

Vectors Questions

Measurement	Quantity	Magnitude?	Direction?	Vector/Scalar
"It's 60°F outside"	Temperature			[Vector Scalar]
"I pushed with 100N north"	Force			[Vector Scalar]
"I walked for 10 m"	Distance			[Vector Scalar]
"I walked 10 m east"	Displacement			[Vector Scalar]
"I drove at 80 mph"	Speed			[Vector Scalar]
"I drove 80mph west"	Velocity			[Vector Scalar]

CONCEPT: INTRO TO VECTOR MATH

- Adding/subtracting scalars is easy. But vectors have direction, so math with vectors is sometimes not as straightforward.
 - Because vectors have direction, they're drawn as _____.

COMBINING SCALARS

"You combine a 3kg & 4kg box"



Total Mass: $3\text{kg} + 4\text{kg} =$ _____

- Simple Addition

COMBINING PARALLEL VECTORS

"You walk 3m right, then 4m right"

Total Displacement: _____

- Add just like normal numbers

COMBINING PERPENDICULAR VECTORS

"You walk 3m right, then 4m up"



Total Displacement: _____

- Forms _____.
- just **TRIANGLE MATH**

EXAMPLE: For each of the following situations, draw your displacement vectors and calculate the total displacement:

(a) You walk 10m to the right, and then 6m to the left

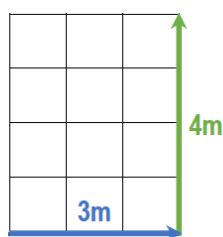
(b) You walk 6m to the right, and then 8m down

PRACTICE: Two perpendicular forces act on a box, one pushing to the right and one pushing up. An instrument tells you the magnitude of the total force is 13N. You measure the force pushing to the right is 12N. Calculate the force pushing up.

CONCEPT: ADDING VECTORS GRAPHICALLY

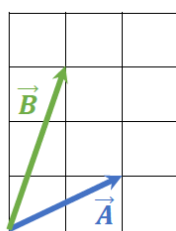
- Vectors are drawn as arrows and are added by _____ the arrows (tip-to-tail).

ADDING PERPENDICULAR VECTORS



Resultant Vector:
(Total Displacement)

ADDING ANY VECTORS



$\vec{A} + \vec{B}$

$\vec{B} + \vec{A}$

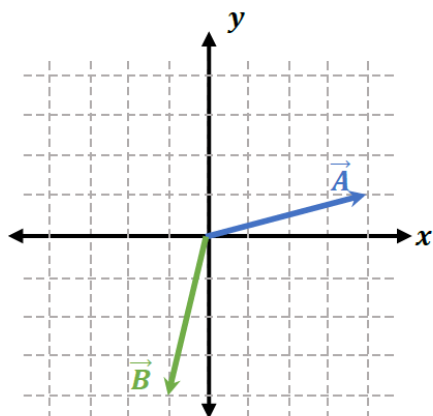


Resultant Vector:
(Total Displacement)

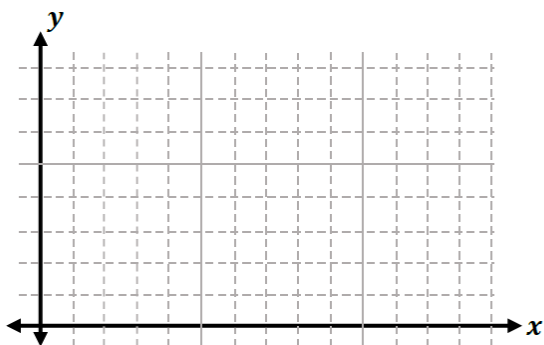
Resultant Vector:
(Total Displacement)

- The **RESULTANT** vector ($\vec{C}$ or $\vec{R}$) is *always* the **SHORTEST PATH** from the **start** of the first vector → **end** of the last.
 - Adding vectors does **NOT** depend on the order (commutative), so $\vec{A} + \vec{B} = \vec{B} + \vec{A}$.

