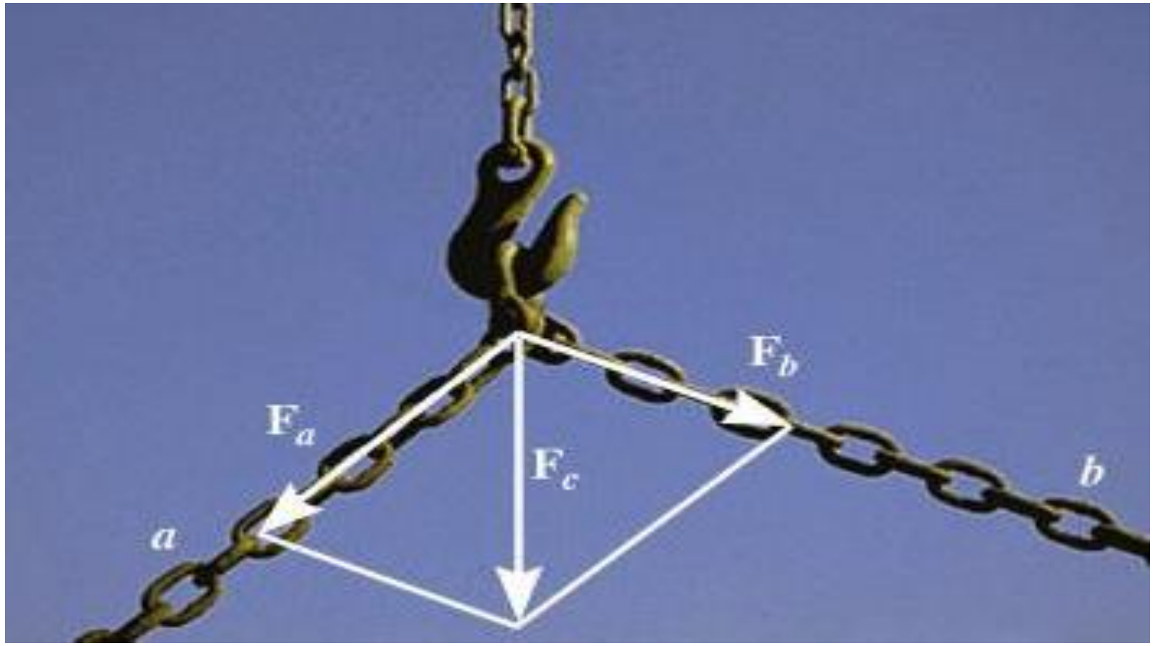
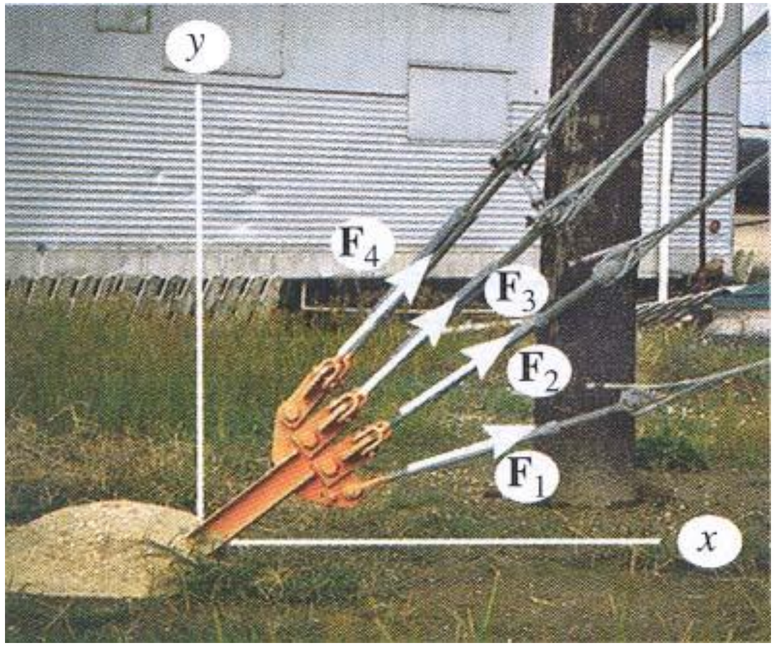
FORCE (VECTOR) OPERATIONS & ADDITION CONCURRENT FORCES





Tow concurrent forces are auditioned by the *parallelogram rule.*

The resultant of the two forces is determined by the parallelogram rule.

