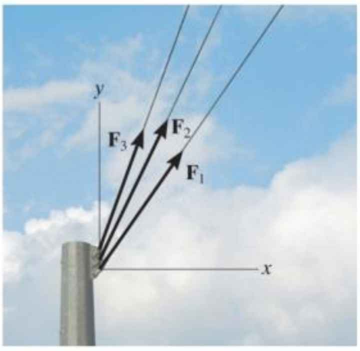
FORCE VECTORS, VECTOR OPERATIONS & ADDITION COPLANAR FORCES

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:

- Check Homework
- Reading Quiz
- Application of Adding Forces
- Parallelogram Law
- Resolution of a Vector Using Cartesian Vector Notation (CVN)
- Addition Using CVN
- Example Problem
- Concept Quiz
- Group Problem
- Attention Quiz

SCALARS AND VECTORS (Section 2.1)

	3kg Scalars	3N *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 red).

$F_2 = 4N$ $F_1 = 10N$

+ve

$F_R = +10 + (-4) = 6N$

6 N

$F_R = 2 - 4 - 6 = -8N$

8N

2N

4N

6 N

VECTOR OPERATIONS (Section 2.2)

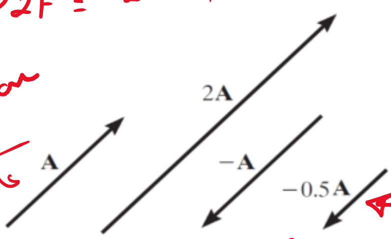
$F = 2N$ 1N = 1cm

$F = 2N$

2F

$\oplus 2F = 2 \times 2 = 4$

Same direction



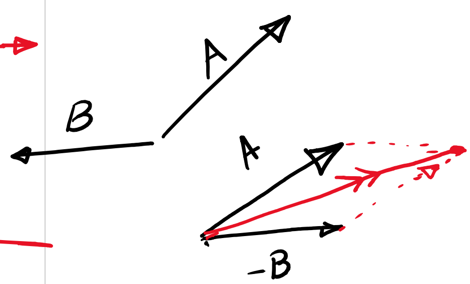
Scalar Multiplication and Division

$-3F$

$\ominus 3F = 3 \times 2 = 6N$

A − B

A + (−B)



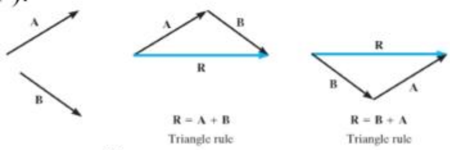
$\ominus 3F = 3 \times 2 = 6N$

$-D$

VECTOR ADDITION USING EITHER THE PARALLELOGRAM LAW OR TRIANGLE

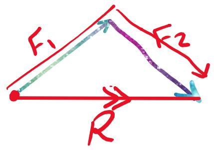
Parallelogram Law:

Triangle method (always 'tip to tail'):

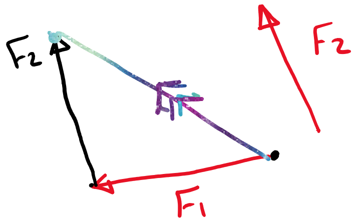


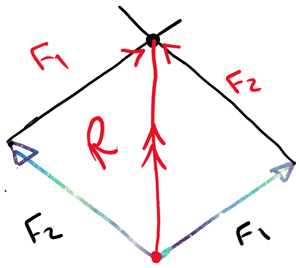
How do you subtract a vector?

How can you add more than two concurrent vectors graphically?



