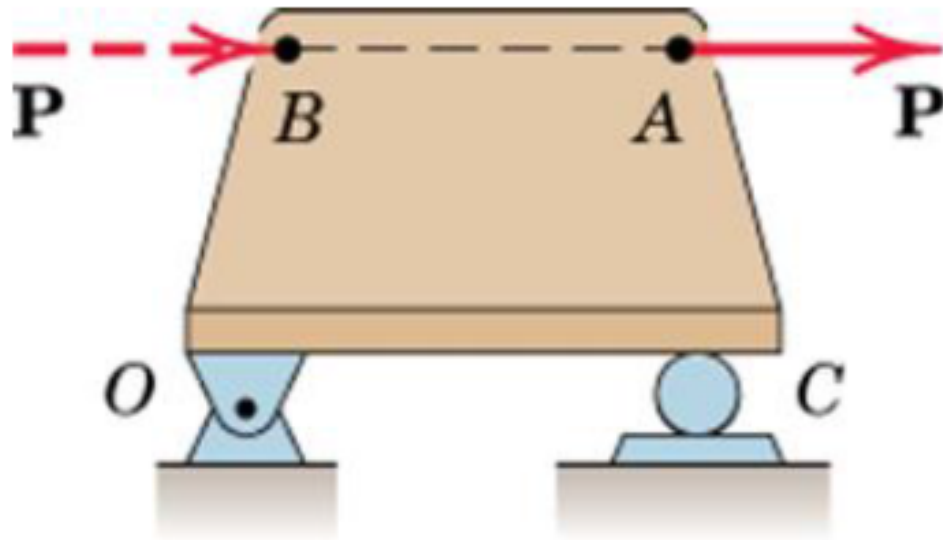
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Force Systems – Lecture Objectives

- We will form a vectorial framework for the analysis of a system of forces acting on a body
- With this lecture, we will
 - Learn about **sliding** (moment) and **free** (couple) vectors
 - Represent **forces**, **moments**, **couples**, and **resultants** in 2-D and 3-D
 - Understand the difference between a moment and couple
 - Understand the relationship between forces, moments, and couples
- The concepts introduced in this lecture is the key to understanding static and dynamic analysis of bodies

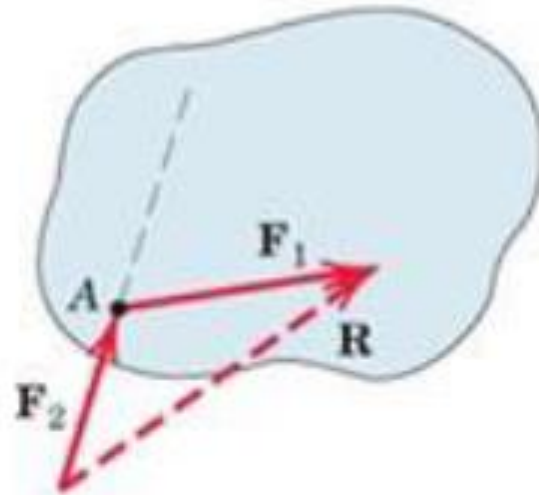
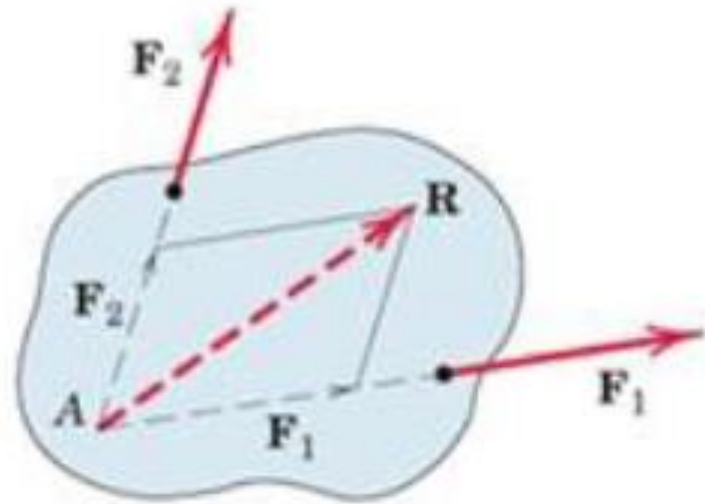
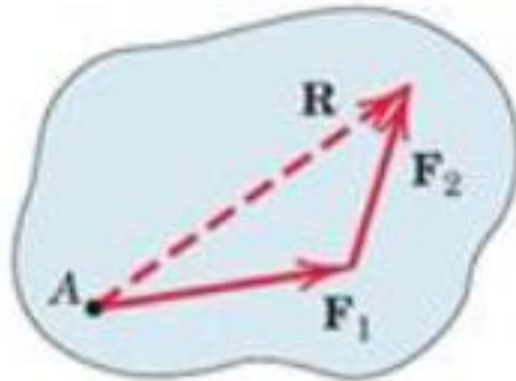
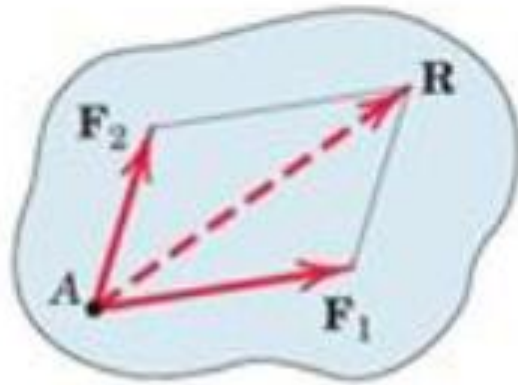
Principle of Transmissibility