There are four concurrent cable forces acting on the bracket.

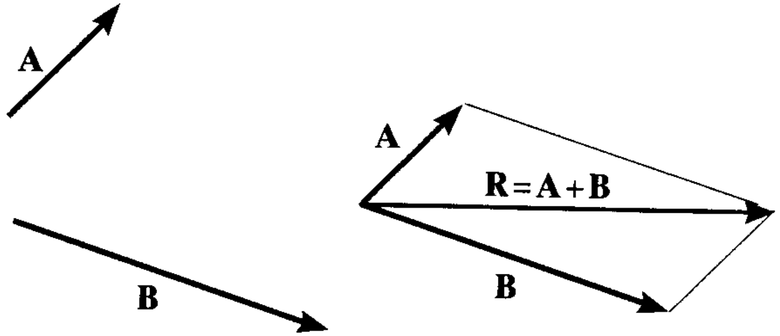
How do you deermine the resultant force acting on the bracket ?

SCALARS AND VECTORS

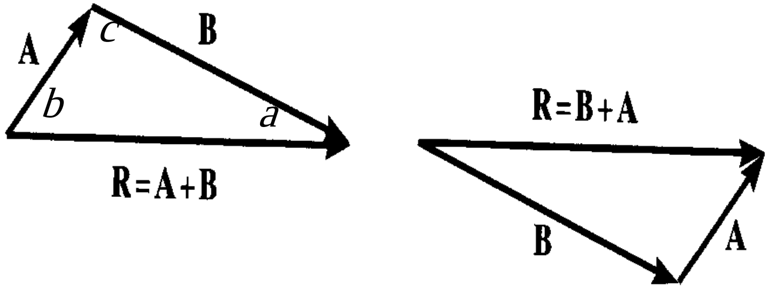
	Scalars	*Vectors*
Examples	mass, volume	force, velocity
Characteristics	Magnitude (±) & Unit	Magnitude & Direction
Addition rule	Simple arithmetic	Parallelogram law
Special Notation	None	Bold font, arrow (→)or a caret (^)

VECTOR ADDITION USING EITHER THE PARALLELOGRAM LAW OR TRIANGLE

Parallelogram Law:



Triangle method
(always ‘tip to tail’):

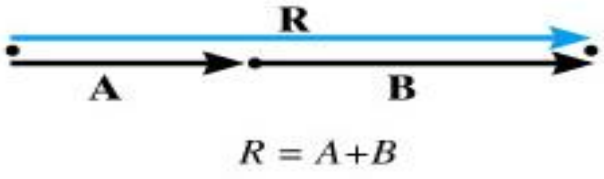


Sine law:

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

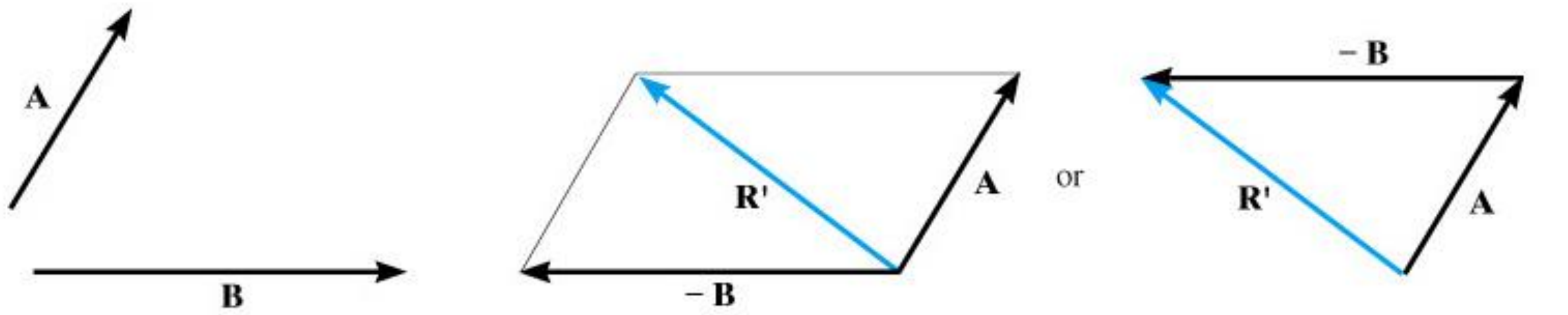
Cosine law:

