The Graphical Addition of Vectors

A wide variety of physical quantities are described by vectors. Vectors are quantities that have both magnitude and direction. Displacement, velocity and acceleration are all examples of vector quantities. Forces are also vector quantities.

In this experiment, we wish to test how vectors add, subtract and break into components. To do this, we will add, subtract and compute components of force vectors graphically. After performing these operations graphically, we will test them experimentally with a force table.

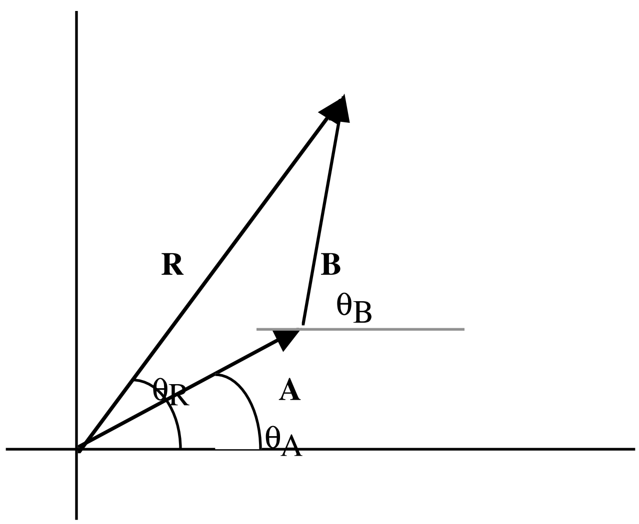
Graphical Addition and Subtraction.

Vectors can be added graphically via two methods.

Tip-to-Tail

Draw the first vector in the sum starting at the origin. Draw the second vector starting on the tip of the first vector. The sum of the two is a vector that starts a the origin of the first vector and ends on the tip of the second. For example:

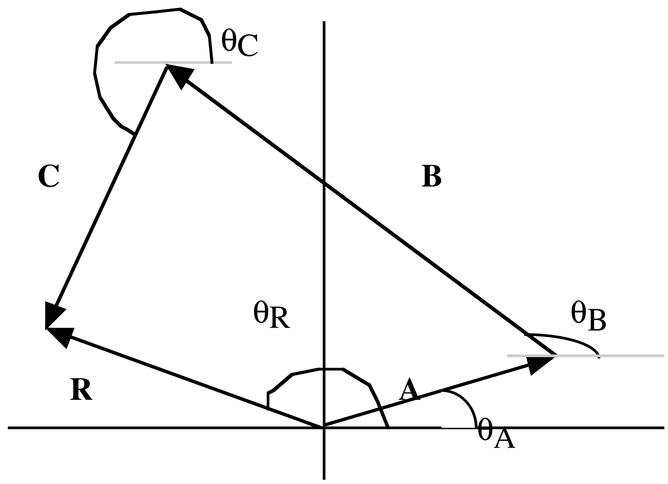
R = A + B



We draw each vector by drawing an arrow to scale with the correct length with the correct angle. Note that the angle is always measured from horizontal. We measure the length of the resultant and the angle, using our scale to compute the magnitude of the resultant vector.

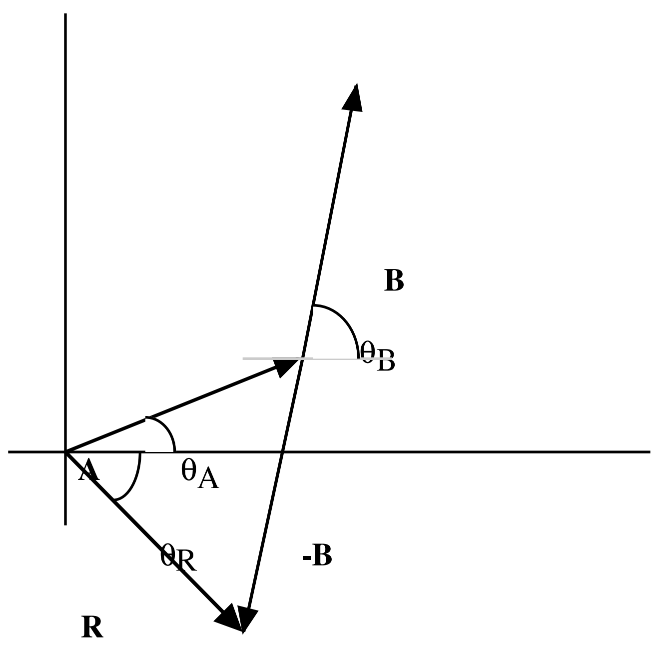
We can use the same technique to compute the sum of more than two vectors. Consider the sum of three vectors.

