Subject Code	PHY 1	**Physics 1**
Module Code	4.0	**Vectors**
Lesson Code	4.1	**Parallelogram Method of Adding Vectors**
Time Frame		30 minutes

Components	Tasks	TA (min)	ATA (min)
Target 	By the end of this learning guide, the student should be able to: • employ the parallelogram method in adding vectors	1	
Hook 	Adding scalars is quite easy! Adding vectors, however, takes a different level of skill. You have learned in grade eight that vectors are quantities with both magnitude and direction. The direction of the vectors must be considered in determining the resultant vector, or the sum of the given vectors. Why do we need to add vectors? Finding the resultant vector gives us a lot of information. One example is in terms of displacement. If one object is displaced several times, the sum of the individual displacements or the resultant vector describes how far and in what direction the object traveled from its starting point to end point. Vectors may be added by graphical means, one of which is by constructing a parallelogram given two vectors, hence the term *Parallelogram Method*. In this method, you simply need graphing paper, ruler, protractor, and pen. Are you ready? Let's start!	1	
Ignite 	A vector quantity is illustrated using an arrow. The length of the arrow, drawn to scale, represents the magnitude of the vector while the arrowhead indicates the direction. The direction may be specified in terms of the vector's orientation on the x-y plane, where the x-axis is along the horizontal and the y-axis is along the vertical. In case the vector is not exactly along any of the two axes the angular direction with respect to either axis is specified. Suppose you are to illustrate a vector with magnitude of 3m and direction of $30°$ above – x-axis (negative x-axis). Starting from the origin of the coordinate axes, measure $30°$ above – x-axis using a	17	

protractor. Then draw an arrow, using a ruler, according to your chosen scale.

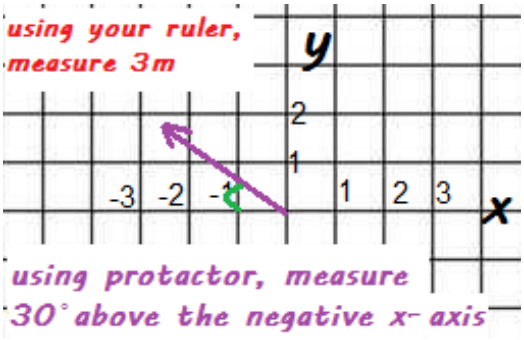


Figure 1. 3m, 30° above – x-axis

The direction may also be specified in terms of cardinal directions North, South, East, and West. Suppose you are to illustrate a vector with magnitude of 3m and direction of 30° East of North. Starting from the origin, measure 30° from North going to East using a protractor. Then draw an arrow, using a ruler, according to your chosen scale.

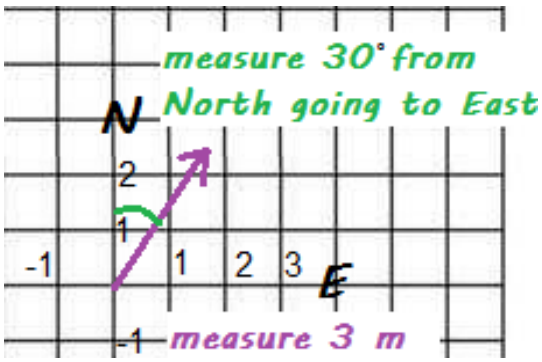


Figure 2. 3m, 30° East of North

Do not forget to use scaling. In the above examples, one marking on the grid corresponds to 1m. A lot of graphing paper measures 1 mm per side of the grid so in this case ***1mm=1m****.*
Keep in mind that the angular direction is always measured at the tail of the vector representation, not at its tip.

Let's start with a simple example of finding the resultant vector of two vectors:

$\vec{A} = 3m,$ 30° above x-axis; and
$\vec{B} = 4m,$ 45° above the negative x-axis

Step 1: Draw the two given vectors such that their tails are at the same point.