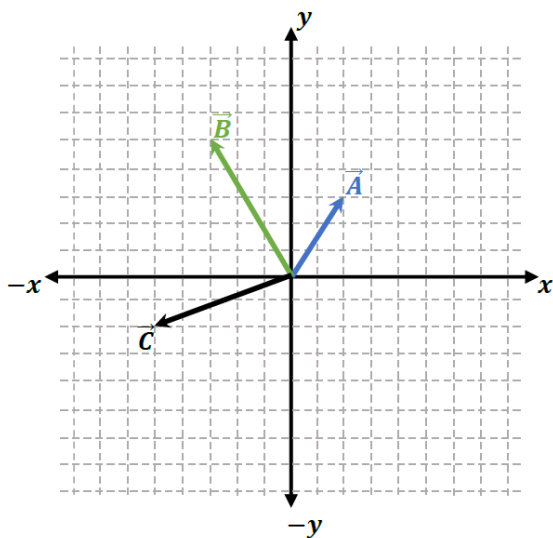
EXAMPLE: Find the magnitude of the Resultant Vector $\vec{C} = \vec{A} + \vec{B}$.



PRACTICE: A delivery truck travels 8 miles in the +x-direction, 5 miles in the +y-direction, and 4 miles again in the +x-direction. What is the magnitude (in miles) of its final displacement from the origin?

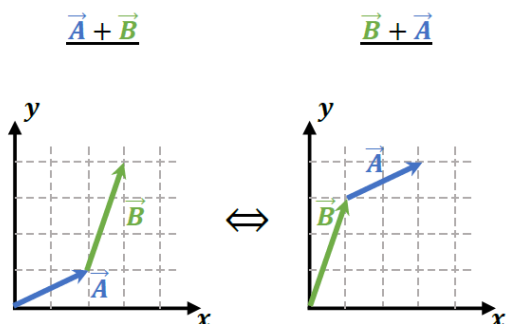


EXAMPLE: Find the magnitude of the Resultant Vector $\vec{D} = \vec{A} + \vec{B} + \vec{C}$.



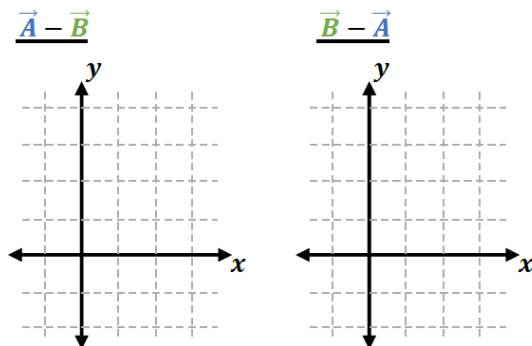
CONCEPT: SUBTRACTING VECTORS GRAPHICALLY

- Subtracting vectors is *exactly* like adding vectors tip-to-tail, but one (or more) of the vectors gets _____.

ADDING VECTORS

Resultant → shortest path:
(Total Displacement)

- When adding, order [**DOES** | **DOES NOT**] matter

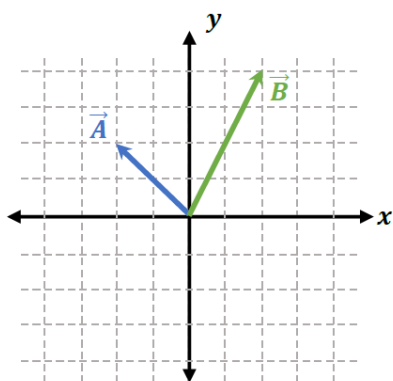
SUBTRACTING VECTORS

Resultant → shortest path:
(Total Displacement)

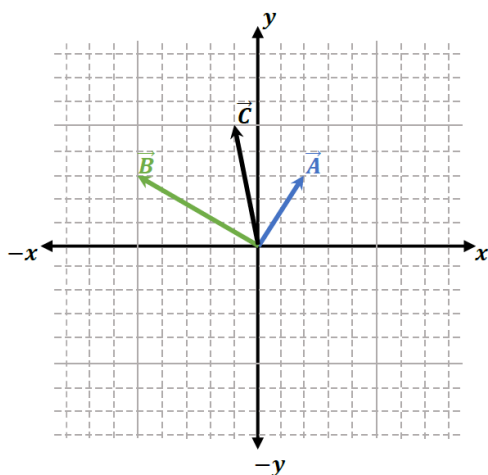
Resultant → shortest path:
(Total Displacement)

- “Negative” vector: SAME magnitude, _____ direction
- When subtracting, order [**DOES** | **DOES NOT**] matter

EXAMPLE: Find the magnitude of the Resultant Vector $\vec{C} = \vec{A} - \vec{B}$.