$$R = \sqrt{(A^2 + B^2 - 2AB\cos c)}$$



Addition of collinear vectors

VECTOR SUBTRACTION USING EITHER THE PARALLELOGRAM LAW OR TRIANGLE

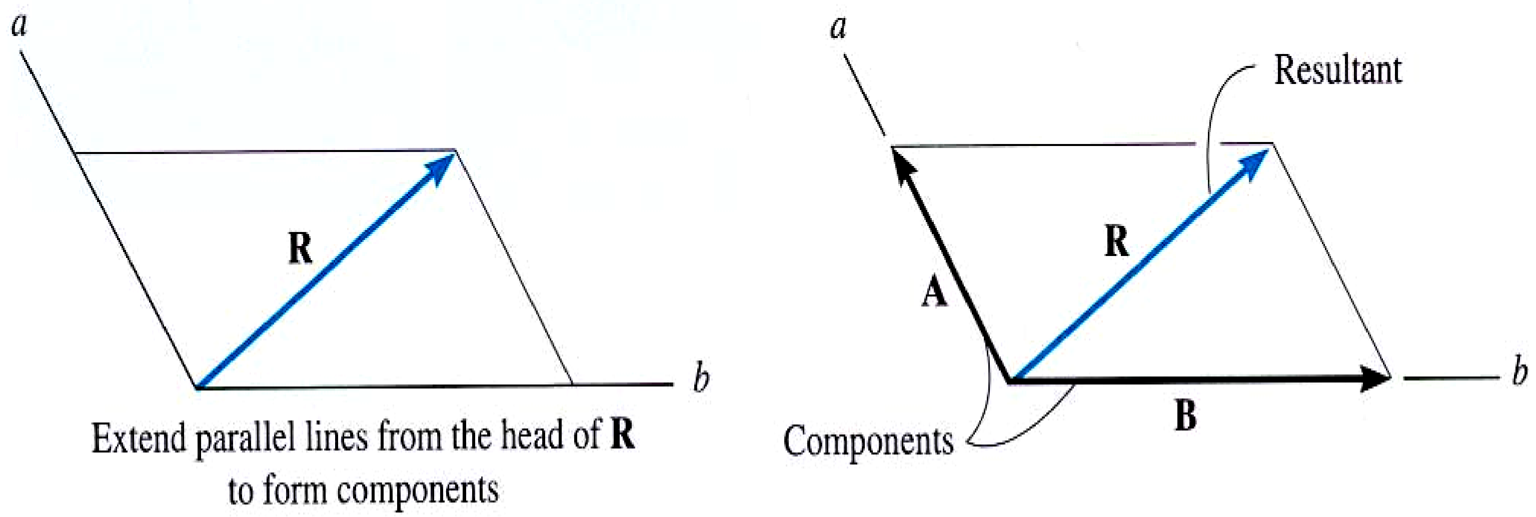


Parallelogram law

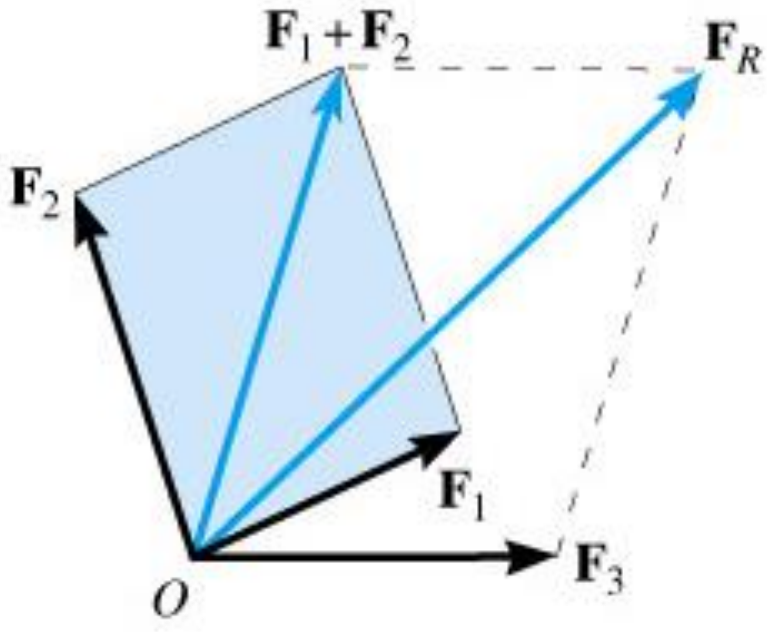
Triangle construction

RESOLUTION OF A VECTOR

“Resolution” of a vector is breaking up a vector into components.
It is kind of like using the parallelogram law in reverse.

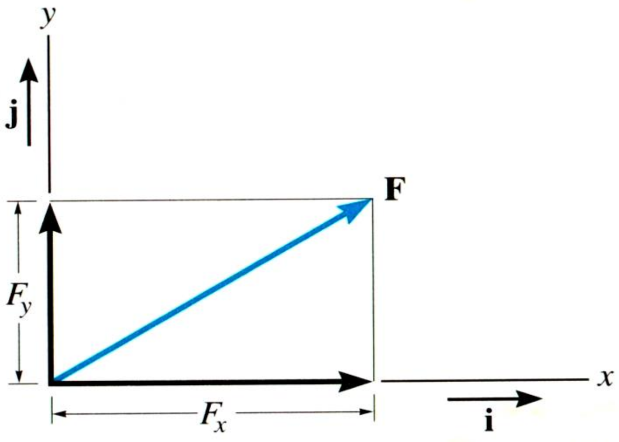


Associativity of Force Addition



