Milwaukee School of Engineering Introductory Physics
PHY 1110

Group Problem Set 5: Vectors

- Recall that vectors are a scaler magnitude with an associated direction. When you give directions, you inadvertently use vectors (i.e. Go 3 blocks toward the lake).

- When you provide directions using a cardinal coordinate system or a city planning map, you usually break vectors into their component (i.e. the Starbucks is 2 blocks east and 1 block south).

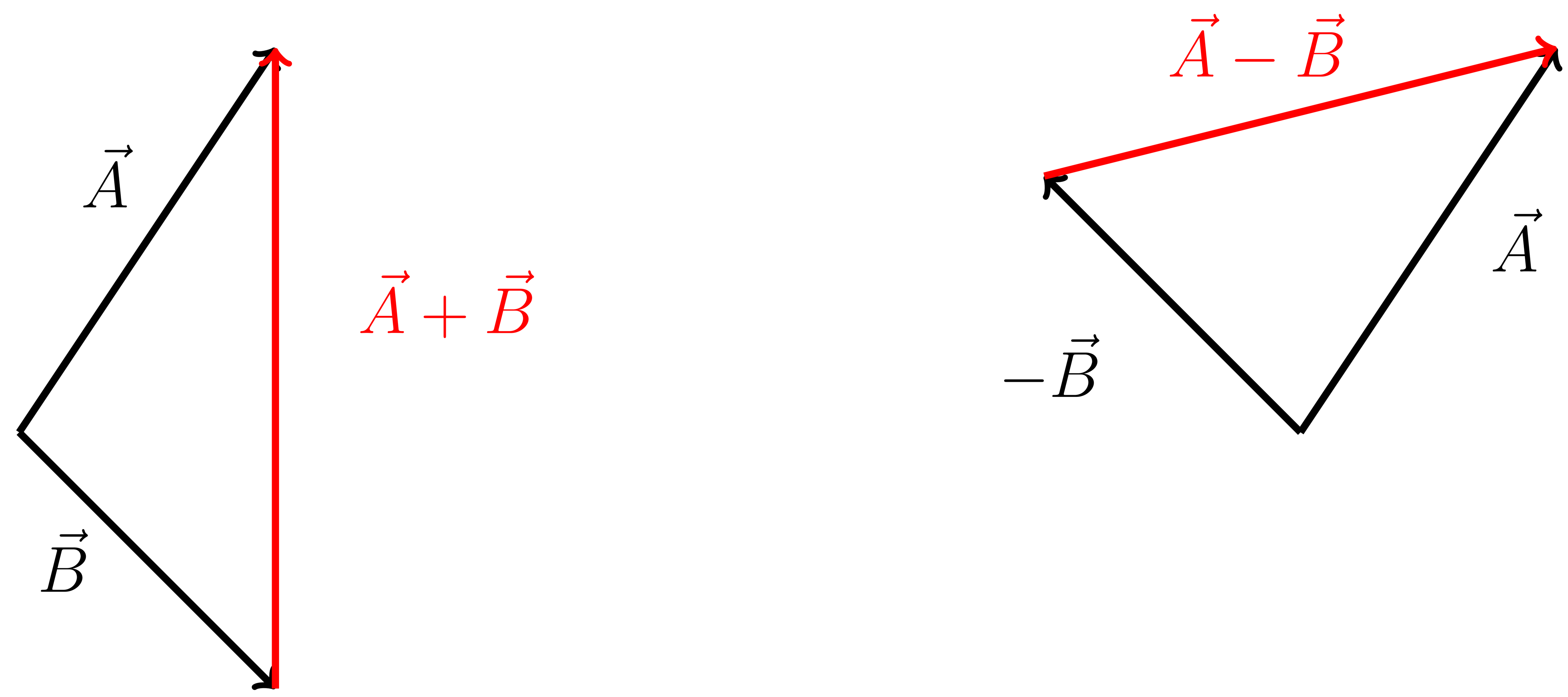
- But, we can also write a vector as a total sum of the components. Graphical representations can help you visualize the components of a vector.

Here are a few helpful rules to drawing, adding and subtracting vectors graphically.