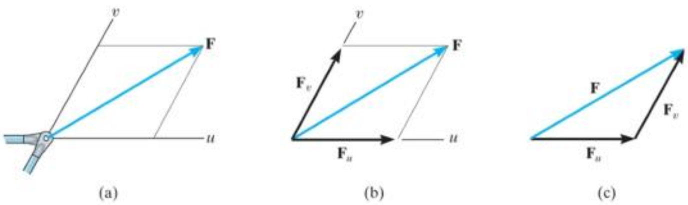
$R = F_1 + F_2$



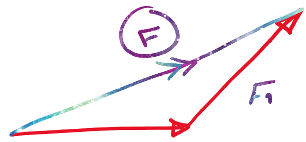


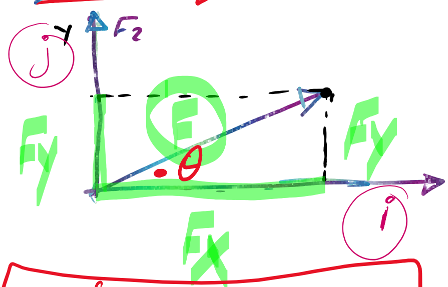
RESOLUTION OF A VECTOR

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



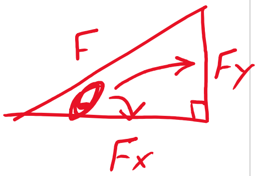
It is kind of like using the parallelogram law in reverse.





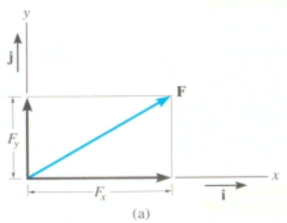
$* \; F = \sqrt{F_x^{2} + F_y^{2}}$

$* \; \theta = \tan^{-1} \frac{F_y}{F_x}$

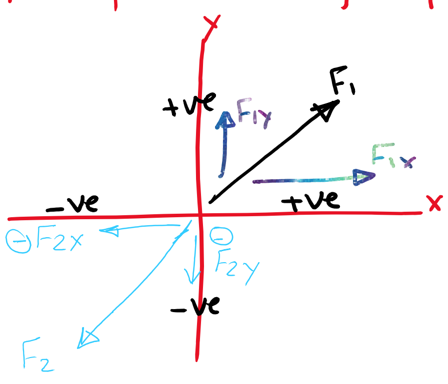


$\boxed{F = \{F_x i + F_y j\} \, N}$

ADDITION OF A SYSTEM OF COPLANAR FORCES (Section 2.4)



- We 'resolve' vectors into components using the x and y-axis coordinate 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.

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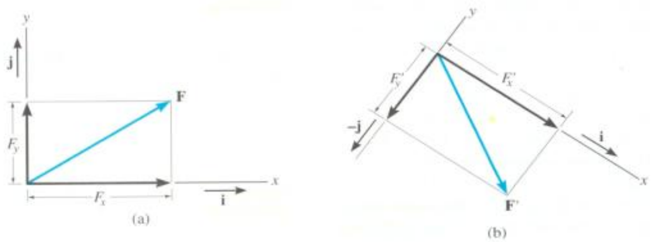
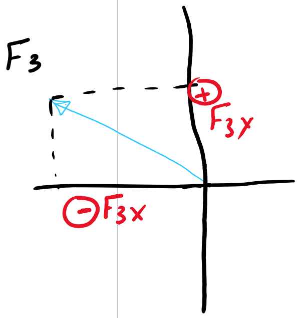
For example,

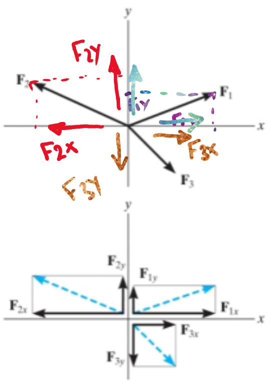
F = Fx ***i*** + Fy ***j*** *or* ***F'*** = F'x ***i*** + (– F'y) ***j***





The x and y-axis are always perpendicular to each other. Together, they can be "set" 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.

$F_1 = \{F_{1x}\, i + F_{1y}\, j\}N$

$F_2 = \{-F_{2x}\, i + F_{2y}\, j\}N$

$F_3 = \{F_{3x}\, i - F_{3y}\, j\}N$

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

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

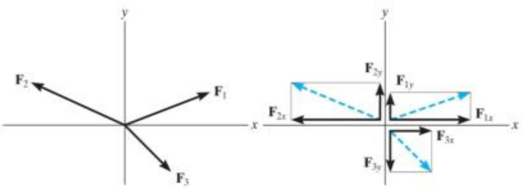
$FR = \{FR_x\, i + FR_y\, j\}N$

$FR = \sqrt{FR_x^2 + FR_y^2}$

$\tan\theta = \frac{FR_y}{FR_x}$

$\theta =$ ✓

An example of the process:



Break the three vectors into components, then add them.

