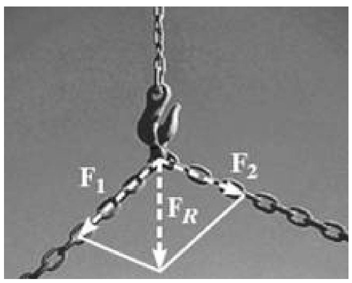
FORCE VECTORS, VECTOR OPERATIONS & ADDITION COPLANAR FORCES

Today's Objective:

Students will be able to :

a) Resolve a 2-D vector into components.

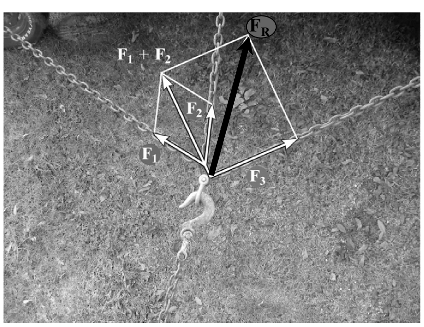
b) Add 2-D vectors using Cartesian vector notations.



In-Class activities:

- Application of Adding Forces
- Parallelogram Law
- Resolution of a Vector Using Cartesian Vector Notation (CVN)
- Addition Using CVN

APPLICATION OF VECTOR ADDITION



There are three concurrent forces acting on the hook due to the chains.

We need to decide if the hook will fail (bend or break)?

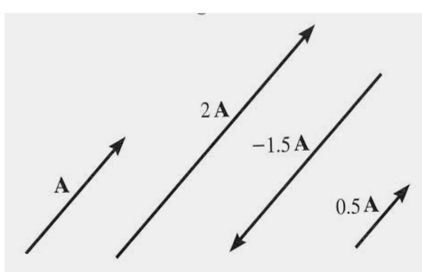
To do this, we need to know the resultant force acting on the hook.

SCALARS AND VECTORS
(Section 2.1)

	Scalars	*Vectors*
Examples:	Mass, Volume	Force, Velocity
Characteristics:	It has a magnitude (positive or negative)	It has a magnitude and direction
Addition rule:	Simple arithmetic	Parallelogram law
Special Notation:	None	Bold font, a line, an arrow or a "carrot"

In these PowerPoint presentations, a vector quantity is represented ***like this*** (in **bold**, *italics*, and yellow).

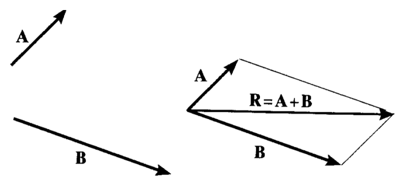
VECTOR OPERATIONS
(Section 2.2)



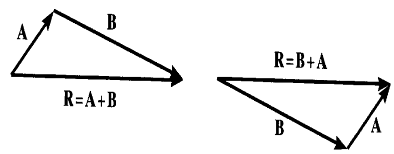
Scalar Multiplication and Division

VECTOR ADDITION USING EITHER THE PARALLELOGRAM LAW OR TRIANGLE

Parallelogram Law:



Triangle method (always 'tip to tail'):

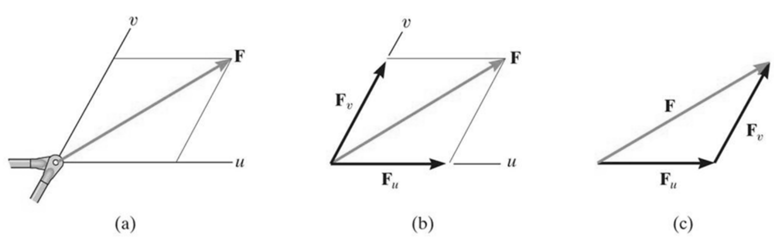


How do you subtract a vector?

How can you add more than two concurrent vectors graphically ?

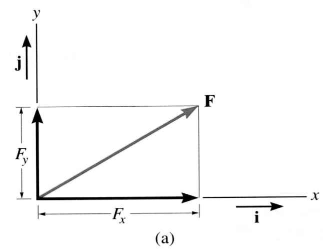
RESOLUTION OF A VECTOR

"Resolution" of a vector is breaking up a vector into components.



