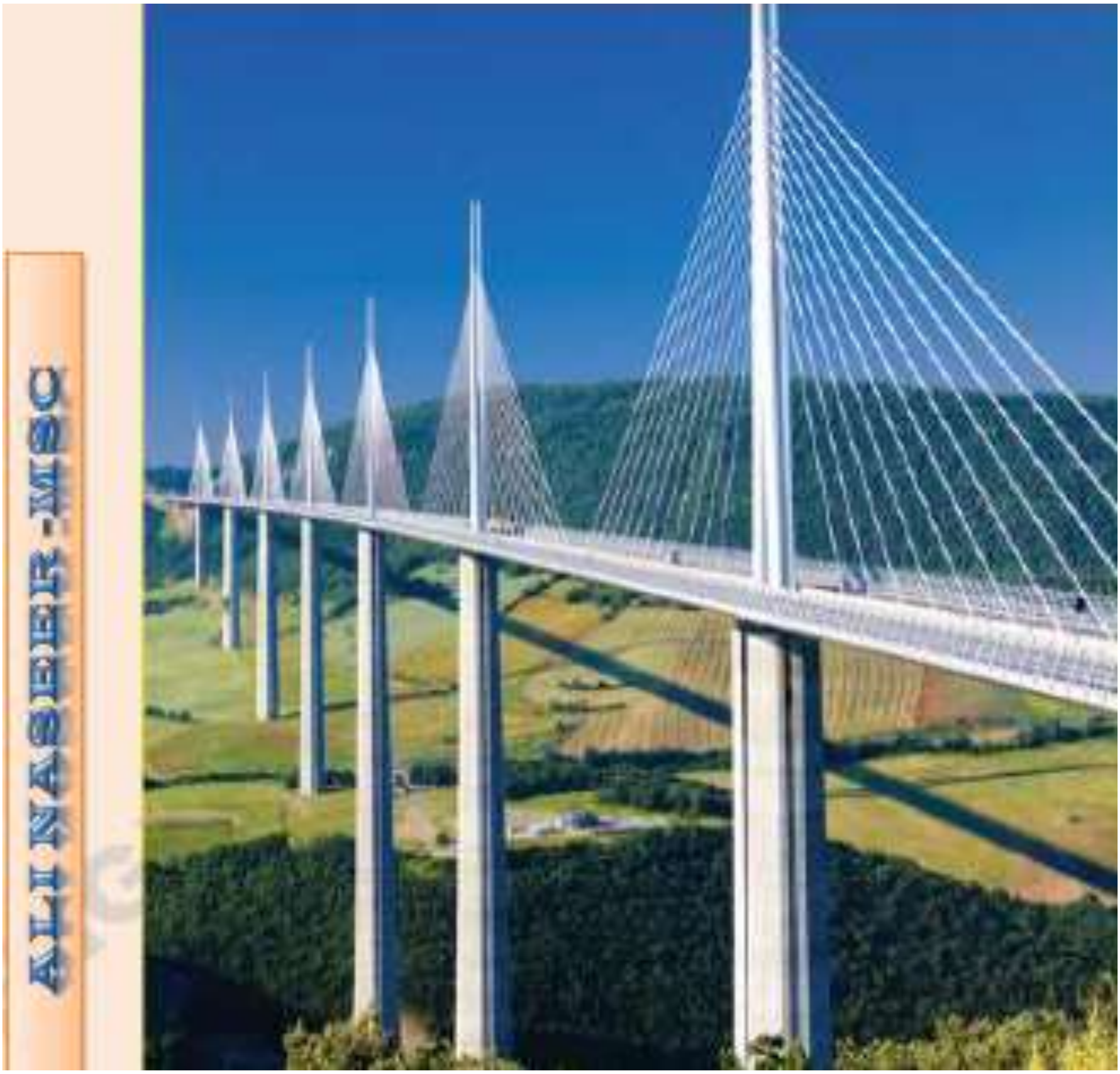
**Ministry of Higher Education and Scientific Research**
**AL- Muthanna University**
**College of Engineering**
**Electronic and Communications Department**
**Course "Engineering Mechanics" (Statics)**
**Stage: First Year**
**Lectures: MSC " Ali Nassir Hussain"**