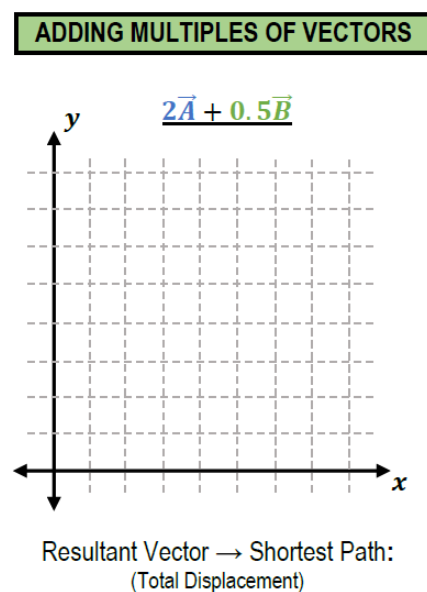
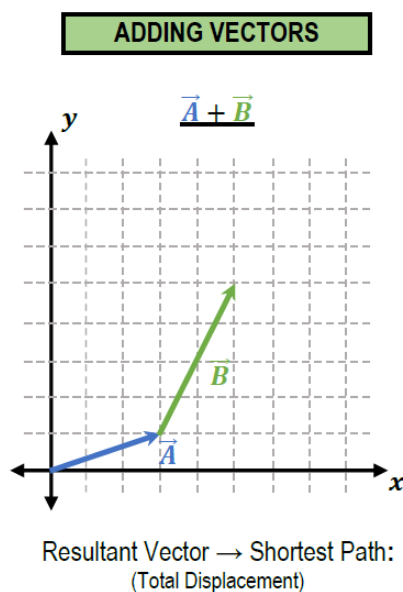


PRACTICE: Find the magnitude of the Resultant Vector $\vec{D} = \vec{C} - \vec{B} - \vec{A}$.



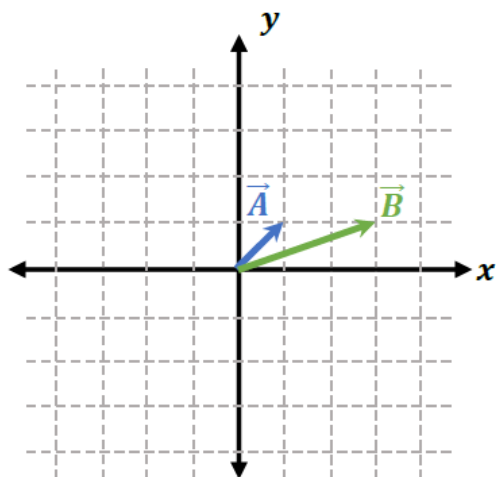
CONCEPT: ADDING MULTIPLES OF VECTORS

- When you multiply a vector by a number ($\vec{A} \rightarrow 2\vec{A}$), the **magnitude** (length) changes but NOT the direction.



- Multiplying by > 1 [**increases** | **decreases**] magnitude/length
- Multiplying by < 1 [**increases** | **decreases**] magnitude/length

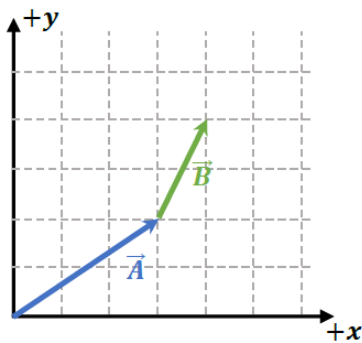
EXAMPLE: Find the magnitude of the Resultant Vector $\vec{C} = 3\vec{A} - 2\vec{B}$.



CONCEPT: VECTOR ADDITION BY COMPONENTS

- You'll need to add vectors together and calculate the magnitude & direction of the resultant *without* counting squares.

EXAMPLE: You walk 5m at 53° above the +x-axis, then 8m at 30° above the +x-axis. Calculate the magnitude & direction of your total displacement.