Applying the parallelogram law becomes more complicated. So …. Des Carte Geometry?

CARTESIAN VECTOR NOTATION



(a)

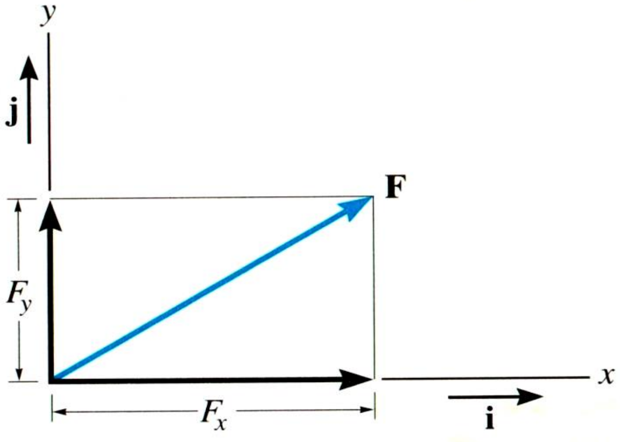
- We ‘resolve’ vectors into components using the x and y axes system.

- Each component of the vector is shown as a magnitude and a direction.

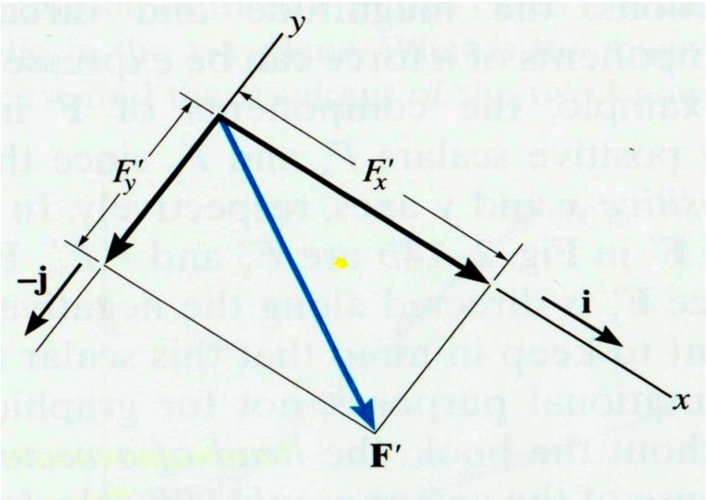
- The directions are based on the *x* and *y* axes. We use the “unit vectors” ***i*** and ***j*** to designate the *x* and *y* axes.