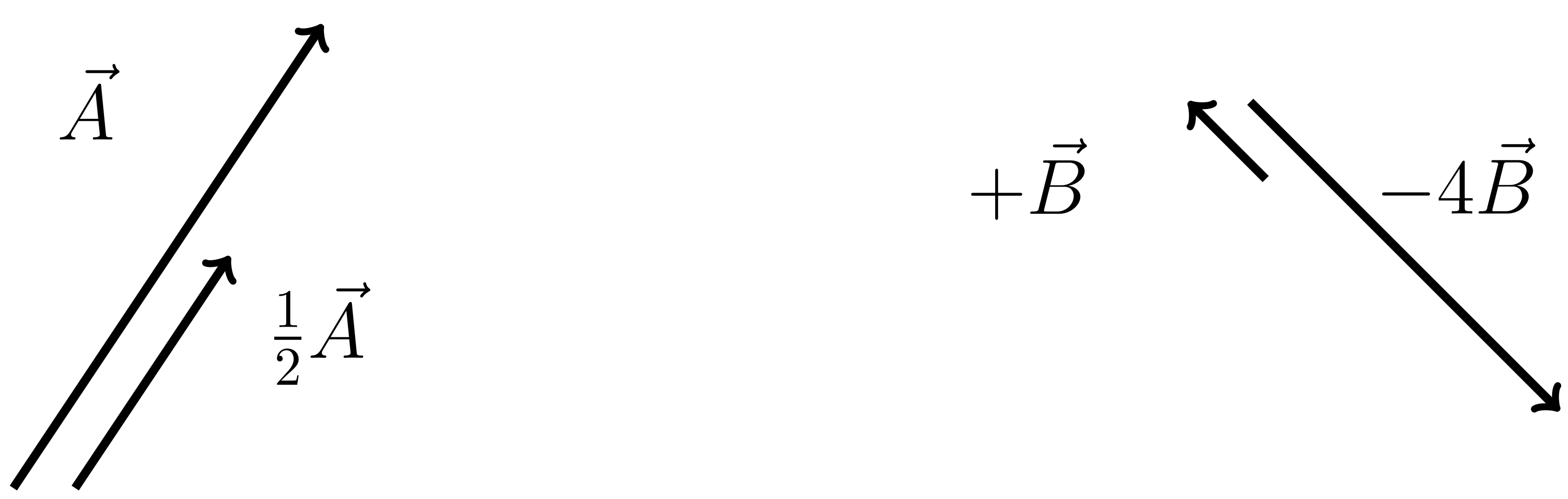
1. **The negative of a vector points in the opposite direction of the vector.**

2. **Vector sums can be drawn Head to Tail.** The resultant vector is then drawn from the tail of the first vector to the head of the second. Vector subtraction is just the addition of the negative vector (or the positive vector pointed in the opposite direction.

3. **Vector sums can also be by drawn Tail to Tail.** The resultant vector is drawn from the head of the first vector to the head of the second vector.

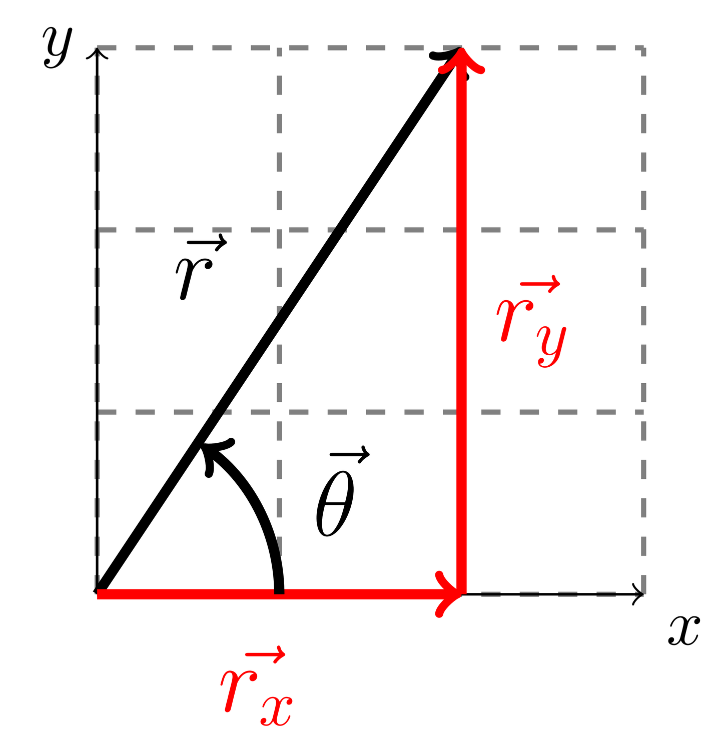


4. **Scaling vectors** results in a change of magnitude (length) but not direction.