**Course Number: PGE102: Engineering Mechanics (Statics)**
**Instructor: MSC " Ali Nassir Hussain**
**Credit hours: 3 Textbook: Engineering mechanics / J.L. Meriam, L.G. Kraige.–7th ed.:**

***References:***

***1.J. L. Meriam and L. G. Kraige, 'Engineering Mechanics: 7th edition,***
**_ Meriam, J. L. (James L.)**
**Engineering mechanics / J.L. Meriam, L.G. Kraige.–7th ed.**

## 2. Chapter Two: Force vectors:

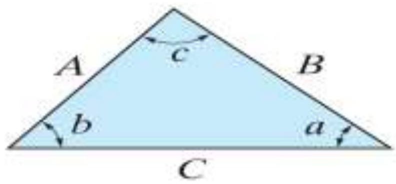
**A *scalar* is any positive or negative physical quantity that can be completely specified by its *magnitude*. Examples of scalar quantities include length, mass, and time.**

**A *vector* is any physical quantity that requires both a *magnitude* and a *direction* for its complete description. Examples of vectors encountered in statics are force, position, and moment.**

### 2.1.Vector Operations

**Procedure for Analysis:**

1. **Redraw a half portion of the parallelogram to illustrate the triangular head-to-tail addition of the components.**
2. **From this triangle, the *magnitude of the resultant force* can be determined using *the law of cosines*, and its *direction* is determined from *the law of sines*. The magnitudes of two force components are determined from the law of sines. The formulas are:**




*Cosine law:* $C = \sqrt{A^2 + B^2 - 2AB\cos(c)}$

Sine law: $\frac{A}{\sin a} + \frac{B}{\sin b} + \frac{C}{\sin c}$

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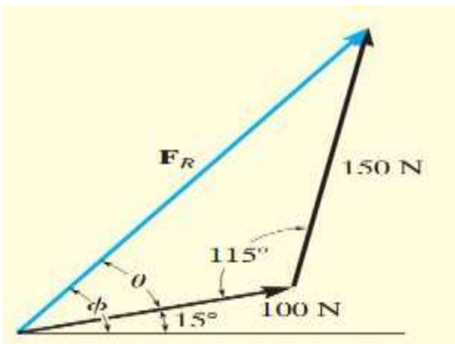
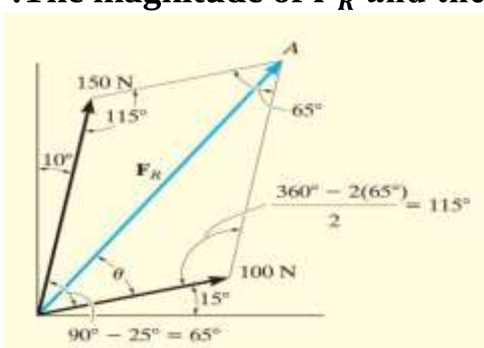
***Example* /1: The screw eye in Figure below is subjected to two forces, F1 and F2.**

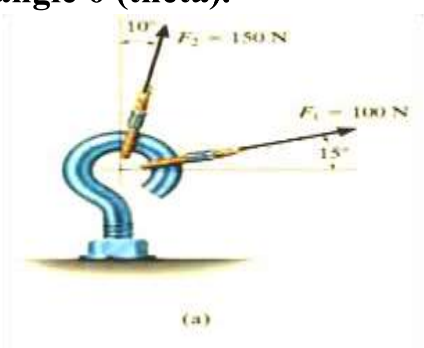
**Determine the magnitude and direction of the resultant force.**

