

MOTION IN A PLANE

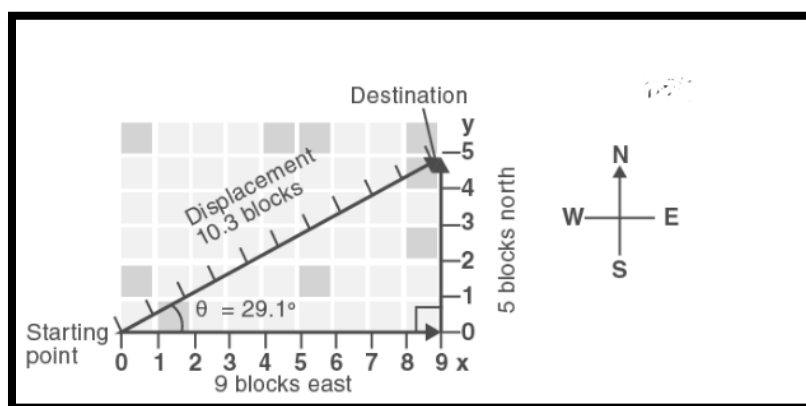
ADDITION AND SUBTRACTION OF VECTORS - GRAPHICAL METHOD

Graphical Method for Vector Addition and Subtraction

A vector defines motion in two perpendicular directions, in two dimensions, that is, vertical and horizontal motion. Each vector is made up of vertical and horizontal components for vertical and horizontal motion. One of these components simply becomes zero in one-dimensional motion.

Concept of Vector Addition and Subtraction

The direction of a vector can be simply represented by a plus or minus sign in a straight-line motion or one-dimensional motion. Therefore, a motion that is in an upward direction or in the forward direction to the right is generally considered to be positive, and a motion that is in a downward direction or in the backward direction to the left is generally considered to be negative.



Let us understand this with an example:

Figure (1) – illustrates the total displacement for a boy walking in a city, that is, a graphical representation of a vector. First, the boy walks in the east – nine blocks and then in the north – five blocks. His total displacement is not equal to the path followed by him towards

the final destination because displacement is simply the shortest distance which connects the starting point and ending point of his motion.

To categorize a vector, its magnitude and direction in this motion, we can use the notations like:

Bold symbol – \mathbf{B} denotes the vector

Italics symbol, B , denotes its magnitude and

Angle θ represents the direction

Vector Addition Using Graphical Method

The graphical method to add vectors is the head-to-tail method. The starting point of the vector is represented by the tail of the vector, and the pointed end of the arrow is represented by the tip or head of the vector.

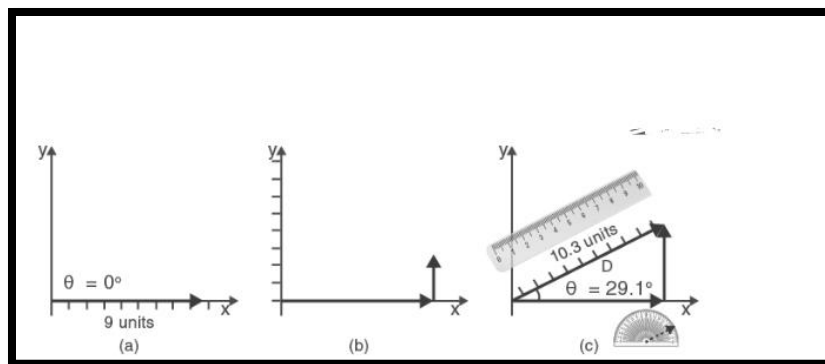
Here are the steps that demonstrate how to use the head-to-tail technique for a graphical method of vector addition:

Let the east-west direction be represented by the x-axis. To signify the first vector, that is, nine blocks to the east, draw an arrow using a ruler and a protractor, as shown in Figure(a).

Draw an arrow to represent the second vector, that is, five blocks to the north, draw an arrow and let the y-axis represent the north-south direction. Now, at the head of the first vector, place the tail of the second vector, as shown in Figure(b).

As explained in step 2, continue to add the vectors head-to-tail if there are more than two vectors.

From the tail of the first vector to the head of the last vector, draw an arrow to find the sum or resultant of the vectors, as shown in Figure (c).



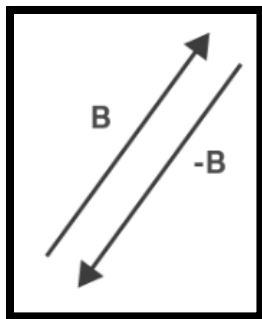
Using a ruler, measure the length of the resultant line to calculate the magnitude of the resultant. Then finally, using the Pythagoras theorem, we can calculate the magnitude of the resultant.

Use a protractor to find the direction of the resultant by measuring the angle it makes with the reference line, that is, the x-axis in this case. While dealing with the vectors methodically, trigonometry is used to find the angle and the direction.

Vector Subtraction Using Graphical Method

The extension of the graphical method of vector addition is the vector subtraction method. Suppose we want to subtract B from A, written $A - B$ to define subtraction; we should define the signs of the vectors first, i.e. the negative of a vector B is denoted by $-B$, which means that graphically the negative of any vector is in the opposite direction but has the same magnitude. As illustrated in Figure (2), fundamentally, the vector has been flipped so that it points in the opposite direction.

Therefore, the addition of vector $-B$ to A simply gives the result of subtraction of vector B from vector A. We can note that subtraction of a vector is simply the addition of a negative vector, and the result is not affected by the order of subtraction.



$$A + (-B) = A - B$$

This is similar to the subtraction of scalars, for instance, $6 - 3 = 6 + (-3)$. Hence, when vectors are subtracted graphically, the result does not depend on the order in which the subtraction is made.

Vectors in Two Dimensions

A quantity that has magnitude, as well as direction, is known as a vector. Velocity, acceleration, displacement, and force are some of the examples of a vector quantity. The direction of a vector can be simply represented by a plus or minus sign in a straight-line motion or one-dimensional motion. On the other hand, in two-dimensional motion, the direction of a vector is specified relative to some reference frame, that is, a system of coordinates that uses an arrow pointing in the direction of the vector and its length proportional to the magnitude of the vector.