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CTE Science Laboratory Investigation

THE COMPOSITION OF VECTORS

**Introduction**

It’s often useful to measure a force in the study of physics, and it’s important to remember that forces are vector quantities. That is, they have both a magnitude and a direction. This is in contrast to scalar quantities, which only have a magnitude. This is not terribly complex when one considers a very simple situation, such as pushing a crate across the floor. The force is in one direction, parallel to the floor, and results in the crate moving in the same direction as the force.

 Life, however, is not always that simple. There are times when the force that is applied to an object results in the object moving in a direction that is different than the force, or when two forces are applied to an object. In the example above, consider what might happen if both you and a friend were applying a force to the crate. You might not be pushing in exactly the same direction, so where would the crate go? Or consider a boat in an ocean with a current. The props of the boat may be pushing the boat in one direction, but the current may be applying a force in another direction. What is the final course that the boat will take?

 This question can be easily answered by adding the vectors together and observing the result. As an example, if you have a 10 N force pushing north and a 10 N force pushing east, then the resultant vector will be somewhere between north and east. In point of fact, because the two vectors have an equal magnitude, the resultant will be directly between north and east: northeast.

 But what if there is a case where the two vectors are uneven? We have to compose the vectors to find the resultant magnitude and direction. Consider the two vectors below:

25 N east

10 N north

What if both of these forces were applied to the same object? Clearly one force would move it north, one would move it east, so it would end up northeast of its starting point, but by how much? We can compose the vectors to find out. Simply line them up tip-to-tail:

Resultant

10 N north

25 N east

So now we have the resultant, but what is its magnitude? And what is the exact direction? It’s not perfectly northeast. To find the magnitude, all you need to do is recognize that we’ve formed a right triangle, and that we can employ Pythagoras’ clever theorem:

**a2 + b2 = c2**

In this situation, a is 25, b is 10 and c is unknown. If we solve the equation, we find that c is 26.92 N, which is the magnitude of our resultant. But how do we find the direction? You can very simply use a bit of trigonometry (remember SOHCAHTOA). The resultant will always be the hypotenuse of the triangle, so you’ll always need to use the tangent function:

**Tan θ = opp/adj**

In this case, the opposite side is 10, the adjacent side is 25, so if we solve that, we get that the angle is 21.8 degrees north of east.

**Purpose**

 The purpose of this lab is to acquaint you with the idea of the composition of vectors, to remind you of how the Pythagorean theorem and trigonometry can be useful, and to give you practice composing vectors physically and mathematically.

**Materials**

 PENCIL Meter sticks

 Scientific calculator Protractor

 String

**Procedure**

1. Attach an arrowhead to each of two meter sticks. On the meter sticks, 1 cm will equal 1 N.

2. Use the meter sticks to answer questions 1 – 5. To answer the questions, simply place the meter sticks in the appropriate location on the desk, and adjust the arrowhead to the appropriate length as described. Use a bit of string to create the resultant vector. Then use the protractor to measure the angle created and measure the length of the string. Remember to line them up tip-to-tail!

QUESTION 1: What is the resultant vector when a force of 50 N north and a force of 75 N east are composed?

QUESTION 2: What is the resultant vector when a force of 25 N north and a force of 90 N east are composed?

QUESTION 3: What is the resultant vector when a force of 50 N north and a force of 60 N south are composed?

QUESTION 4: What is the resultant vector when a force of 10 N west and a force of 75 N south are composed?

QUESTION 5: What is the resultant vector when a force of 50 N north and a force of 60 N north are composed?

3. Use a scientific calculator to answer questions 6 – 10. Remember that directions can be expressed with degrees, with 0/360 being north, 90 being east, 180 being south and 270 being west.

QUESTION 6: What is the resultant vector when a force of 50 N east and a force of 70 N west are composed?

QUESTION 7: What is the resultant vector when a force of 10 N east and a force of 75 N east are composed?

QUESTION 8: What is the resultant vector when a force of 20 N north and a force of 100 N west are composed?

QUESTION 9: What is the resultant vector when a force of 30 N north and a force of 30 N west are composed?

QUESTION 10: What is the resultant vector when a force of 40 N north and a force of 45 N east are composed?