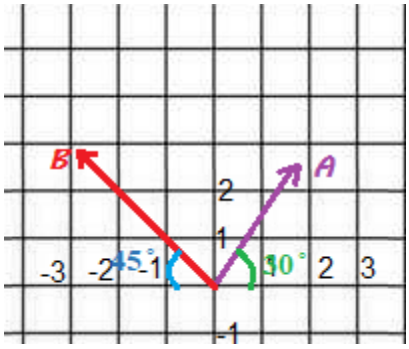


Figure 3. Vectors $\vec{A}$ and $\vec{B}$

Step 2. Construct a parallelogram by drawing imaginary lines that are of the same length and parallel to each of the two vectors that are being added.

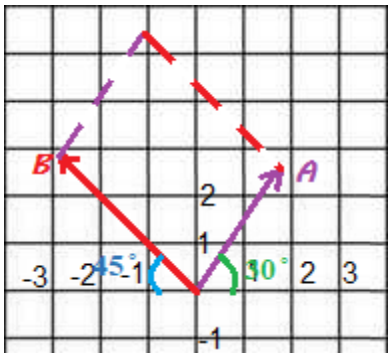


Figure 4. Parallelogram formed from the given vectors. Opposite to each given vector is an imaginary line (dashed line) that is of the exact length and parallel to the given vector.

Step 3: Draw an arrow from the tail of the two vectors to the point of intersection of the imaginary lines. This arrow is the resultant vector, $\vec{R}$, of given vectors $\vec{A}$ and $\vec{B}$.

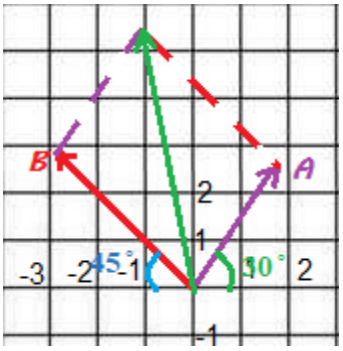


Figure 5. Resultant vector $\vec{R}$ drawn from the tail of vectors $\vec{A}$ and $\vec{B}$ to the point of intersection of the imaginary lines

Step 4: Measure the length of the resultant vector using your ruler. Measure its direction above the x-axis using your protractor.

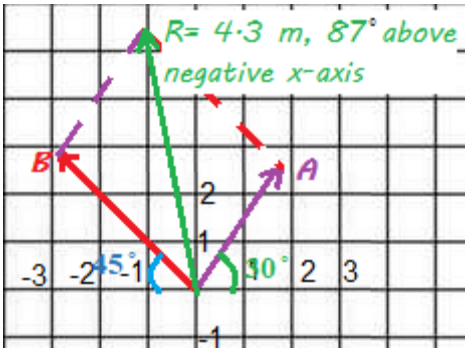


Figure 6. Measuring resultant vector, $\vec{R}$

Good job!

Now how about adding more than two vectors?
Don't worry. It is easier than you think!

Let us add another vector, $\vec{C} = 5m$, 20° below the negative x-axis, to $\vec{A}$ and $\vec{B}$.

Step 1: Add the first two vectors, $\vec{A}$ and $\vec{B}$, the resultant of which we will denote as $\vec{R}_{AB}$. We already did that so let us continue from where we left off.

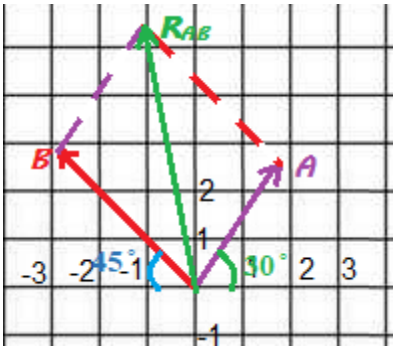


Figure 7. Vector $\vec{R}$ in the previous example denoted here as $\vec{R}_{AB}$

Step 2: Plot vector $\vec{C}$, I only draw $\vec{R}_{AB}$, so the figure doesn't look too crowded.

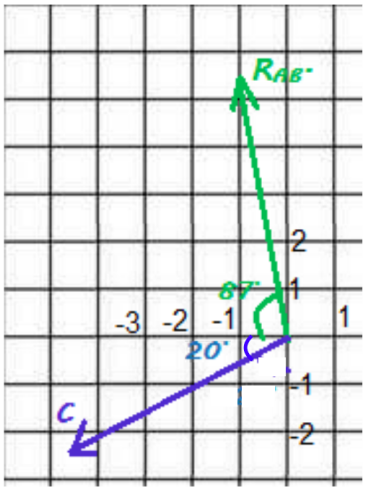


Figure 8. Plotting vector $\vec{C}$

Step 3: Use parallelogram method in adding vectors, $\vec{R}_{AB}$ and $\vec{C}$. Draw the imaginary lines to make a parallelogram.