For example,

$\boldsymbol{F} = F_x\, \boldsymbol{i} + F_y\, \boldsymbol{j}$ ***or*** $\boldsymbol{F'} = F'_x\, \boldsymbol{i} - F'_y\, \boldsymbol{j}$



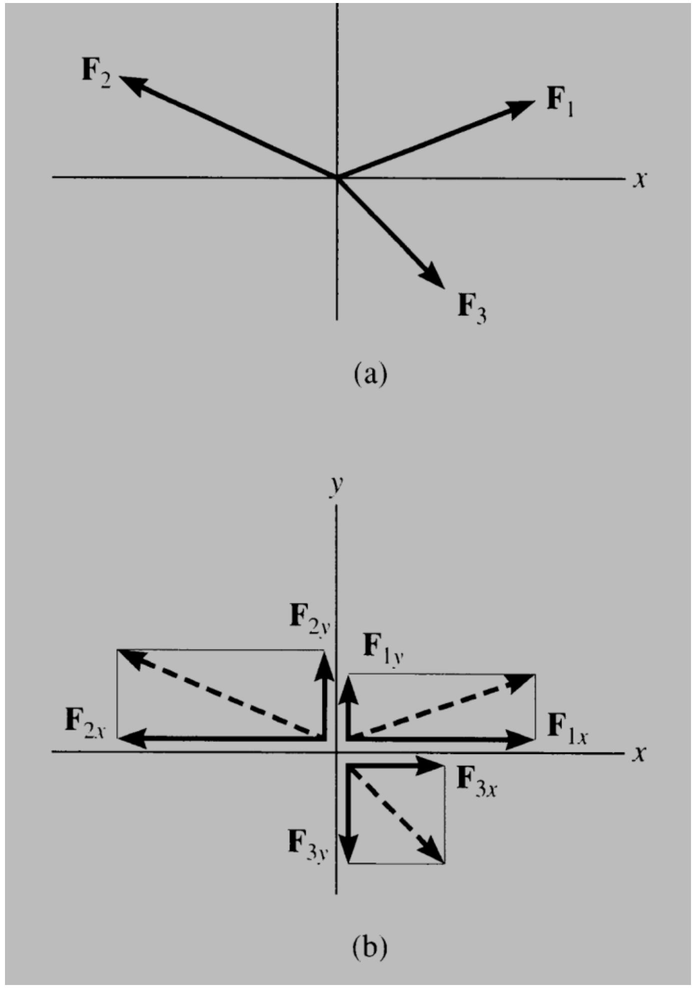
(a)



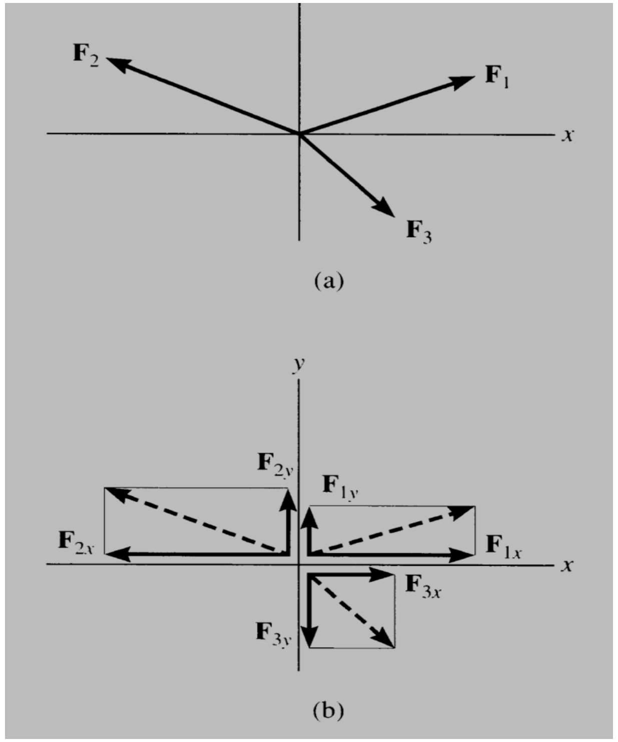
(b)

The *x* and *y* axes are always perpendicular to each other. Together, they can be directed at any inclination.