R = A + B + C



We can subtract one vector from another by adding a vector of the opposite direction.   For example

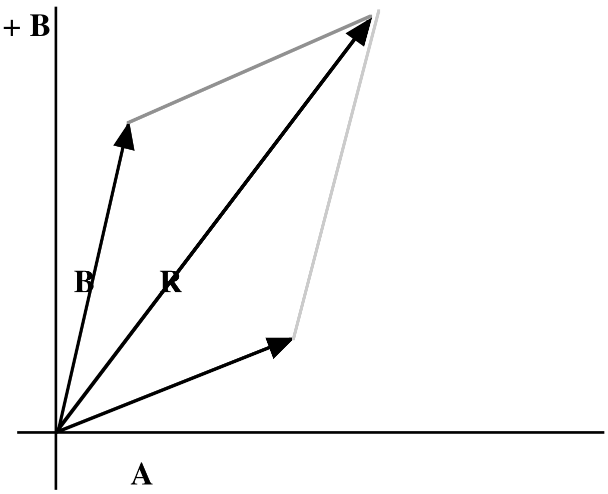
R = A - B



Parallelogram Method

Draw both vectors from the origin. Complete the parallelogram. The resultant vector is a vector from the origin along the diagonal to the corner of the completed parallelogram.

R = A + B

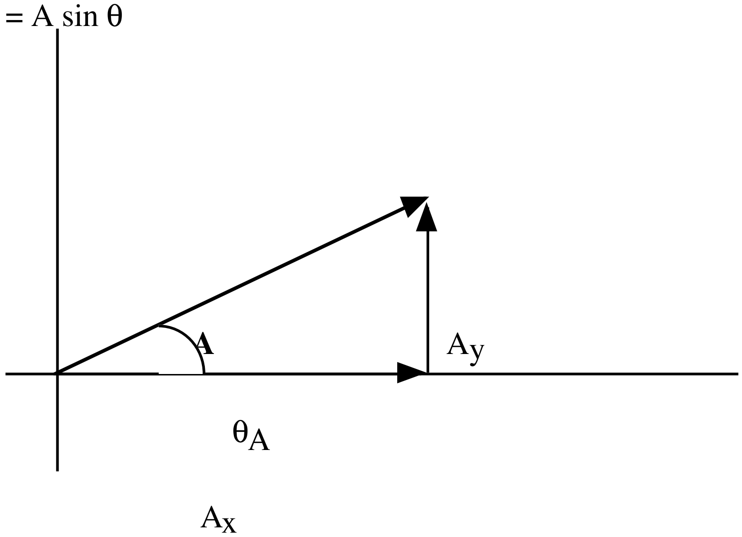


Vector Components

We can compute the components of a vector using simple trigonometry.

$A_x = A \cos \theta$

$A_y = A \sin \theta$



Procedure

To test the graphical techniques that we have discussed, we will add force vectors graphically and then test the results on a force table. The forces that we will add are tensions in strings created by gravity acting weights. Although the force due to gravity is mg, we will use just m. This will simplify the procedure.

Graphical addition.

Each student should do a graph for each of these steps.

1 Addition of two vectors using the Tip-to-Tail method. Using a scale of 1 cm = 10 g, add the following two vectors graphically using the Tip-to-tail method.

A = 105 g at 30 deg
B = 145 g at 70 deg

R = **A** + **B**

Measure the length and angle of the resultant and convert it back to grams.

2. Addition of vectors using the parallelogram method. Using a scale of 1cm =10 g, add the vectors **C** and **D** using the parallelogram method.

C= 125 g at 50 deg
D = 75 g at 150 deg.

R = **C** + **D**.

Measure the length and angle of the resultant and convert it back to grams.

3. Subtraction of one vector from another using the Tip-to-Tail method. Using the same vectors A and B (and the same scale), subtract B from A using the Tip-to-Tail method.

A = 105 g at 30 deg
B = 145 g at 70 deg

R = **A** - **B**.

Measure the length and angle of the resultant and convert it back to grams.

4. Addition of three vectors using the Tip to Tail method. Using a scale of 1 cm = 10 g, add the following three vectors graphically using the Tip-to-tail method.

A = 100 g at 30 deg
B = 165 g at 70 deg
D = 75 g at 150 deg.

R = A + B + D.

Measure the length and angle of the resultant and convert it back to grams.

5. Draw vector D. Compute and label its components.

D = 85 g at 150 deg.

Measure Dx and Dy on the graph and convert back to grams.

Testing of graphical results.

To test each result, we will set up the vectors to be added on the force table. To measure **R** experimentally, we will find the **-R** necessary to balance the **R** that arises from the summing vectors.

Record the measured value of R in each case and compare it to your prediction in each case. Be sure to compute a percent difference in each case.

Note: To test the components that you determined graphically in #5, find out what masses need to placed at 0 degrees and 270 degrees to balance against D.

Questions.

1. How does this experiment test the addition of vectors?

2. What experimental problems limit the precision of our test in this case?

3. Why is important that the Force Table be level?