<u>It is kind of like using the parallelogram law in reverse.</u>

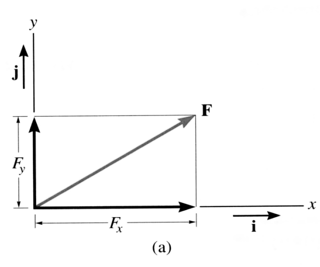
ADDITION OF A SYSTEM OF COPLANAR FORCES (Section 2.4)

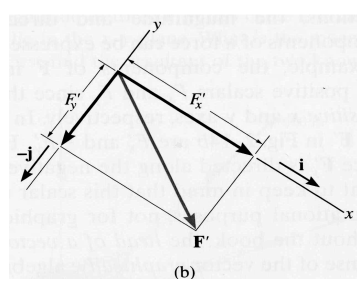


- We 'resolve' vectors into components using the x and y axis system.
- Each component of the vector is shown as a magnitude and a direction.
- The directions are based on the x and y axes. We use the "<u>unit vectors</u>" ***i*** and ***j*** to designate the x and y axes.

For example,

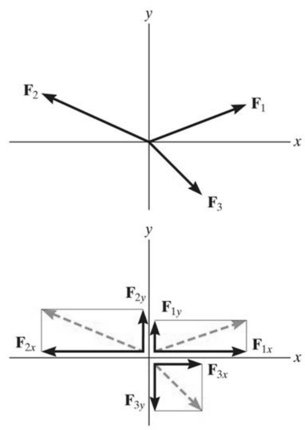
$$\boldsymbol{F} = \mathrm{F_x}\,\boldsymbol{i} + \mathrm{F_y}\,\boldsymbol{j} \qquad \textit{or} \qquad \boldsymbol{F'} = \mathrm{F'_x}\,\boldsymbol{i} + (-\,\mathrm{F'_y})\,\boldsymbol{j}$$





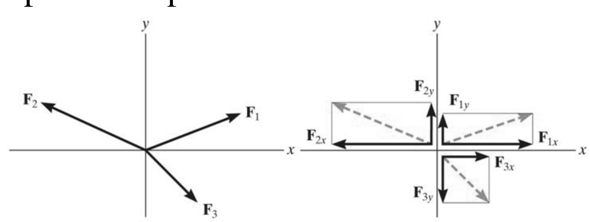
The x and y axis are always perpendicular to each other. Together, they can be directed at any inclination.

ADDITION OF SEVERAL VECTORS



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

An example of the process:



Break the three vectors into components, then add them.

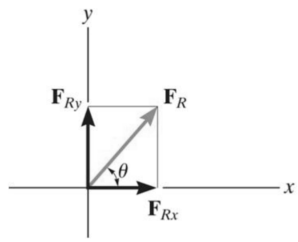
$$\boldsymbol{F_R} = \boldsymbol{F_1} + \boldsymbol{F_2} + \boldsymbol{F_3}$$

$$= F_{1x}\,\boldsymbol{i} + F_{1y}\,\boldsymbol{j} - F_{2x}\,\boldsymbol{i} + F_{2y}\,\boldsymbol{j} + F_{3x}\,\boldsymbol{i} - F_{3y}\,\boldsymbol{j}$$

$$= (F_{1x} - F_{2x} + F_{3x})\,\boldsymbol{i} + (F_{1y} + F_{2y} - F_{3y})\,\boldsymbol{j}$$

$$= (F_{Rx})\,\boldsymbol{i} + (F_{Ry})\,\boldsymbol{j}$$

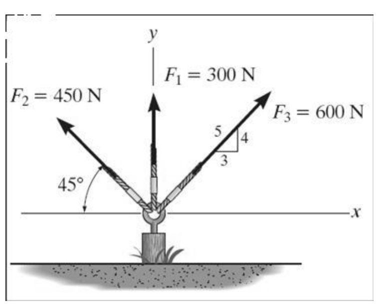
You can also represent a 2-D vector with a magnitude and angle.



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

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

EXAMPLE



Given: Three concurrent forces acting on a tent post.

Find: The magnitude and angle of the resultant force.