**ADDING VECTORS GRAPHICALLY
(WITH SQUARES)****ADDING VECTORS BY COMPONENTS
(WITHOUT SQUARES)**

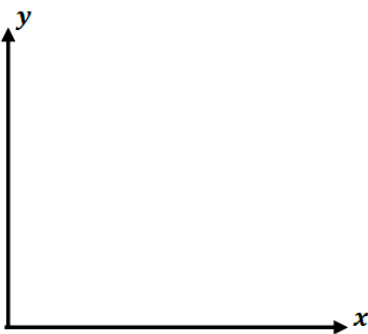
	x	y
$\vec{A}$		
$\vec{B}$		
$\vec{R} =$		

VECTOR ADDITION

- 1) Draw & connect vectors tip-to-tail
- 2) Draw Resultant & components
- 3) Calculate ALL X&Y components
- 4) Combine X & Y components according to R equation
- 5) Calculate R and θ_R

Vector Composition (Components → Vector)	Vector Decomposition (Vector → Components)
$R = \sqrt{R_x^2 + R_y^2}$	$A_x = A \cos(\theta_X)$
$\theta_X = \tan^{-1}\left(\frac{R_y}{R_x}\right)$	$A_y = A \sin(\theta_X)$

EXAMPLE: Vector $\vec{A}$ has a magnitude of 10m at a direction 40° above the +x-axis. $\vec{B}$ has magnitude 3 at a direction 20° above the x-axis. Calculate the magnitude and direction of $\vec{R} = \vec{A} - 2\vec{B}$.

**VECTOR ADDITION**

- 1) Draw & connect vectors tip-to-tail
- 2) Draw Resultant & components
- 3) Calculate ALL X&Y components
- 4) Combine X & Y components according to R equation
- 5) Calculate R and θ_R

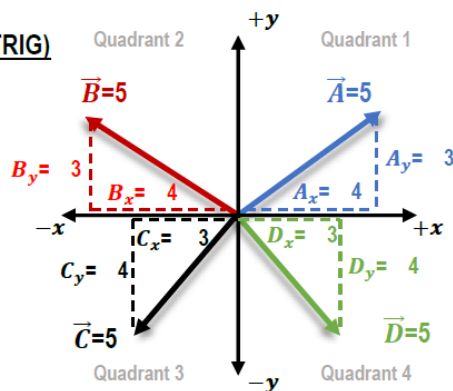
Vector Composition (Components → Vector)	Vector Decomposition (Vector → Components)
$R = \sqrt{R_x^2 + R_y^2}$	$A_x = A \cos(\theta_X)$
$\theta_X = \tan^{-1}\left(\frac{R_y}{R_x}\right)$	$A_y = A \sin(\theta_X)$

CONCEPT: DOING MATH WITH VECTORS IN ANY QUADRANT (MORE TRIG)

- You'll need to do math with vectors in ALL Quadrants, not just Quadrant 1.

Signs of Magnitudes & Components of Vectors:

- Magnitudes $\rightarrow$ Always positive, but Components may be + or –
 - Positive Components = pointing [UP | DOWN] or [RIGHT | LEFT]
 - Negative Components = pointing [UP | DOWN] or [RIGHT | LEFT]

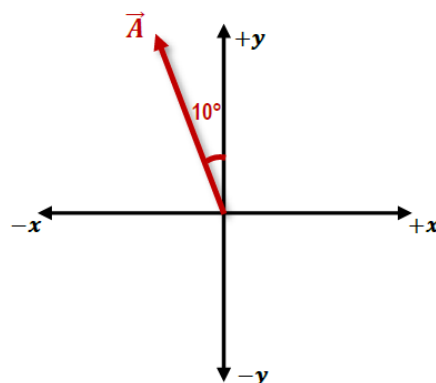
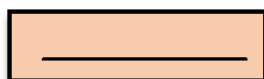
**When given a Non-Reference Angle:**

- Remember: We always use the Reference Angle θ_x to calculate components:

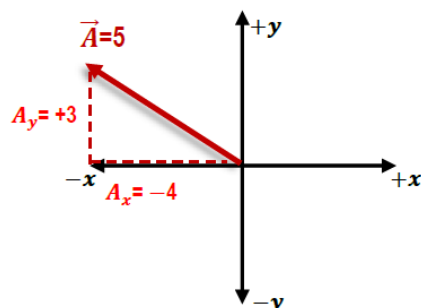
$$A_x = A \cos(\theta_x)$$

$$A_y = A \sin(\theta_x)$$

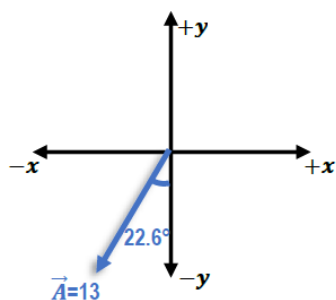
- All right angles add up to 90° , so we'll use this simple equation to get θ_x :

**Calculating the Absolute Angle (Positive Angle from +x axis) from the Arctangent**

- Taking arctan of components $\left[\theta_x = \tan^{-1} \left(\frac{|A_y|}{|A_x|} \right) \right]$ always gives reference angle θ_x .
 - Remember to always plug in positive value of components!
 - To find the Absolute Angle, work your way back to +x-axis (0°)



EXAMPLE: Calculate a) the components and b) the absolute angle for the given vector $\vec{A}$:



A position vector has components $x = 34.6$ m and $y = -53.5$ m. Find the vector's length and angle with the x-axis.