- In Statics & Dynamics, we are not interested in the deformation of the body (internal effect)
- For such cases, the **line of action** of the force is more important than the point of application

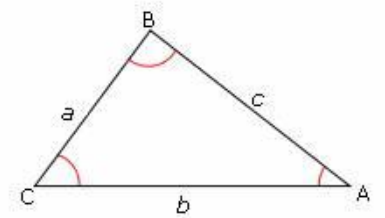


Force P will have the same effect whether applied at point B or A

Principle of Transmissibility



Use the parallelogram law to add/subtract vectors and assure that the line of action is preserved



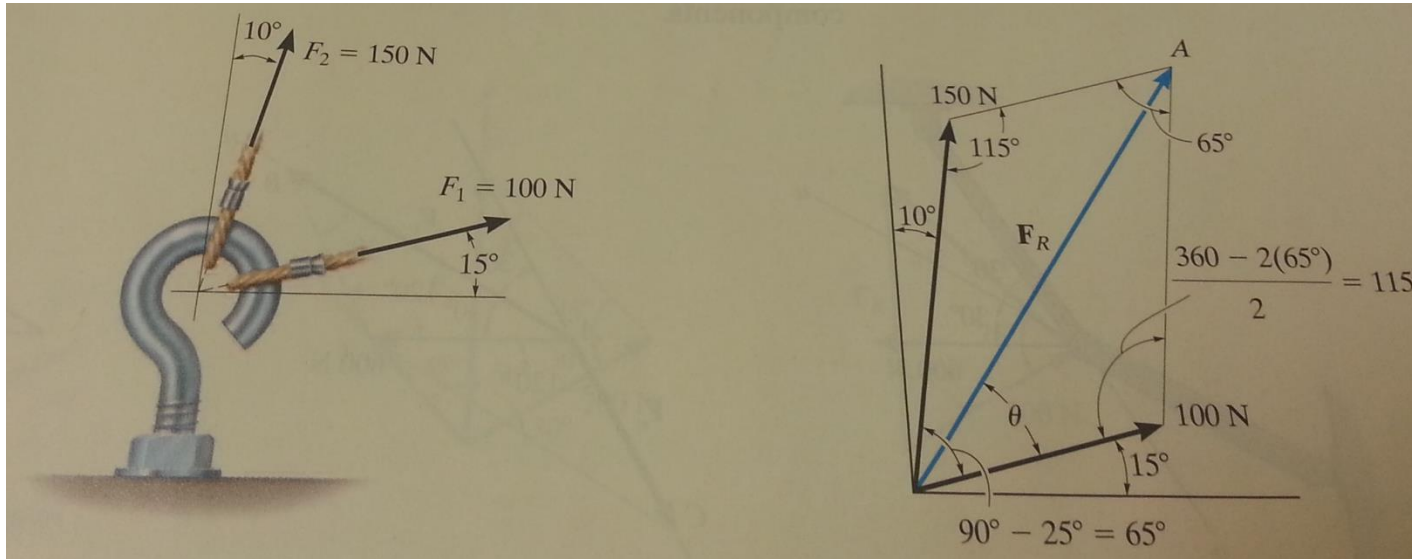
$$c^2 = a^2 + b^2 - 2ab \cdot \cos C$$

$$b^2 = a^2 + c^2 - 2ac \cdot \cos B$$

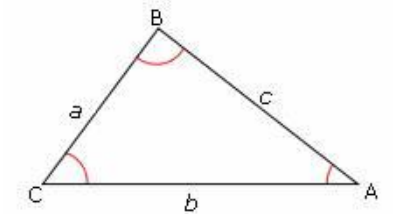
$$a^2 = b^2 + c^2 - 2bc \cdot \cos A$$

Example

The screw eye in Fig. is subjected to two forces F_1 and F_2 . Determine the magnitude and direction of the resultant force.



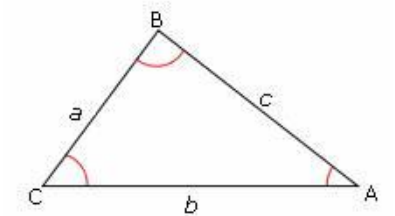
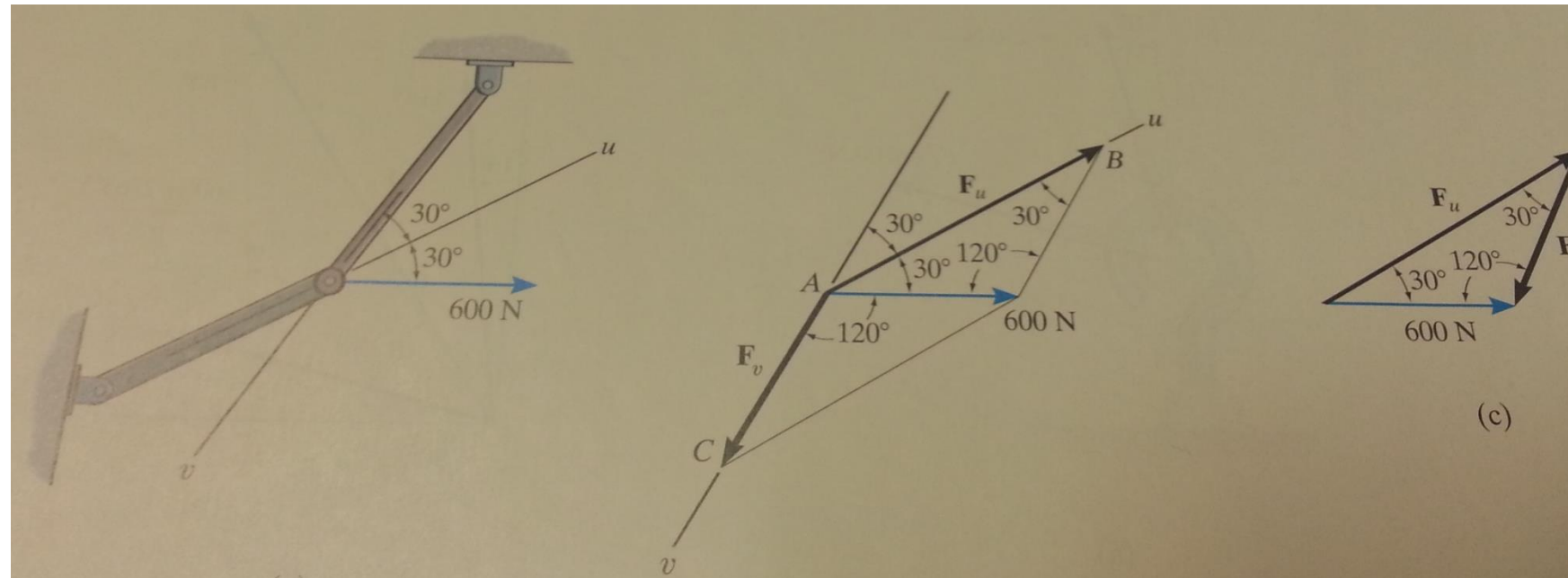
$F_R =$



