

9.2.5: Graphical Methods of Vector Addition


 This man shooting a basketball requires a subconscious understanding of vectors

Figure 9.2.5.1: Copy and Paste Caption here. (Copyright; author via source)

Successfully shooting a basketball requires a subconscious understanding of the vectors involved in how the basketball moves through the air. The vertical and horizontal vectors must be perfectly organized if the ball is to pass through the basket.

Graphical Methods Vector Addition

In physics, a quantity, such as mass, length, or speed that is completely specified by its magnitude and has no direction is called a **scalar**. A **vector**, on the other hand, is a quantity possessing both magnitude and direction. A vector quantity is typically represented by an arrow-tipped line segment. The length of the line, drawn to scale, represents the magnitude of the quantity. The direction of the arrow indicates the direction of the vector. Not only can vectors be represented graphically, but they can also be added graphically.

For one dimensional **vector addition**, the first vector is placed on a number line with the tail of the vector on the origin. The second vector is placed with its tail exactly on the arrow head of the first vector. The sum of the two vectors is the vector that begins at the origin and ends at the arrow head of the final added vector.

Consider the following two vectors.


 The top number line shows a vector with magnitude 11 in the positive direction and the bottom number line shows a vector with magnitude -3

Figure 9.2.5.2

The red vector has a magnitude of 11 in the positive direction on the number line. The blue vector has a magnitude of -3, indicating 3 units in the negative direction on the number line. In order to add these two vectors, we place one of the vectors on a number line and then the second vector is placed on the same number line such that its origin is on the arrow head of the first vector.


 One number line with one vector with magnitude 11 in the positive direction and another vector overlapping with magnitude -3

Figure 9.2.5.3

The sum of these two vectors is the vector that begins at the origin of the first vector (the red one) and ends at the arrow head of the second (blue) vector. So the sum of these two vectors is the purple vector, as shown below.


 One number line with one vector with magnitude 11 in the positive direction and another vector overlapping with magnitude -3, showing the sum of the two vectors with a third with magnitude 8

Figure 9.2.5.4

The vector sum of the first two vectors is a vector that begins at the origin and has a magnitude of 8 units in the positive direction. If we were adding three or four vectors all in one dimension, we would continue to place them head to toe in sequence on the number line. The sum would be the vector that begins at the beginning of the first vector and goes to the ending of the final vector.

Adding Vectors in Two Dimensions

In the following image, vectors A and B represent the two displacements of a person who walked 90. m east and then 50. m north. We want to add these two vectors to get the vector sum of the two movements.


 Graph of two vectors, representing two displacements of a person who walked 90 mi east and then 50 mi north

Figure 9.2.5.5: Copy and Paste Caption here. (Copyright; author via source)

The graphical process for adding vectors in two dimensions is to place the tail of the second vector on the arrow head of the first vector as shown above.

The sum of the two vectors is the vector that begins at the origin of the first vector and goes to the ending of the second vector, as shown below.


 Two vectors representing two displacements of a person who walked 90 mi east and then 50 mi north, with the third vector connecting the two, creating a triangle indicating the sum

Figure 9.2.5.6: Copy and Paste Caption here. (Copyright; author via source)

If we are using totally graphic means of adding these vectors, the magnitude of the sum would be determined by measuring the length of the sum vector and comparing it to the original standard. We would also use a compass to measure the angle of the summation vector.

If we are using calculation means, we can divide 50. m by 90. m and determine inverse tangent of the dividend. The result of 29.05 indicates the angle of 29° north of east. The length of the sum vector can also be determined mathematically by the Pythagorean theorem, $a^2+b^2=c^2$. In this case, the length of the hypotenuse would be the square root of (8100 + 2500) or 103 m.

If three or four vectors are to be added by graphical means, we would continue to place each new vector head to toe with the vectors to be added until all the vectors were in the coordinate system. The sum vector is the vector from the origin of the first vector to the arrowhead of the last vector. The magnitude and direction of the sum vector can be measured.



Figure 9.2.5.7: Copy and Paste Caption here. (Copyright; author via source)

Have you ever used a phone app that provides directions or a navigation system in your car? These programs help you get from Point A to Point B by breaking it down into a series of left and right turns that exemplify many of the graphical methods of vector addition described above. The navigation systems in self-driving cars are even more advanced. Continue to practice vector addition by helping a driverless car get to its destination in the following simulation:

Summary

- Scalars are quantities, such as mass, length, or speed, that are completely specified by magnitude and have no direction.
- Vectors are quantities possessing both magnitude and direction and can be represented by an arrow; the direction of the arrow indicates the direction of the quantity and the length of the arrow is proportional to the magnitude.
- Vectors that are in one dimension can be added arithmetically.
- Vectors that are in two dimensions are added geometrically.
- When vectors are added graphically, graphs must be done to scale and answers are only as accurate as the graphing.

Review

1. On the following number line, add the vector 7.5 m/s and the vector -2.0 m/s.

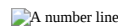


Figure 9.2.5.8

2. On a sheet of graph paper, add a vector that is 4.0 km due east and a vector that is 3.0 km due north.

Explore More

Use this resource to answer the questions that follow.



1. What is a resultant?
2. What are the steps necessary to add vectors in two dimensions?

Additional Resources

PLIX: Play, Learn, Interact, eXplore: Submarine Target Practice

Real World Application: Drift

Real World Application: Threading the Needle

Video:



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