Sketch the vectors with the components $\vec{A} = (A_x, A_y) = (30.0 \text{ m}, -50.0 \text{ m})$ and $\vec{B} = (B_x, B_y) = (-30.0 \text{ m}, 50.0 \text{ m})$, and find the magnitudes of these vectors.

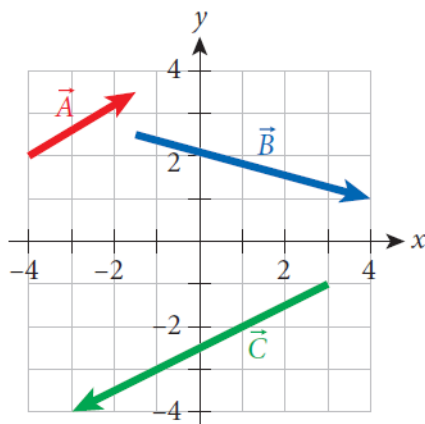
What angle does $\vec{A} = (A_x, A_y) = (30.0 \text{ m}, -50.0 \text{ m})$ make with the positive x-axis? What angle does it make with the negative y-axis?

Find the magnitude and direction of each of the following vectors, which are given in terms of their x- and y-components: $\vec{A} = (23.0, 59.0)$, and $\vec{B} = (90.0, -150.0)$.

Find the vector $\vec{C}$ that satisfies the equation $3\hat{x} + 6\hat{y} - 10\hat{z} + \vec{C} = -7\hat{x} + 14\hat{y}$

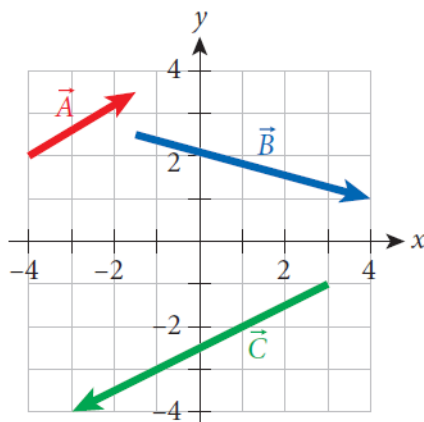
•1.79 Find the magnitude and direction of (a) $9\vec{B} - 3\vec{A}$ and (b) $-5\vec{A} + 8\vec{B}$, where $\vec{A} = (23.0, 59.0)$, $\vec{B} = (90.0, -150.0)$.

1.105 Find the magnitude and direction of $-5\vec{A} + \vec{B}$, where $\vec{A} = (23.0, 59.0)$, $\vec{B} = (90.0, -150.0)$.



determine the **length** and **direction** of the vector $\vec{E} = \vec{B} - \vec{A}$

	Length	Direction
A	4.2	45°
B	8.5	315°
C	8.5	45°
D	4.2	315°



determine the **length** and **direction** of the vector $\vec{E} = \vec{C} - \vec{B}$

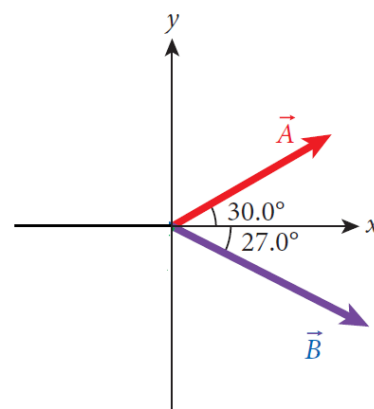
	Length	Direction
A	11.6	7.4°
B	4.5	7.4°
C	11.6	262.2°
D	4.2	262.2°

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The figure shows two vectors $|\vec{A}| = 8 \text{ m}$ and $|\vec{B}| = 10 \text{ m}$