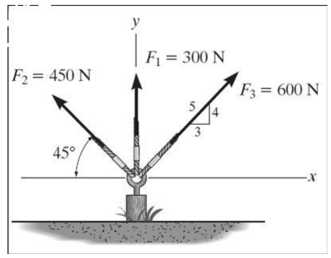
Plan:

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

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

c) Find magnitude and angle from the resultant components.

EXAMPLE (continued)



$\boldsymbol{F_1}$ = {0 $\boldsymbol{i}$ + 300 $\boldsymbol{j}$ } N

$\boldsymbol{F_2}$ = {– 450 cos (45°) $\boldsymbol{i}$ + 450 sin (45°) $\boldsymbol{j}$ } N

= {– 318.2 $\boldsymbol{i}$ + 318.2 $\boldsymbol{j}$ } N

$\boldsymbol{F_3}$ = { (3/5) 600 $\boldsymbol{i}$ + (4/5) 600 $\boldsymbol{j}$ } N

= { 360 $\boldsymbol{i}$ + 480 $\boldsymbol{j}$ } N

EXAMPLE
(continued)

Summing up all the ***i*** and ***j*** components respectively, we get,

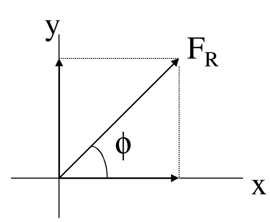
$\boldsymbol{F_R}$ = { (0 – 318.2 + 360) $\boldsymbol{i}$ + (300 + 318.2 + 480) $\boldsymbol{j}$ } N

= { 41.80 $\boldsymbol{i}$ + 1098 $\boldsymbol{j}$ } N

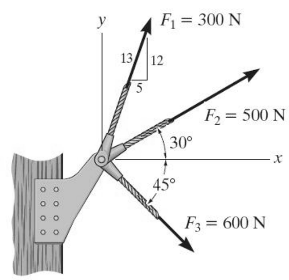
Using magnitude and direction:

$F_R = ((41.80)^2 + (1098)^2)^{1/2} = 1099$ N

$\phi = \tan^{-1}(1098/41.80) = 87.8°$



GROUP PROBLEM SOLVING



Given: Three concurrent forces acting on a bracket

Find: The magnitude and angle of the resultant force.

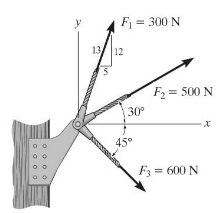
<u>Plan:</u>

a) Resolve the forces into their x and y components.

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

c) Find magnitude and angle from the resultant components.

GROUP PROBLEM SOLVING (continued)



$\boldsymbol{F_1} = \{ (5/13)\ 300\ \boldsymbol{i} + (12/13)\ 300\ \boldsymbol{j} \}$ N

$= \{ 115.4\ \boldsymbol{i} + 276.9\ \boldsymbol{j} \}$ N

$\boldsymbol{F_2} = \{500 \cos (30°)\ \boldsymbol{i} + 500 \sin (30°)\ \boldsymbol{j} \}$ N

$= \{ 433.0\ \boldsymbol{i} + 250\ \boldsymbol{j} \}$ N

$\boldsymbol{F_3} = \{ 600 \cos (45°)\ \boldsymbol{i} - 600 \sin (45°)\ \boldsymbol{j} \}$ N

$\{ 424.3\ \boldsymbol{i} - 424.3\ \boldsymbol{j} \}$ N

GROUP PROBLEM SOLVING (continued)

Summing up all the ***i*** and ***j*** components respectively, we get,

$\boldsymbol{F_R} = \{ (115.4 + 433.0 + 424.3)\, \boldsymbol{i} + (276.9 + 250 - 424.3)\, \boldsymbol{j} \}\text{N}$

$= \{ 972.7\, \boldsymbol{i} + 102.7\, \boldsymbol{j} \}\ \text{N}$

Now find the magnitude and angle,

$F_R = ((972.7)^2 + (102.7)^2)^{1/2} = 978.1\ \text{N}$

$\phi = \tan^{-1}(102.7 / 972.7) = 6.03°$

From Positive x axis, $\phi = 6.03°$