***Solution:***

**The two unknowns are .The magnitude of $F_R$ and the angle θ (theta).**




**Using the law of cosines:**

$$F_R = \sqrt{(100)^2 + (150)^2 - 2(100)(150)\cos 115^0}$$

$$F_R = \sqrt{(1000) + (22500) - 3000(-0.4226)}$$

$F_R = 212.6$

**Applying the law of sines to determine θ:**

$$\frac{150}{\sin\theta} = \frac{212.6}{sin115^0}$$

$$\sin\theta = \frac{150(sin115^0)}{212.6}$$

$$\theta = 39.8^0$$

***Thus, the direction Φ (phi) of FR, measured from the horizontal, is:***

$\theta = 39.8^0 + 15^0 = 54.8^0$

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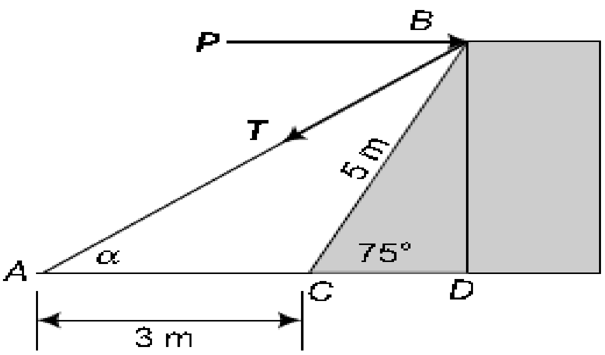
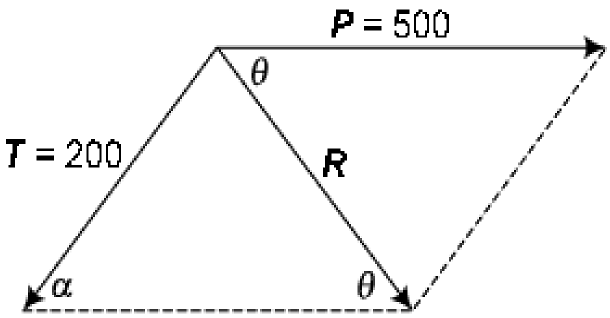
**Example( 3) / Refer to the Fig. 2.24. The structure shown is subjected to force vectors *P* and *T* having magnitude 500 N and 200 N respectively. Combine *P* and *T* into a single force *R*.**

**Solution Given *P* = 500 N ، *T* = 200 N ، Let the angle between *P* and *T* be $\alpha$.So, *P* and *T* can be represented by two adjacent sides of the parallelogram and the resultant *R* can be represented by the diagonal.**




From the given geometry,

$$\tan\ \alpha = \frac{BD}{AD} = \frac{5\sin 75°}{3 + 5\cos 75°} \Rightarrow \alpha = 48.4°$$

Using Law of cosines:

$$c^2 = a^2 + b^2 - 2ab\ \cos\ \alpha$$
$$R^2 = 200^2 + 500^2 - 2(200)(500)\ \cos\ (48.4°)$$
$$R = 396.5\ \text{N}$$

Using Law of sines, we get $\dfrac{200}{\sin\theta} = \dfrac{396.5}{\sin 48.4°}$

$$\theta = 22.2°$$

Thus the magnitude of $R$ is $R = 396.5\ N$ and its inclination with $P$ is 22.2°.

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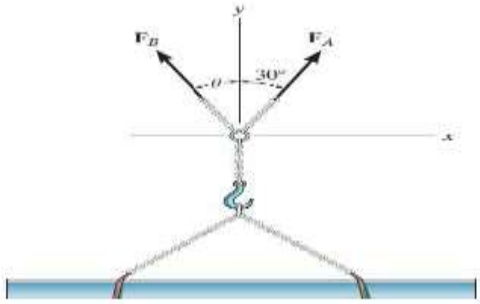
**(H.W).3: determine the magnitude of forces FA and FB acting on each chain In order to develop a resultant force of 600 N directed along the positive Y-axis.**