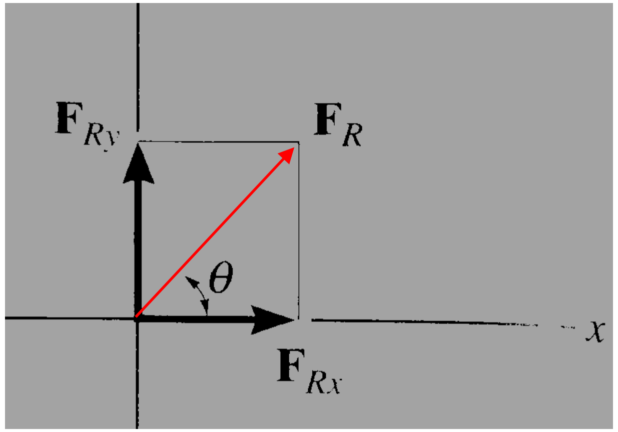
ADDITION OF SEVERAL VECTORS



- Step 1 is to resolve each force into its components
- Step 2 is to add all the *x* components together and add all the *y* components together. These two totals become the resultant vector.
- Step 3 is to find the magnitude and angle of the resultant vector.



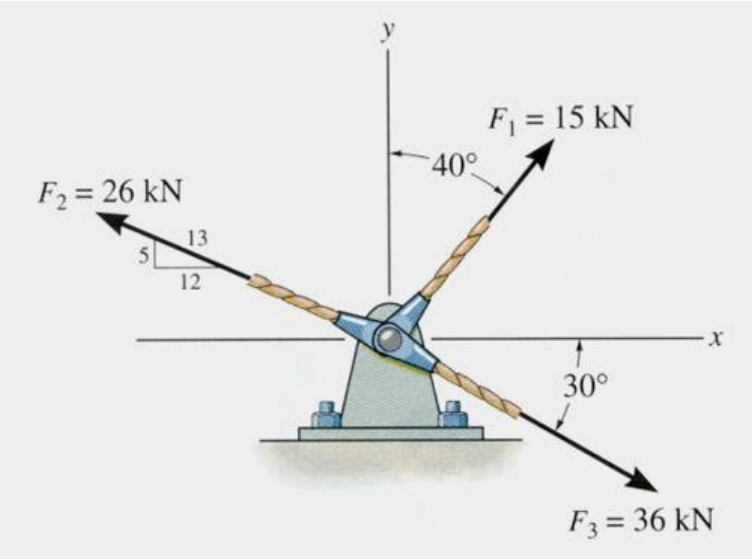
$$\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3$$
$$= F_{1x}\mathbf{i} + F_{1y}\mathbf{j} - F_{2x}\mathbf{i} + F_{2y}\mathbf{j} + F_{3x}\mathbf{i} - F_{3y}\mathbf{j}$$
$$= (F_{1x} - F_{2x} + F_{3x})\mathbf{i} + (F_{1y} + F_{2y} - F_{3y})\mathbf{j}$$
$$= (F_{Rx})\mathbf{i} + (F_{Ry})\mathbf{j}$$



$$F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2}$$

$$\theta = \tan^{-1}\left|\frac{F_{Ry}}{F_{Rx}}\right|$$

EXAMPLE



Given: Three concurrent forces acting on a bracket.

Find: The magnitude and angle of the resultant force.

<u>Plan:</u>

a) Resolve the forces in their x-y components.

b) Add the respective components to get the resultant vector.

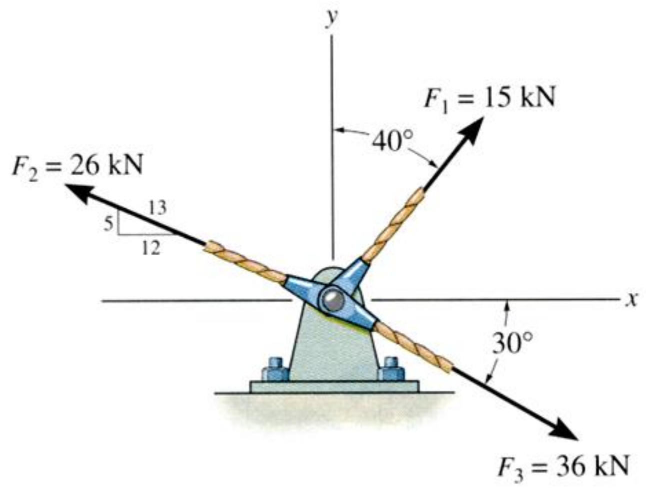
c) Find magnitude and angle from the resultant components.