5. **Multiplying Vectors** is possible but will be ignored until later in the semester. If you are interested though, there are two forms of vector multiplication (dot and cross products) each with very specific consequences!

Sometimes it is easier to work with vectors that are written in polar coordinates $\vec{r}$ and $\vec{\theta}$. This is especially true if we know that our object of interest is moving along the circumference of a circle (like a tire or marry-go-round). You can easily convert from cartesian to polar coordinates or from polar coordinates to cartesian:



Polar to Cartesian Coordinates: To convert from polar coordinates (a,θ) to cartesian coordinates (x,y),

$$a_x = |\vec{a}|cos\theta \qquad \text{and} \qquad a_y = |\vec{a}|sin\theta$$

You may also write cartesian coordinates in terms of their unit vectors ($\hat{\imath}$ and $\hat{\jmath}$).

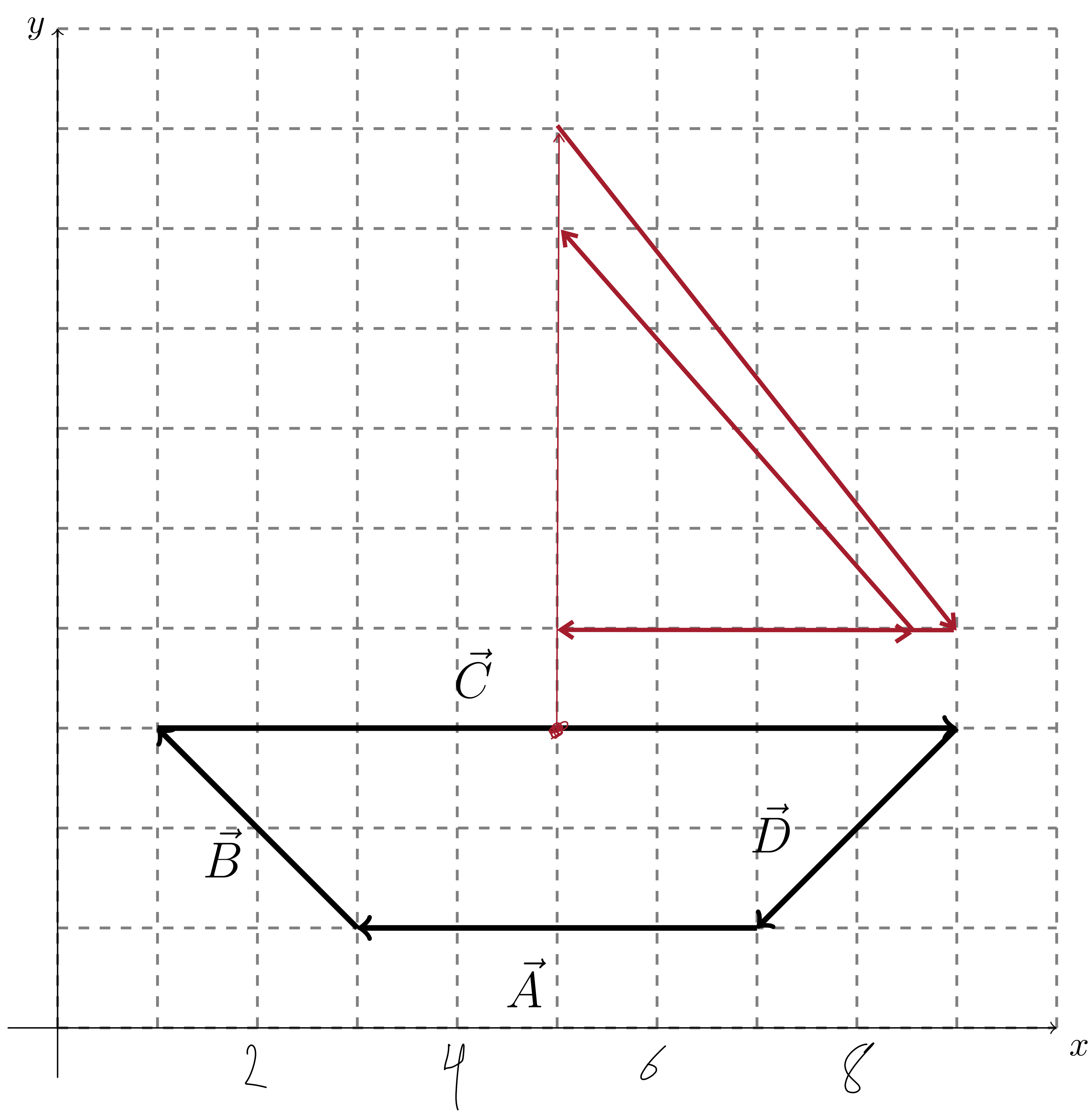
$$\vec{a} = a_x\hat{\imath} + a_y\hat{\jmath} \qquad \text{where } \hat{\imath} \text{ and } \hat{\jmath} \text{ each have a unit length of 1.}$$