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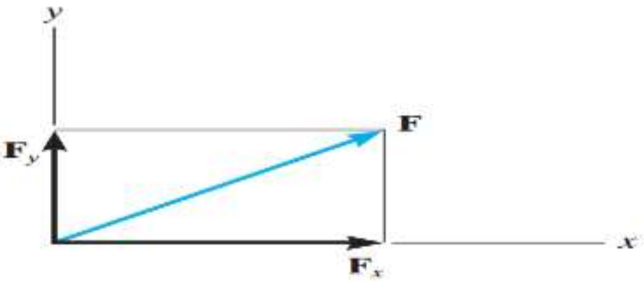
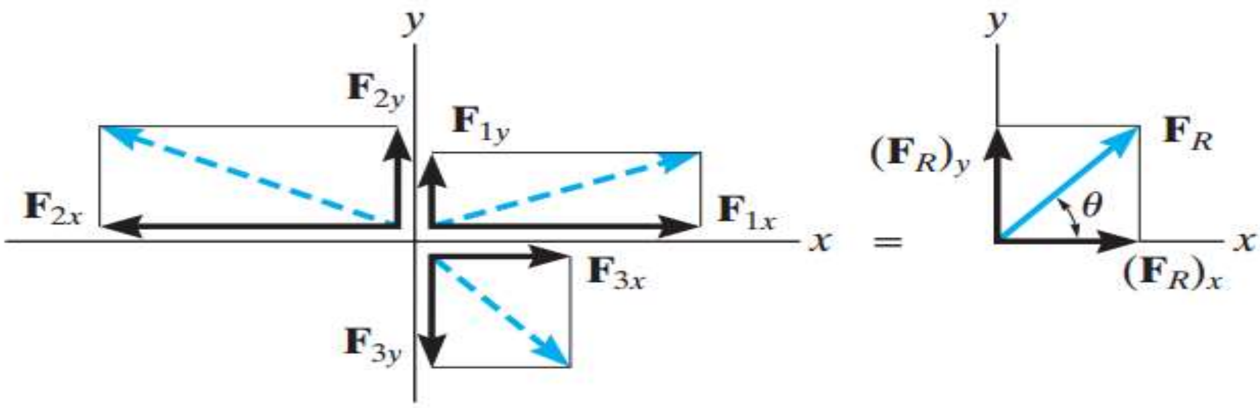
## 2.2.Rectangular Components :Two Dimensions:

**Vectors *Fx* and *Fy* are rectangular components of F.**




**The resultant force is determined from the algebraic sum of its components.**




$$(F_R)_x = \Sigma F_x$$

$$(F_R)_y = \Sigma F_y$$

$$F_R = \sqrt{(F_R)_x^2 + (F_R)_y^2}$$

$$\theta = \tan^{-1}\left|\frac{(F_R)_y}{(F_R)_x}\right|$$

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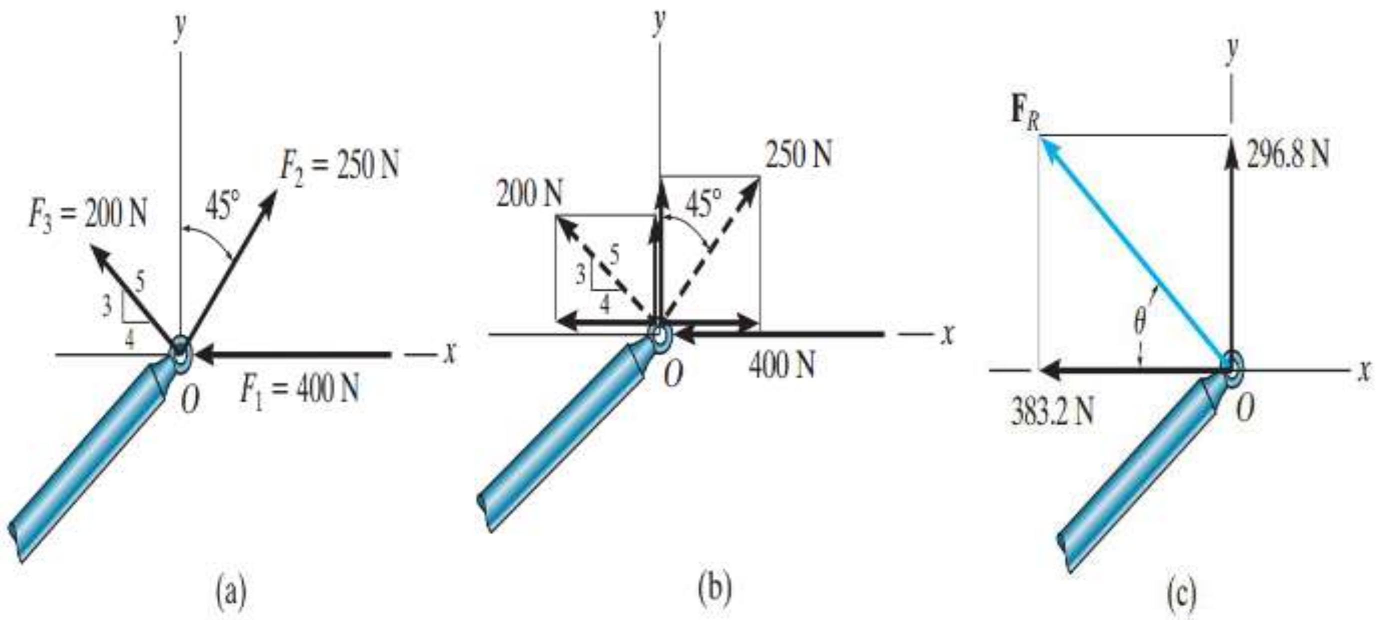
***Example:*** **The end of the boom O in Figure (a) below is subjected to three concurrent and coplanar forces. Determine the *magnitude* and *direction* of the resultant force.**