FR = ***F1*** + ***F2*** + ***F3***

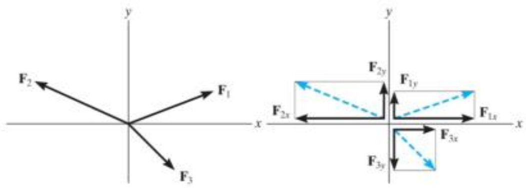
= F1x ***i*** + F1y ***j*** – F2x ***i*** + F2y ***j*** + F3x ***i*** – F3y ***j***

= (F1x – F2x + F3x) ***i*** + (F1y + F2y – F3y) ***j***

$\tan\theta = \frac{}{F_{Rx}}$

$\theta = \checkmark$

An example of the process:



Break the three vectors into components, then add them.

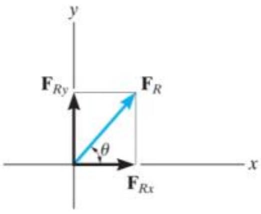
FR = **F1** + **F2** + **F3**

$= F1x\, \mathbf{i} + F1y\, \mathbf{j} - F2x\, \mathbf{i} + F2y\, \mathbf{j} + F3x\, \mathbf{i} - F3y\, \mathbf{j}$

$= (F1x - F2x + F3x)\, \mathbf{i} + (F1y + F2y - F3y)\, \mathbf{j}$

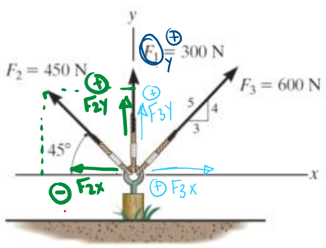
$= (FRx)\, \mathbf{i} + (FRy)\, \mathbf{j}$

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



$$\theta = \tan^{-1}\left|\frac{F_{Ry}}{F_{Rx}}\right| \qquad F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2}$$

EXAMPLE I



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.

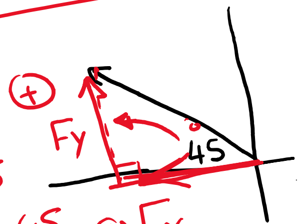
b) Add the respective components to get the resultant vector.

c) Find magnitude and angle from the resultant components.

$F_1 \rightarrow F_{1y}$ ⊕$300\,\mathbf{j}$

$\boxed{F_1 = \{0\,\mathbf{i} + 300\,\mathbf{j}\}\ N}$

$F_2 = 450$

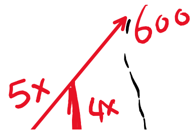


$F_y = F \sin 45$
$= 450 \sin 45$
$= 318.2\,\mathbf{j}$

$F_x = F\cos 45 = 318.2\,\mathbf{i}$

$\boxed{F_2 = \{-318.2\,\mathbf{i} + 318.2\,\mathbf{j}\}\ N}$

$5x \rightarrow 600$



600 120

EXAMPLE I (continued)

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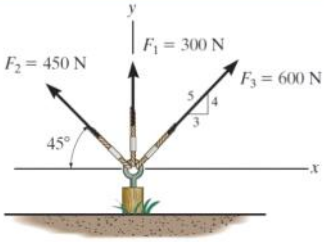


$\boldsymbol{F1} = \{0\,\boldsymbol{i} + 300\,\boldsymbol{j}\}$ N

$\boldsymbol{F2} = \{-\,450 \cos (45°)\,\boldsymbol{i} + 450 \sin (45°)\,\boldsymbol{j}\}$ N

$= \{-\,318.2\,\boldsymbol{i} + 318.2\,\boldsymbol{j}\}$ N

$\boldsymbol{F3} = \{\,(3/5)\,600\,\boldsymbol{i} + (4/5)\,600\,\boldsymbol{j}\,\}$ N

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

EXAMPLE I (continued)