$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

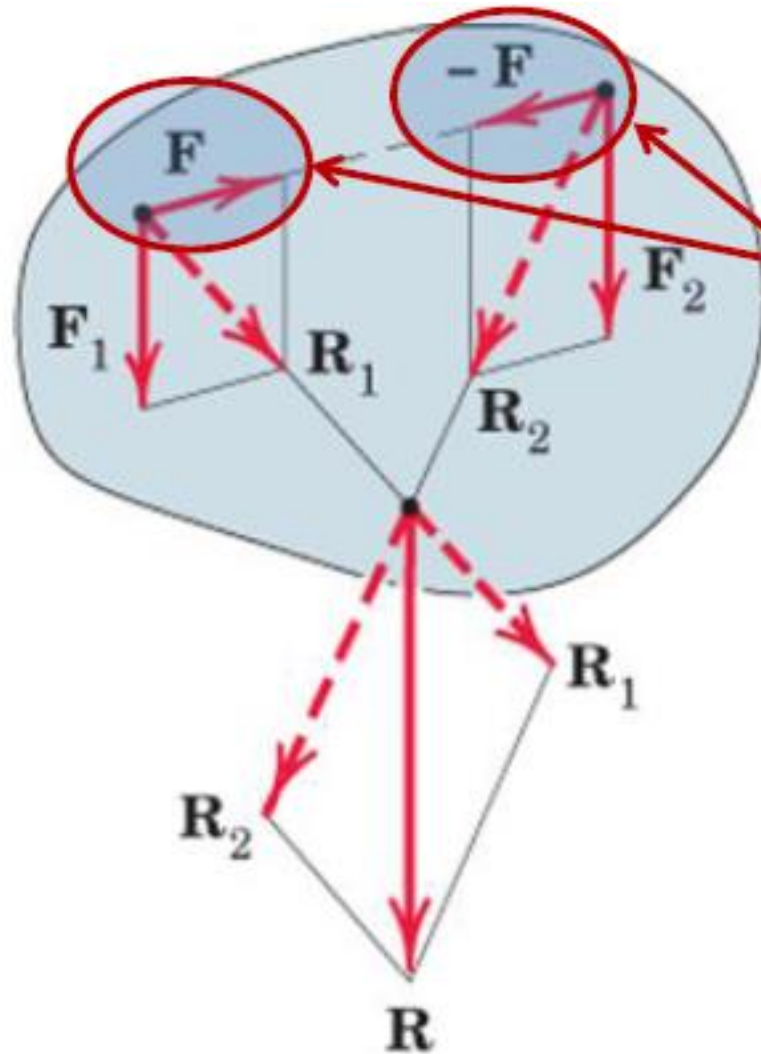
Example

Resolve the horizontal 600 N force in the Fig. into components acting along the u and v axes and determine the magnitude of these components.



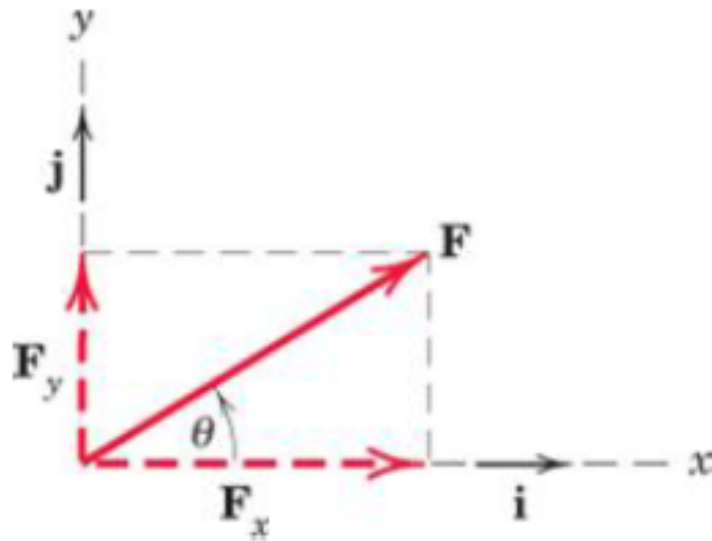
$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