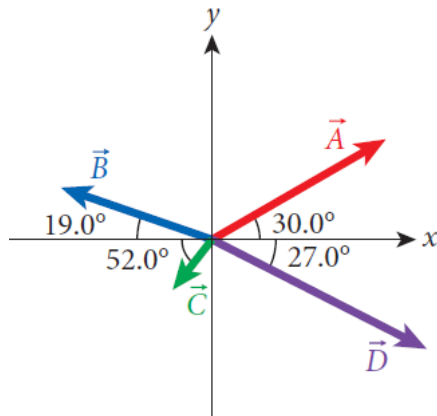
If $\vec{D} = \vec{A} + \vec{B}$ Answer the following

A) find the x-component D_x and the y-component D_y



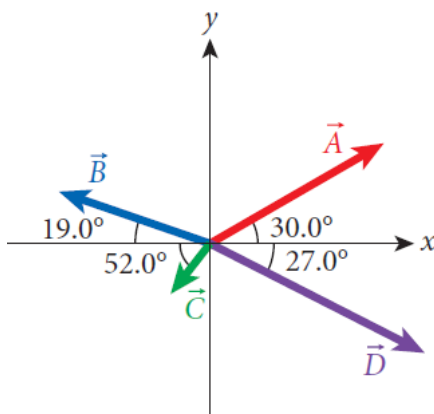
B) find the angle between vector $\vec{D}$ and the positive x-axis

Mark		8	الدرجة
Question		①	السؤال
8	1	$D_x = A_x + B_y$	①
	1	$D_x = (8 \times \cos 30^\circ) + (10 \times \cos 27^\circ)$	
	1	$D_x = 15.84 \text{ m}$	
	1	$D_y = A_y + B_y$	
	1	$D_y = (8 \times \sin 30^\circ) + (10 \times \sin(-27^\circ))$	
	1	$D_y = -0.54 \text{ m}$	
	1	$\theta = \tan^{-1}\left(\frac{D_y}{D_x}\right) = \tan^{-1}\left(\frac{-0.54}{15.84}\right)$	②
	1	$\theta = -1.95 + 360 = 358^\circ$	



if the lengths of the four vectors are given by $A = 75.0$, $B = 60.0$, $C = 25.0$, $D = 90.0$ and their direction angles are as shown. What is the **magnitude** and **direction** of $\vec{E} = \vec{A} - \vec{C}$

	<i>magnitude</i>	<i>Direction</i>
A	52.7	35.4°
B	98.7	35.4°
C	52.7	19.7°
D	98.7	19.7°



if the lengths of the four vectors are given by $A = 75.0$, $B = 60.0$, $C = 25.0$, $D = 90.0$ and their direction angles are as shown. What is the **magnitude** and **direction** of $\vec{E} = \vec{A} - \vec{B} + \vec{D}$

EXAMPLE 1.5 Angle Between Two Position Vectors

PROBLEM

What is the angle α between the two position vectors shown in Figure 1.25, $\vec{A} = (4.00, 2.00, 5.00)$ cm and $\vec{B} = (4.50, 4.00, 3.00)$ cm?

SOLUTION

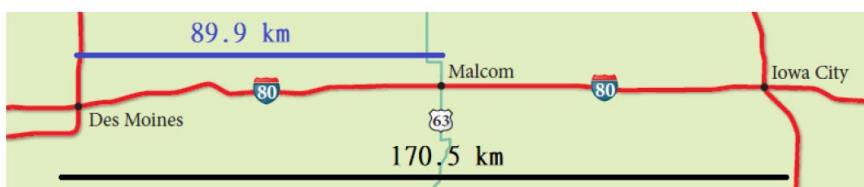
To solve this problem, we have to put the numbers for the components of each of the two vectors into equation 1.27 and equation 1.25 then use equation 1.28:

$$|\vec{A}| = \sqrt{4.00^2 + 2.00^2 + 5.00^2} \text{ cm} = 6.71 \text{ cm}$$

$$|\vec{B}| = \sqrt{4.50^2 + 4.00^2 + 3.00^2} \text{ cm} = 6.73 \text{ cm}$$

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z = (4.00 \cdot 4.50 + 2.00 \cdot 4.00 + 5.00 \cdot 3.00) \text{ cm}^2 = 41.0 \text{ cm}^2$$

$$\Rightarrow \alpha = \cos^{-1} \left(\frac{41.0 \text{ cm}^2}{6.71 \text{ cm} \cdot 6.73 \text{ cm}} \right) = 24.7^\circ.$$



If we drive from Malcom to Des Moines and then go to Iowa City, what are the **total distance** and **total displacement** for this trip?