$$F_1 = \{ 15 \sin 40° \, \boldsymbol{i} + 15 \cos 40° \, \boldsymbol{j} \} \text{ kN}$$

$$= \{ 9.642 \, \boldsymbol{i} + 11.49 \, \boldsymbol{j} \} \text{ kN}$$

$$F_2 = \{ -(12/13)26 \, \boldsymbol{i} + (5/13)26 \, \boldsymbol{j} \} \text{ kN}$$

$$= \{ -24 \, \boldsymbol{i} + 10 \, \boldsymbol{j} \} \text{ kN}$$



$$F_3 = \{ 36 \cos 30° \, \boldsymbol{i} - 36 \sin 30° \, \boldsymbol{j} \} \text{ kN}$$

$$= \{ 31.18 \, \boldsymbol{i} - 18 \, \boldsymbol{j} \} \text{ kN}$$

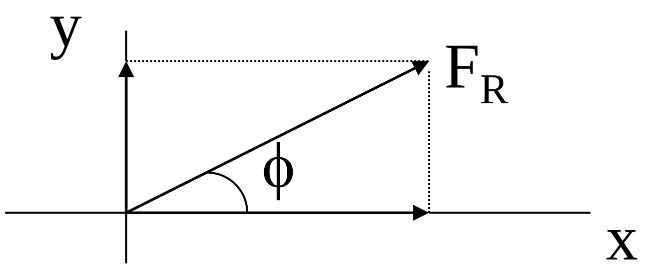
Summing up all the $\boldsymbol{i}$ and $\boldsymbol{j}$ components respectively, we get,

$$F_R = \{ (9.642 - 24 + 31.18) \, \boldsymbol{i} + (11.49 + 10 - 18) \, \boldsymbol{j} \} \text{ kN}$$

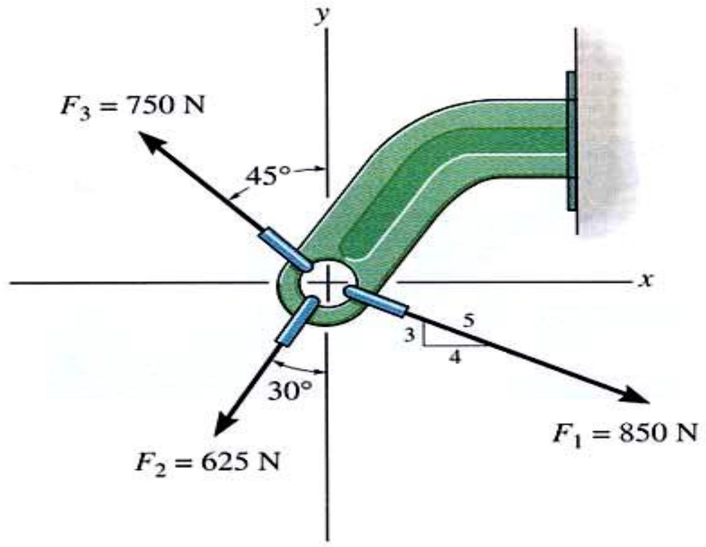
$$= \{ 16.82 \, \boldsymbol{i} + 3.49 \, \boldsymbol{j} \} \text{ kN}$$

$$F_R = ((16.82)^2 + (3.49)^2)^{1/2} = 17.2 \text{ kN}$$

$$\phi = \tan^{-1}(3.49/16.82) = 11.7°$$



PROBLEM 1.



Given: Three concurrent forces acting on a bracket

Find: The magnitude and angle of the resultant force.

Plan:

a) Resolve the forces in their x-y components.

b) Add the respective components to get the resultant vector.

c) Find magnitude and angle from the resultant components.

Problem 2. Two forces act on the hook. Determine the magnitude of the resultant force and its direction measured from the horizontal axis

R_x=344.215N & R_y=-569.846N $\Rightarrow$ R=666N & θ=(-58.9)°