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

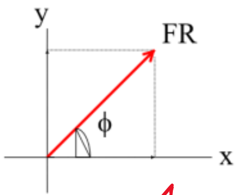
$\boldsymbol{FR} = \{\,(0 - 318.2 + 360)\,\boldsymbol{i} + (300 + 318.2 + 480)\,\boldsymbol{j}\,\}$ N

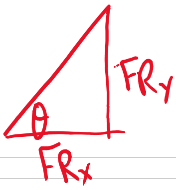
$= \{\,41.80\,\boldsymbol{i} + 1098\,\boldsymbol{j}\,\}$ N

Using magnitude and direction:

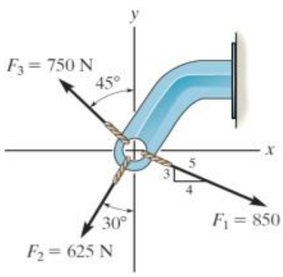
$FR = ((41.80)^2 + (1098)^2)^{1/2} =$ 1099 N

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





GROUP PROBLEM SOLVING



Given: Three concurrent forces acting on a bracket.

Find: The magnitude and angle of the resultant force. Show the resultant in a sketch.

Plan:

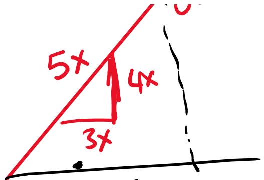
a) Resolve the forces into their x and y-components.

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

c) Find magnitude and angle from the resultant components.

$5x \rightarrow 600$

$x = \frac{600}{5} = 120$



$F_{3y} = 4x = 4 \times 120 = 480\,j$

$F_{3x} = 3x = 3 \times 120 = 360\,i$

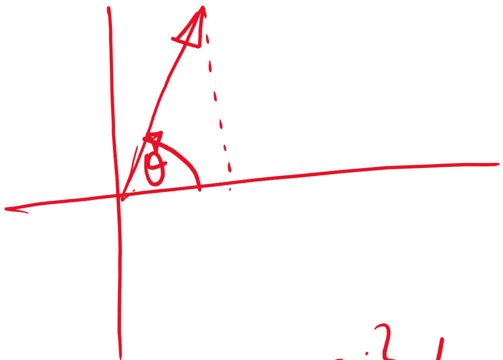
$\boxed{F_3 = \{360 i + 480 j\}\,N}$

$FR_x = \{0 + (-318.2) + 360\}\,i$

$= 41.8\,i$

$FR_y = (360 + 318.2 + 480)\,j$

$= 1098\,j$



$FR = \{41.8 i + 1098 j\}\,N$

$FR = \sqrt{41.8^2 + 1098^2}$

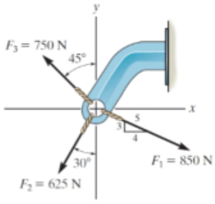
$= 1099\,N$

$\tan\theta = \frac{FR_y}{FR_x}$

$\theta = \tan^{-1} \frac{1098}{41.8}$

$\theta = 87.8°$

GROUP PROBLEM SOLVING (continued)



F1 = {850 (4/5) ***i*** – 850 (3/5) ***j*** } N

= { 680 ***i*** – 510 ***j*** } N

F2 = {- 625 sin (30°) ***i*** – 625 cos (30°) ***j*** } N

= {- 312.5 ***i*** – 541.3 ***j*** } N

F3 = {-750 sin (45°) ***i*** + 750 cos (45°) ***j*** } N

{- 530.3 ***i*** + 530.3 ***j*** } N

GROUP PROBLEM SOLVING (continued)

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

FR = { (680 – 312.5 – 530.3) ***i*** + (–510 – 541.3 + 530.3) ***j*** }N

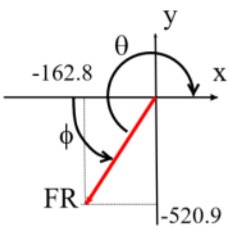
= {– 162.8 ***i*** – 520.9 ***j*** } N

Now find the magnitude and angle,

FR = ((– 162.8)^2 + (– 520.9)^2) ½ = 546 N

ϕ = tan^{-1}(520.9 / 162.8) = 72.6°

From the positive x-axis, θ = 287.4°



End of the Lecture
Let Learning Continue