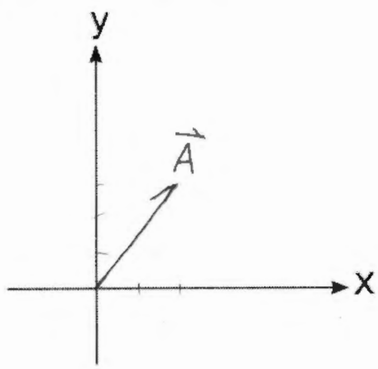
Kinematics Problems – Set 1

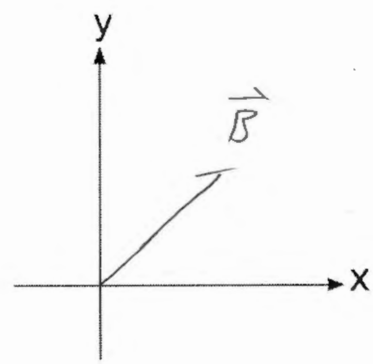
Consider the two vectors:

$$\vec{A} = 2\hat{i} + 3\hat{j}$$
$$|\vec{B}| = 5, \theta_B = 30^o$$

a. Sketch the two vectors below:

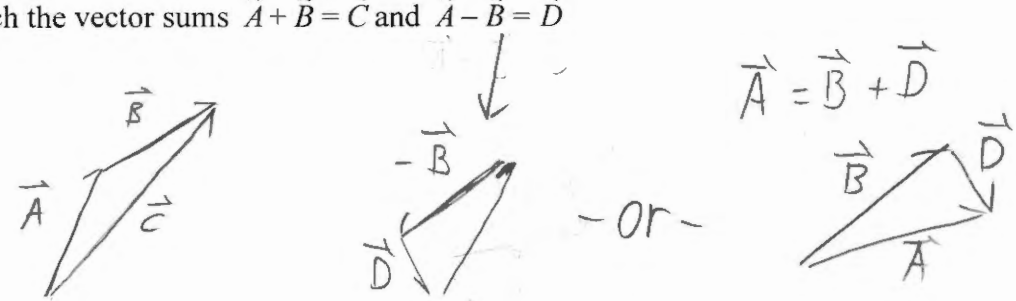


Vector A



Vector B

b. Sketch the vector sums $\vec{A} + \vec{B} = \vec{C}$ and $\vec{A} - \vec{B} = \vec{D}$



components of $\vec{D}$ are the same

c. Solve the vector equations in part b. Write vectors $\vec{C}$ and $\vec{D}$ in *unit vector notation.*

$$\vec{C} = \vec{A} + \vec{B}$$
$$= (A_x\hat{i} + A_y\hat{j}) + (B_x\hat{i} + B_y\hat{j})$$
$$= (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j}$$
$$\boxed{\vec{C} = (A_x + |\vec{B}|\cos\theta_B)\hat{i} + (A_y + |\vec{B}|\sin\theta_B)\hat{j}}$$

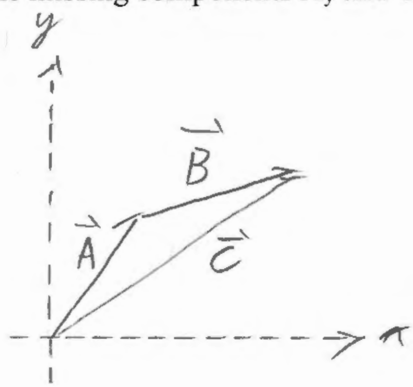
$$\vec{D} = \vec{A} - \vec{B}$$
$$= (A_x\hat{i} + A_y\hat{j}) - (B_x\hat{i} + B_y\hat{j})$$
$$= (A_x - B_x)\hat{i} + (A_y - B_y)\hat{j}$$
$$\boxed{\vec{D} = (A_x - |\vec{B}|\cos\theta_B)\hat{i} + (A_y - |\vec{B}|\sin\theta_B)\hat{j}}$$

Kinematics Problems – Set 1

Consider 3 vectors.