Adding Parallel Forces



Adding two opposing forces F and $-F$ with the same line of action will not alter the mechanics of the body

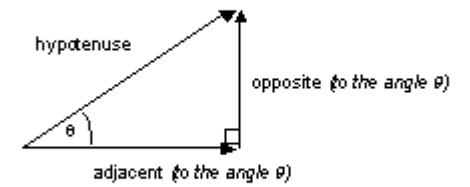
2-D Forces in Cartesian Coordinates



$$F_x = F \cos \theta, \quad F = \sqrt{F_x^2 + F_y^2}$$
$$F_y = F \sin \theta, \quad \theta = \tan^{-1} F_y / F_x$$

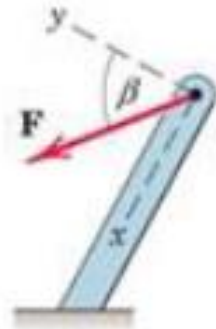
$$\vec{F} = \vec{F}_x + \vec{F}_y$$
$$= F_x \hat{i} + F_y \hat{j}$$

Trigonometry

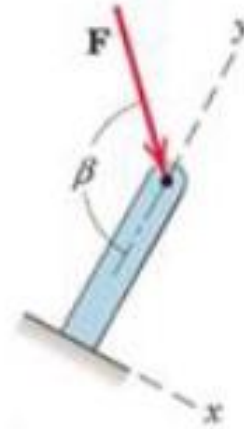


$$\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}} \quad \cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}} \quad \tan \theta = \frac{\text{opposite}}{\text{adjacent}}$$

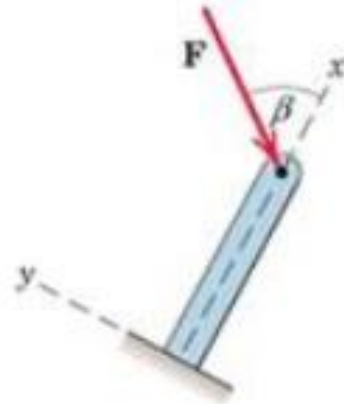
2-D Forces in Cartesian Coordinates



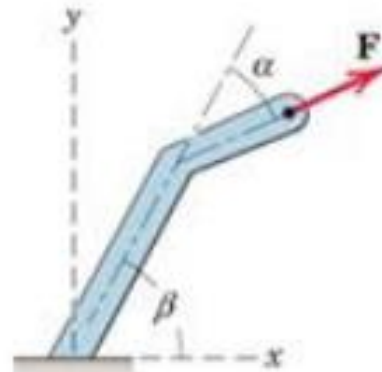
$$F_x = F \sin \beta$$
$$F_y = F \cos \beta$$