It is also commonly accepted that vectors be written in their coordinate pairs (x,y) or (r,θ) as well.

Cartesian to Polar Coordinates:

$$\vec{r} = r_x\hat{\imath} + r_y\hat{\jmath} \qquad r = |\vec{r}| = \sqrt{r_x^2 + r_y^2} \qquad tan\theta = \frac{a_y}{a_x}$$

1. Several vectors are graphed below. Fill out the vector components for each vector in the associated table. Draw vectors highlighted in red from table. The starting point for these vectors is written under each vector in (x,y) coordinates.



Vector	$\vec{x}$	$\vec{y}$
$\vec{A}$ (7,1)	-4	0
$\vec{B}$ (3,1)	-2	2
$\vec{C}$ (1,3)	8	0
$\vec{D}$ (9,3)	-2	-2
$\vec{E}$ (5,3)	0	6
$\vec{F}$ (5,9)	4	-5
$\vec{G}$ (9,4)	-4	0
$\vec{H}$ (8.2,4)	-3.2	4

2. Calculate the following using the components from the table above:

   (a) Calculate $\vec{B} + \vec{D}$:

   $\langle -4, 0 \rangle$

   (b) Calculate $\vec{C} + 2\vec{A}$:

   $\langle 0, 0 \rangle$

   (c) Calculate $\vec{A} + \vec{B} + \vec{C} + \vec{D}$:

   $\langle 0, 0 \rangle$

   (d) Calculate $\frac{1}{5}(\vec{F} + \vec{G})$:

   $\langle 0, -1 \rangle$

   (e) Calculate $\frac{1}{5}(\vec{F} + \vec{G}) - \frac{1}{6}\vec{E}$

   $\langle 0, -1 \rangle + (-1)\langle 0, 1 \rangle = \langle 0, -2 \rangle$

3. Convert the following vector into polar coordinates.

$$\vec{a} = 3\vec{i} + 4\vec{j}$$

$a = |\vec{a}| = \sqrt{a_x^2 + a_y^2} = \sqrt{9+16} = 5$ $\quad tan\theta = \frac{a_y}{a_x} = \frac{4}{3}$ $\quad \theta =$ ________

4. Convert the following vector, $(3, 60^o)$ into cartesian coordinates.

$a_x = |a|cos\theta =$ ________ $\quad a_y = |a|sin\theta =$ ________

5. Fill in the following table converting polar coordinates to cartesian coordinates or cartesian coordinates to polar coordinates.

$\vec{x}$	$\vec{y}$	$\vec{r}$	$\vec{\theta}$
1	1		
-1	-1		
		2	90^o
		-2	270^o
1	2		
3	1		
		5	32^o
		3	-32^o
		-1	360^o
- 2	3		
1	-2		
-1	3		