$\vec{A} = 4.00\hat{\imath} + A_y\hat{\jmath}$
$|\vec{B}| = 6.00, \theta_B = 35.0^o$
$\vec{C} = C_x\hat{\imath} + 7.00\hat{\jmath}$

a. Explicitly list the given and wanted information assigning variables.
b. Sketch a vector diagram of the equation $\vec{A} + \vec{B} = \vec{C}$.
c. Solve the vector equation $\vec{A} + \vec{B} = \vec{C}$ for the missing components A_y and C_x. Wr
d. Write $\vec{C}$ in unit vector notation.
e. Find $|\vec{C}|$ and θ_C



Given

$A_x = 4.00$
$|\vec{B}| = 6.00$
$\theta_B = 35.0^\circ$
$C_y = 7.00$

Want

A_y
C_x

Split vector equation into two scalar equations.

$A_x + B_x = C_x$

$\boxed{A_x + |\vec{B}|\cos\theta_B = C_x}$

$C_x = 8.9$

$A_y + B_y = C_y$

$A_y = C_y - B_y$

$\boxed{A_y = C_y - |\vec{B}|\sin\theta_B}$

$A_y = 3.56$

$\boxed{\vec{C} = 8.9\hat{\imath} + 7.00\hat{\jmath}}$

$\boxed{|\vec{C}| = (C_x^2 + C_y^2)^{1/2} = 11.3}$

$\boxed{\theta_C = \tan^{-1}\left(\frac{C_y}{C_x}\right) = 38^\circ}$

Kinematics Problems – Set 1

A hiker begins a trip by first walking 25 km in a direction 45° South of East from her base camp. On the second day, she walks 40 km in a direction 60° north of east. How far is she from her base camp?

(a) Explicitly list the given information and assign a variable to each piece of information.
(b) Explicitly list the wanted information and assign a variable.
(c) Sketch a **vector diagram** of the hiker's trip. Label the diagram with variables (NOT numbers).
(d) Use your vector diagram to write a vector equation for the hiker's trip. (Use variables NOT numbers).
(e) Solve the vector equation for the desired variable (NOT number).
(f) Plug numbers into your equation and find a numeric solution.

a) Given

$|\vec{A}| = 25\,km$

$\theta_A = -45^\circ$

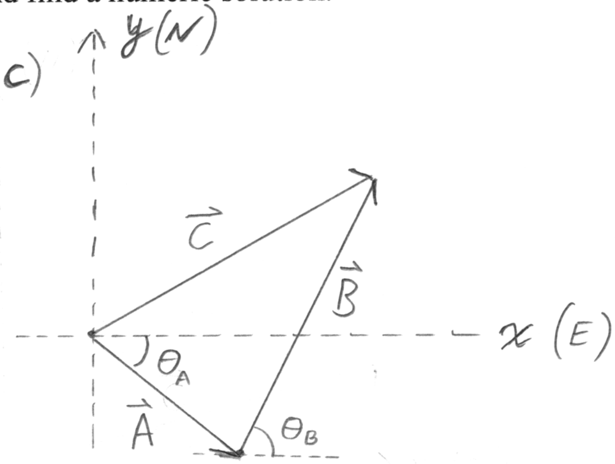
$|\vec{B}| = 40\,km$

$\theta_B = 60^\circ$

b) Want

$|\vec{C}|$

c)



d) $\vec{A} + \vec{B} = \vec{C}$

e) $A_x + B_x = C_x$ $\qquad$ $A_y + B_y = C_y$

$\Rightarrow |\vec{A}|\cos\theta_A + |\vec{B}|\cos\theta_B = C_x$ $\qquad$ $|\vec{A}|\sin\theta_A + |\vec{B}|\sin\theta_B = C_y$

$$\Rightarrow |\vec{C}| = \left(C_x^2 + C_y^2\right)^{1/2}$$

$$\boxed{|\vec{C}| = \left[\left(|\vec{A}|\cos\theta_A + |\vec{B}|\cos\theta_B\right)^2 + \left(|\vec{A}|\sin\theta_A + |\vec{B}|\sin\theta_B\right)^2\right]^{1/2}}$$