$$F_x = F \sin(\pi - \beta)$$
$$F_y = -F \cos(\pi - \beta)$$

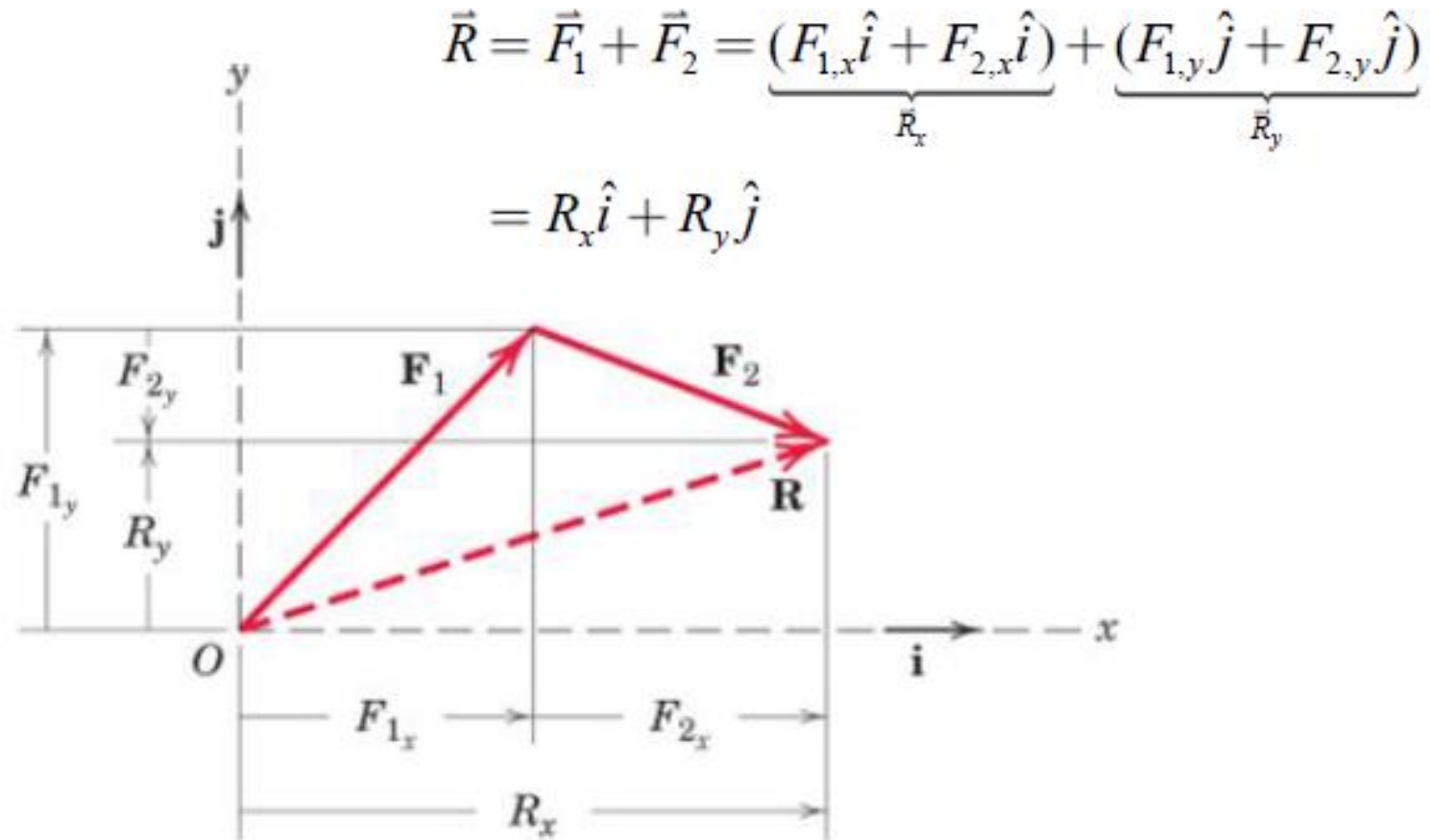


$$F_x = -F \cos \beta$$
$$F_y = -F \sin \beta$$



$$F_x = F \cos(\beta - \alpha)$$
$$F_y = F \sin(\beta - \alpha)$$

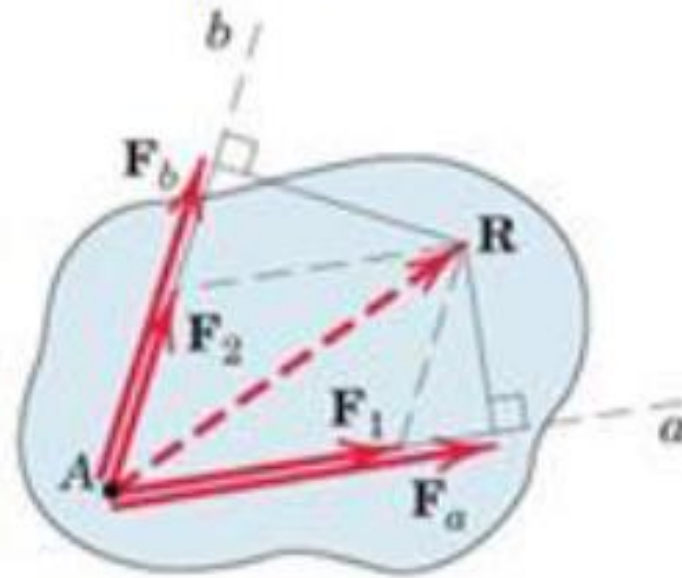
Summation of 2-D Forces



Projection vs Components