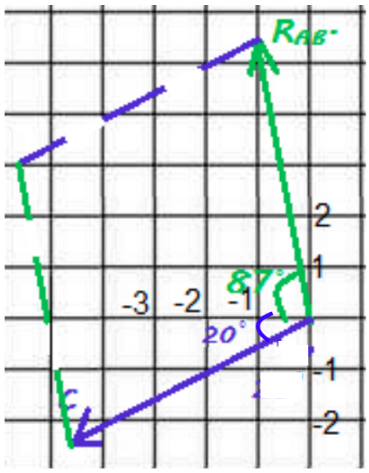
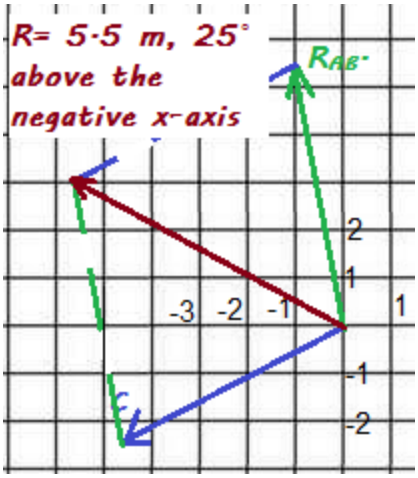


Figure 9. Making a parallelogram for vectors, $\vec{C}$ and $\vec{R}_{AB}$

	Step 4: Draw an arrow from the tail of the two vectors, $\vec{R}_{AB}$ and $\vec{C}$, to the point of intersection of the imaginary lines. This arrow is the resultant vector, $\vec{R}_{ABC}$, or simply $\vec{R}$, of vectors, $\vec{A}$, $\vec{B}$, and $\vec{C}$. Measure the length of the resultant vector, using your ruler, and its direction, using your protractor.  Figure 10. Plotting and measuring the resultant vector, $\vec{R}$, for vectors, $\vec{A}$, $\vec{B}$, $\vec{C}$ Good job! Now you can add two or more vectors using the parallelogram method!		
Navigate	Try what you've learned and do the following exercises. Write your answers on a clean sheet of paper. Follow your teacher's instructions regarding submission. All items will be graded. 1. John is lost in a market. From his motorcycle, he walked 12 meters, $30°$ East of South while playing with his phone. He lifted his face up and saw that he is lost, then, he turned and walk 7 meters, $50°$ South of West. How far is John from his motorcycle and in what direction? Use the *Parallelogram Method* to find the resultant vector of John's displacements. 2. Add the following vectors: $\vec{D}$ = 2m, 15° above the positive x-axis $\vec{E}$ = 4m, 25° below the positive x-axis $\vec{F}$ = 6m, 80° below the negative x-axis	10	

Knot 	In adding vectors using the *Parallelogram Method*, draw two given vectors such that their tails are at the same point. Construct a parallelogram by drawing imaginary lines that are parallel to each of the two vectors. Draw an arrow from the tail of the two vectors to the point of intersection of the imaginary lines. This arrow is the resultant vector. Things to remember while graphically adding vectors: 1. Choose a scale that is suitable to the given vectors. Measurements will be difficult if the vectors are too small. The scaling should also be enough to accommodate all the given vectors in your drawing space. 2. Pay attention to the given direction. Read it carefully. Is it above the x-axis or below the x-axis. Is it North of East or East of South? Simple misinterpretations and inattentiveness could lead to mistakes. Keep in mind that the direction is always measured at the tail of the vector representation, not at its tip.	1	

References:

1. Giancoli, Douglas C. (2014). *Physics Principles with Applications 7th ed*. United States of America: Pearson Education, Inc.
2. *Young, H. D., & Freedman, R. A. (2019). University physics. Upper Saddle River: Pearson*

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