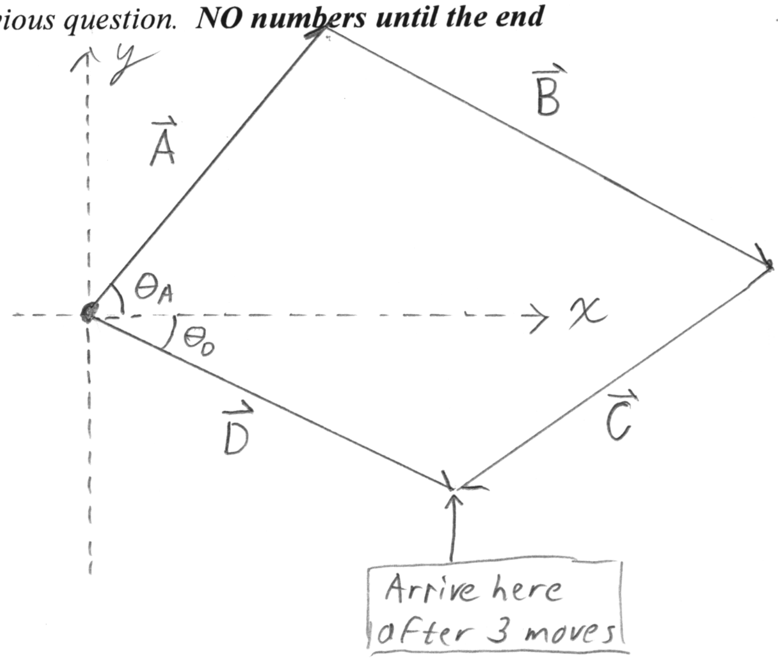
f) $$|\vec{C}| = \left[\left(25\,km\cdot\cos(-45^\circ) + 40\,km\cdot\cos(60^\circ)\right)^2 + \left(25\,km\cdot\sin(-45^\circ) + 40\,km\cdot\sin(60^\circ)\right)^2\right]^{1/2} = \boxed{41\,km}$$

After moving three times, you find yourself 5.39 m away from where you started and 21.8° below the x-axis. Your first move was 5.00 m at an angle of 53.1°. Your second move was 6.00 m along the x-axis and some unknown distance along the y-axis. Your third move was some unknown distance along the x-axis and –3.00 m along the y-axis.

What are the unknown components of your second and third moves?

Follow the procedure from the previous question. ***NO numbers until the end***

Given	Want
$\lvert\vec{D}\rvert = 5.39\,m$	B_y
$\theta_D = -21.8^\circ$	C_x
$\lvert\vec{A}\rvert = 5.00\,m$	
$\theta_A = 53.1^\circ$	
$B_x = 6.00\,m$	
$C_y = -3.0\,m$	



$$\vec{A} + \vec{B} + \vec{C} = \vec{D}$$

$$A_x + B_x + C_x = D_x$$

$$\Rightarrow |\vec{A}|\cos\theta_A + B_x + \underline{C_x} = |\vec{D}|\cos\theta_D$$

$$\Rightarrow \boxed{C_x = |\vec{D}|\cos\theta_D - |\vec{A}|\cos\theta_A - B_x}$$

$$C_x = 5.39\,m \cdot \cos(-21.8^\circ) - 5\,m \cdot \cos(53.1^\circ) - 6.0\,m$$

$$\Rightarrow \boxed{C_x = -4.0\,m}$$

$$A_y + B_y + C_y = D_y$$

$$\Rightarrow |\vec{A}|\sin\theta_A + \underline{B_y} + C_y = |\vec{D}|\sin\theta_D$$

$$\Rightarrow \boxed{B_y = |\vec{D}|\sin\theta_D - |\vec{A}|\sin\theta_A - C_y}$$