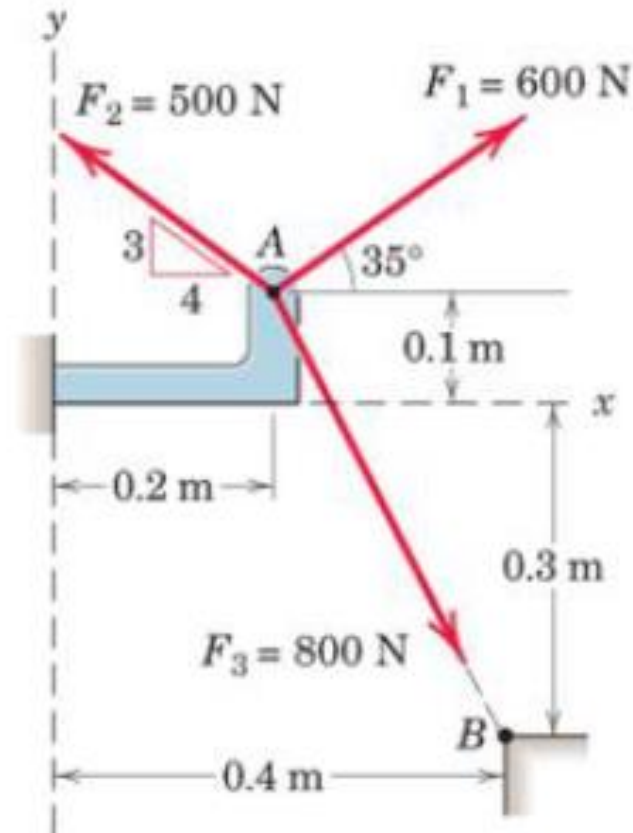
- Be careful not to confuse the components of a vector along two axes and the projection of the vector onto those axes
 - Components of \mathbf{R} along a - & b -axes are \mathbf{F}_1 & \mathbf{F}_2
 - Projection of \mathbf{R} onto a - & b -axes are \mathbf{F}_a & \mathbf{F}_b