	Distance	Displacement
A	80.6	260.4 West
B	260.4	80.6 East
C	80.6	260.4 East
D	260.4	80.6 West

Your dorm room is located **0.25 mile** from the Dairy Store. You walk from your room to the Dairy Store and back. **Which of the following statements about your trip is true?**

- A. The distance is 0.50 mile, and the displacement is 0.50 mile.
- B. The distance is 0.50 mile, and the displacement is 0.00 mile.
- C. The distance is 0.00 mile, and the displacement is 0.50 mile.
- D. The distance is 0.00 mile, and the displacement is 0.00 mile.

A car travels north at 30.0 m/s for 10.0 min . It then travels south at 40.0 m/s for 20.0 min . What are the total distance the car travels and its displacement ?		
	Distance	Displacement
A	3.3×10^4	6.6×10^4 north
B	6.6×10^4	3.3×10^4 north
C	6.6×10^4	3.3×10^4 south
D	3.3×10^4	6.6×10^4 south

Which of the following is **true** about **distance** and **displacement**?

- A. displacement cannot be zero
- B. displacement magnitude is greater than the distance travelled by the object
- C. displacement may or may not be equal to the distance
- D. Distance is always greater than displacement

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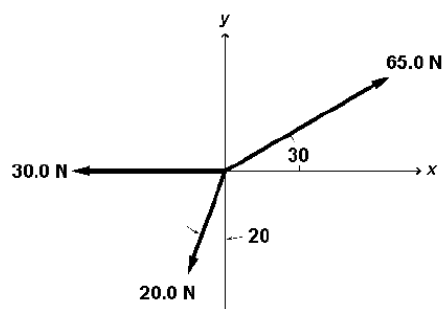
5. $\vec{A}$ and $\vec{B}$ have the same non-zero magnitude. The magnitude of $\vec{A} + \vec{B}$ is equal to the magnitude of $\vec{A} - \vec{B}$. What is the angle between $\vec{A}$ and $\vec{B}$?
 - a. 30 degrees
 - b. 45 degrees
 - c. 60 degrees
 - d. 90 degrees
6. $\vec{A}$ and $\vec{B}$ have the same magnitude v . The direction of $\vec{A}$ is north and the direction of $\vec{B}$ is 60 degrees west of south. What is the magnitude of $\vec{A} - \vec{B}$?
 - a. zero
 - b. v
 - c. $\sqrt{3v}$
 - d. $2v$
7. How many significant figures are in the number 0.00640?
 - a. 1
 - b. 2
 - c. 3
 - d. 4
 - e. 5
9. A farmer has a field which is 0.50 km in length and 0.70 km in width. What is the area of his field?
 - a. 0.35 km^2
 - b. 3.5 km^2
 - c. 35 km^2
 - d. $3.5 \times 10^2 \text{ km}^2$
10. A vector $\vec{A}$ with magnitude 25.0 m points along the positive y direction. If it is rotated by 50.0 degrees counterclockwise, what are the components of the vector?
 - a. $A_x = 25.0 \cos 50.0^\circ$ and $A_y = 25.0 \sin 50.0^\circ$
 - b. $A_x = 25.0 \cos 140^\circ$ and $A_y = 25.0 \sin 140^\circ$
 - c. $A_x = 25.0 \sin 140^\circ$ and $A_y = 25.0 \cos 140^\circ$
 - d. $A_x = 25.0 \tan 50.0^\circ$ and $A_y = 25.0 \sin 50.0^\circ$
11. A vector $\vec{A}$ with magnitude 25.0 m points along the positive x direction. If it is rotated by 50.0 degrees counterclockwise, what are the components of the vector?
 - a. $A_x = 25.0 \sin 50.0^\circ$ and $A_y = 25.0 \cos 50.0^\circ$
 - b. $A_x = 25.0 \cos 50.0^\circ$ and $A_y = 25.0 \sin 50.0^\circ$
 - c. $A_x = 25.0 \sin 310^\circ$ and $A_y = 25.0 \cos 310^\circ$
 - d. $A_x = 25.0 \cos 310^\circ$ and $A_y = 25.0 \sin 310^\circ$
12. A vector $\vec{A}$ with magnitude 25.0 m points along the negative x direction. If it is rotated by 50.0 degrees counterclockwise, what are the components of the vector?
 - a. $A_x = 25.0 \cos 50.0^\circ$ and $A_y = 25.0 \sin 50.0^\circ$
 - b. $A_x = 25.0 \sin 50.0^\circ$ and $A_y = 25.0 \cos 50.0^\circ$
 - c. $A_x = 25.0 \sin 230^\circ$ and $A_y = 25.0 \cos 230^\circ$
 - d. $A_x = 25.0 \cos 230^\circ$ and $A_y = 25.0 \sin 230^\circ$