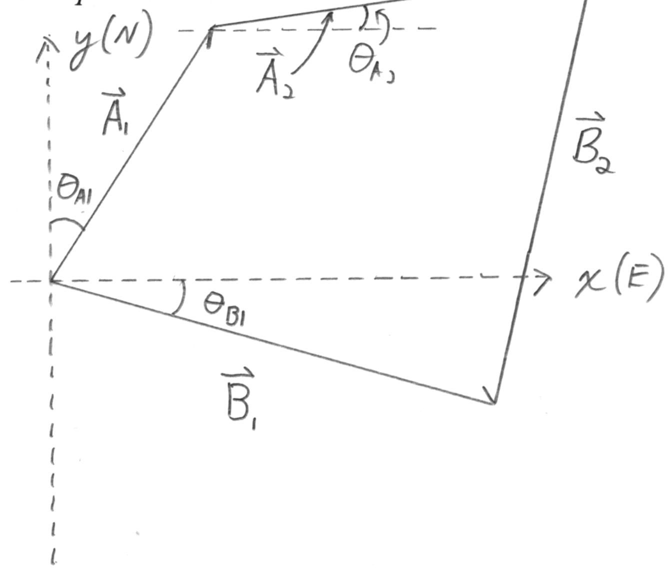
$$B_y = 5.39\,m \cdot \sin(-21.8^\circ) - 5\,m\,\sin(53.1^\circ) + 3.0\,m$$

$$\Rightarrow \boxed{B_y = -3.0\,m}$$

Alice and Ben need to check insect traps at three field sites. Alice will check one, Ben one, and the two will meet at the third.
Alice travels 2.00 km at 20° E of N to the first site and then 2.50 km at 11° N of E to the next.
Ben travels 3.00 km at 15° S of E to his first site.

What are the x and y components of the displacement required for Ben to walk toAlice.

Follow the procedures from the previous questions. **NO numbers until the end**



Given	Want
$\lvert\vec{A}_1\rvert = 2.0\,km$	B_{2x}
$\theta_{A1} = 20^\circ$	B_{2y}
$\lvert\vec{A}_2\rvert = 2.5\,km$	
$\theta_{A2} = 11^\circ$	
$\lvert\vec{B}_1\rvert = 3.0\,km$	
$\theta_{B1} = -15^\circ$	

$$\vec{A}_1 + \vec{A}_2 = \vec{B}_1 + \vec{B}_2$$

$$A_{1x} + A_{2x} = B_{1x} + \underline{B_{2x}}$$

$$\Rightarrow \boxed{B_{2x} = |A_1| \sin\theta_{A1} + |A_2| \cos\theta_{A2} - |B_1| \cos\theta_{B1}}$$

$$\Rightarrow B_{2x} = 2.0\,km \cdot \sin(20^\circ) + 2.5\,km \cdot \cos(11^\circ) - 3.0\,km \cdot \cos(-15^\circ)$$

$$\Rightarrow \boxed{B_{2x} = 0.24\,m}$$

$$A_{1y} + A_{2y} = B_{1y} + \underline{B_{2y}}$$

$$\Rightarrow \boxed{B_{2y} = |\vec{A}_1| \cos\theta_{A1} + |\vec{A}_2| \sin\theta_{A2} - |\vec{B}_1| \sin\theta_{B1}}$$

$$\Rightarrow B_{2y} = 2.0\,km \cdot \cos(20^\circ) + 2.5\,km \cdot \sin(11^\circ) - 3.0\,km \sin(-15) \Rightarrow \boxed{B_{2y} = 3.1\,km}$$