$$\vec{F}_1 \neq \vec{F}_a$$
$$\vec{F}_2 \neq \vec{F}_b$$



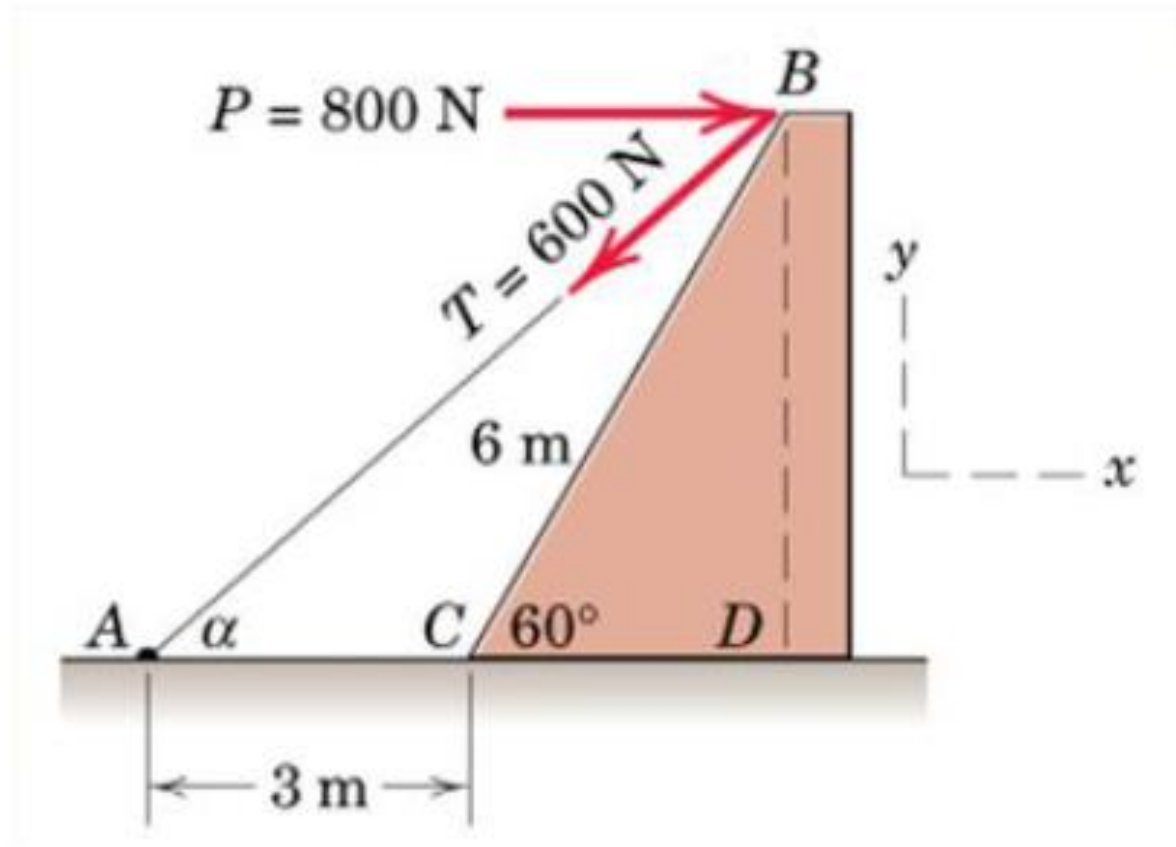
Example: 2-D Forces

- Determine the x- and y- components of the forces \mathbf{F}_1 , \mathbf{F}_2 , and \mathbf{F}_3 acting at point A of the bracket shown below



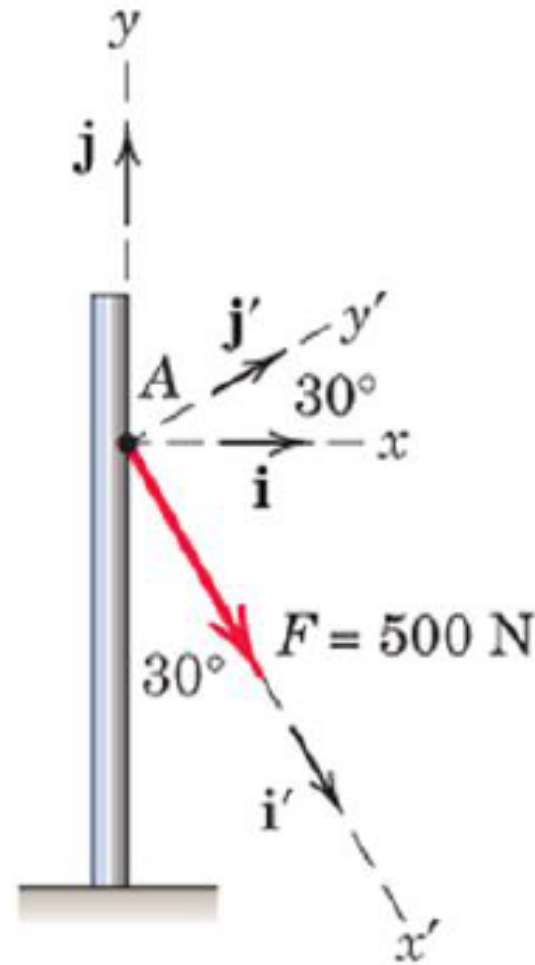
Example: 2-D Forces

- Determine the resultant due to the forces **P** and **T** shown below



Example: 2-D Forces

- For the 500 N force \mathbf{F} shown below
 - Write \mathbf{F} in terms of the unit vectors \mathbf{i} and \mathbf{j}
 - Determine the scalar components of \mathbf{F} along the x' - and y' -axes
 - Determine the scalar components of \mathbf{F} along the x - and y -axes



Example: 2-D Forces

- Determine the projection of the resultant \mathbf{R} of the forces onto the b -axis