# Solution:

***Each force is resolved into its x and y components, Figure (b), Summing the x-components and y-components***

$$\overset{+}{\rightarrow} (F_R)_x = \Sigma F_x; \qquad (F_R)_x = -400\text{ N} + 250 \sin 45^\circ\text{ N} - 200\left(\tfrac{4}{5}\right)\text{ N}$$
$$= -383.2\text{ N} = 383.2\text{ N} \leftarrow$$

$$+\uparrow (F_R)_y = \Sigma F_y; \qquad (F_R)_y = 250 \cos 45^\circ\text{ N} + 200\left(\tfrac{3}{5}\right)\text{ N}$$
$$= 296.8\text{ N} \uparrow$$

**The resultant force, shown in Figure c, has a magnitude of:**

$$F_R = \sqrt{(-383.2\text{ N})^2 + (296.8\text{ N})^2}$$
$$= 485\text{ N}$$

**The direction angle θ is:**

$$\theta = \tan^{-1}\left(\frac{296.8}{383.2}\right) = 37.8^\circ$$

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## Sample Problem

**Forces *F1* and *F2* act on the bracket as shown. Determine the projection *Fb* of their resultant *R* onto the b-axis.**

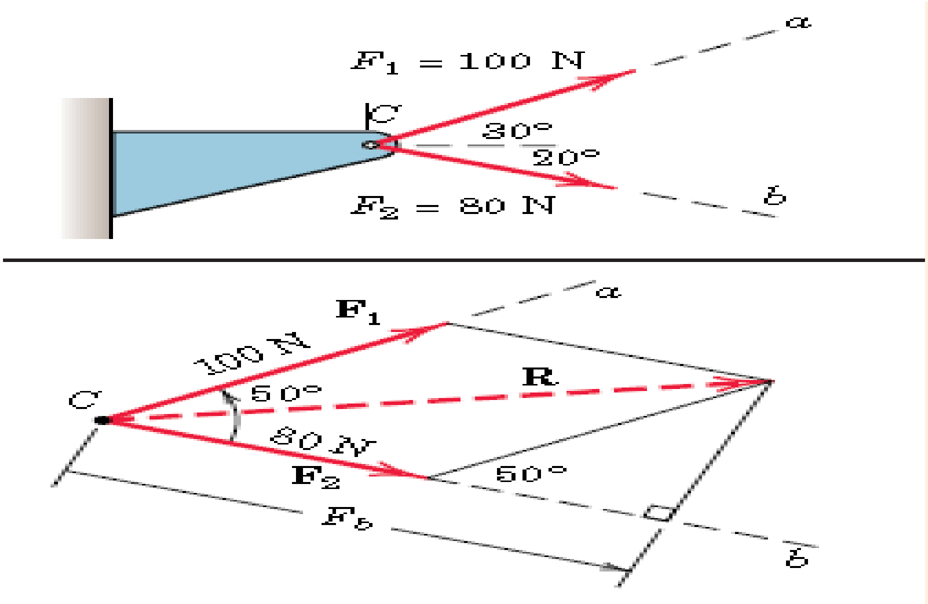
**Solution.**

**The parallelogram addition of *F1* and F2 is shown in the figure. Using the law of cosines gives us**

$R^2 = (80)^2 + (100)2 - 2(80)(100)\cos 130^0$ **$R$ = 163.4 N**

**The figure also shows the orthogonal projection F*b* of R onto the *b*-axis. Its length is:**

***Fb* = 80 +100 cos $50^0$ =144.3 N** ***Ans.***




**H.W // Determine the X and Y components of the 800-lb force.**