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13. A vector $\vec{A}$ with magnitude 25.0 m points along the negative y direction. If it is rotated by 50.0 degrees counterclockwise, what are the components of the vector?
- $A_x = 25.0 \sin 320^\circ$ and $A_y = 25.0 \cos 320^\circ$
 - $A_x = 25.0 \sin 50.0^\circ$ and $A_y = 25.0 \cos 50.0^\circ$
 - $A_x = 25.0 \cos 50.0^\circ$ and $A_y = 25.0 \sin 50.0^\circ$
 - $A_x = 25.0 \cos 320^\circ$ and $A_y = 25.0 \sin 320^\circ$
14. What is the magnitude of the vector $\vec{A} = 4.0\hat{x} - 6.0\hat{y}$?
- 2.0
 - 6.0034
 - 7.2
 - 10
 - 24
33. Given two vectors, $\vec{A}$ and $\vec{B}$:
- $$\vec{A} = 3\hat{i} + 4\hat{j}$$
- $$\vec{B} = -2\hat{i} + 5\hat{j}$$
- What is the magnitude of the vector $\vec{A} + 3\vec{B}$?
- 15.3
 - 17.6
 - 18.8
 - 19.0
 - 20.0
34. What are the polar coordinates of the vector $3\hat{i} - 2\hat{j}$?
- (3.6; 33.7°)
 - (3.6; 146.3°)
 - (4.2; 33.7°)
 - (4.2; -33.7°)
 - (3.6; -33.7°)

Exhibit 3-1

The three forces shown act on a particle.



Use this exhibit to answer the following question(s).

18. Refer to Exhibit 3-1. What is the magnitude of the resultant of these three forces?
- a. 27.0 N
 - b. 33.2 N
 - c. 36.3 N
 - d. 23.8 N
 - e. 105 N

ANS: D

PTS: 2

DIF: Average

19. Refer to Exhibit 3-1. What is the direction of the resultant of these three forces?
- a. 35°
 - b. 45°
 - c. 65°
 - d. 55°
 - e. 85°

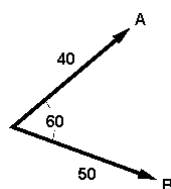
ANS: A

1. If $\vec{A} = [15, 80^\circ]$ and , $\vec{B} = 12 \hat{x} - 16 \hat{y}$ what is the magnitude of $\vec{A} - \vec{B}$?

- a. 15
- b. 35
- c. 32
- d. 5.0

ANS: C

2. Vectors $\vec{A}$ and $\vec{B}$ are shown. What is the magnitude of a vector $\vec{C}$ if $\vec{C} = \vec{A} - \vec{B}$?



- a. 46
- b. 10
- c. 30
- d. 78

ANS: A

3. If $\vec{A} = 12 \hat{x} - 16 \hat{y}$ and , $\vec{B} = -24 \hat{x} + 10 \hat{y}$ what is the magnitude of the vector $\vec{C} = 2\vec{A} - \vec{B}$?

- a. 42
- b. 22
- c. 64
- d. 90

ANS: C

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4. If $\vec{A} = 12\hat{x} - 16\hat{y}$ and $\vec{B} = -24\hat{x} + 10\hat{y}$ what is the direction of the vector $\vec{C} = 2\vec{A} - \vec{B}$?

- a. -49°
- b. -41°
- c. -90°
- d. $+49^\circ$

ANS: B

5. If $\vec{C} = [10 \text{ m}, 30^\circ]$ and $\vec{D} = [25 \text{ m}, 130^\circ]$, what is the magnitude of the sum of these two vectors?

- a. 20 m
- b. 35 m
- c. 15 m
- d. 25 m

ANS: D PTS: 2 DIF: Average

6. If $\vec{C} = [10 \text{ m}, 30^\circ]$ and $\vec{D} = [25 \text{ m}, 130^\circ]$, what is the direction of the sum of these two vectors?

- a. 17°
- b. 73°
- c. 107°
- d. 163°

ANS: C PTS: 2 DIF: Average

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