PHYSICS 203

Vectors Lab

This lab uses PhET Vector Addition Simulation:

https://phet.colorado.edu/sims/html/vector-addition/latest/vector-addition_en.html

Introduction

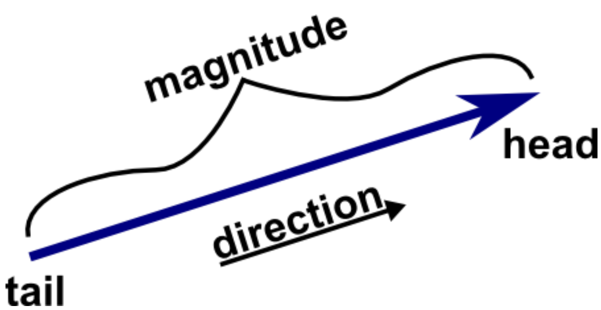
Two quantities which are normally introduced together are Scalars and Vectors.

Scalar quantity has magnitude only. Examples of scalar quantities are: 10 apples, 9 bananas, 12 km, 300^0 C etcetera.

Vector quantity has both magnitude and direction. Examples of vector quantities are: travel 12 km due north, 3 m due east, cycling at 5 km/h due west, force of 25N acting in a southeast direction, etcetera.

In Fig. 1 below, vector B has magnitude represented by its length; arrowhead represents its head which points in the direction of the vector; and it has a tail or start point.

Figure 1: Vector **B**



Vector Components

Each vector has two components; a horizontal component and a vertical component. Components are always at 90^0 to each other. See Fig. 2 below.

Horizontal component of vector A_x = A * sine (θ)

Vertical component of vector A_y = A * cosine (θ)

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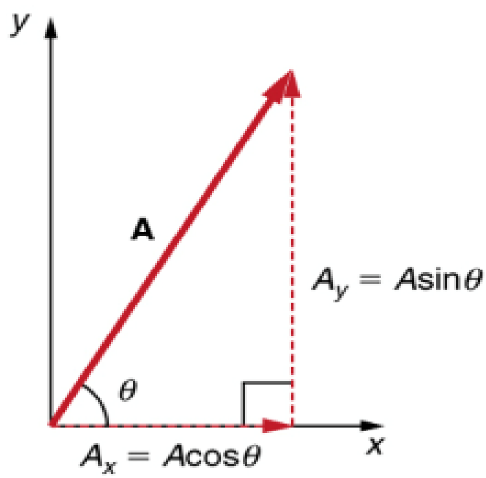
Figure 2: Components of vector A

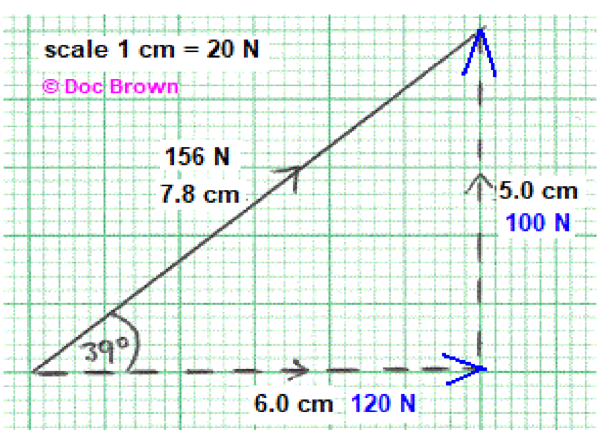


{Note use of SohCahToa – trig. functions}

Vector Addition – vectors can be added graphically or analytically.

As a rule vectors are added 'Head to Tail'. Therefore, the head of one vector is joined to the tail of the other vector it is being added to. This rule is obeyed for graphical addition of vectors, where vectors are drawn to scale on graph paper. An example of this is shown in Fig. 3 below. Here scale is 1 cm = 20 N, with parent vectors 120 N @ 0^0 and 100 N, @ 90^0. In graphical addition angle of resultant vector can be measured directly with a protractor (+X -axis has angle measure of 0^0). Here resultant vector R is 156 N @ 39^0.

Figure 3: Graphical addition of vectors



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Analytical method to add two vectors shown in Fig. 3 looks like this:

$$|R| = [(100)^2 + (120)^2]^{0.5}$$

$$|R| = 156.2 \text{ N}$$

Angle $\theta^0 = \tan^{-1}(A_y/A_x) = \tan^{-1}(100/120)$

$$\theta = 39.8^0$$

Therefore, resultant R = 156.2 N @ 39.8^0

Note use of Pythagoras Theorem ($c^2 = a^2 + b^2$), because two parent vectors are orthogonal (at 90^0 angle) where head of one vector (100 N) meets tail of other vector (120 N). Also, note use of trig function to calculate angle.

Procedure

Part I: Exploring One Dimensional Vectors

1. Click to launch simulation if not already done:

https://phet.colorado.edu/sims/html/vector-addition/latest/vector-addition_en.html

2. Click ‘Explore 1D’.
3. On right side of screen, click ‘Values’, ‘grid’ and ‘$\longleftrightarrow$‘ for horizontal plane or X – axis.
4. Drag three vectors a, b, c one at a time from right side of screen onto grid.
5. What direction do the vectors point to (specify positive or negative direction)?
6. Extend one of the vectors on grid by clicking on it and dragging.
7. Check ‘Sum’ on right to determine resultant sum of 1D vectors.
8. Click ‘eraser’ symbol below grid to clear grid.
9. Click on ‘$\updownarrow$‘ to get vertical plane or Y - axis vectors.
10. Repeat steps 4 through 7 above.

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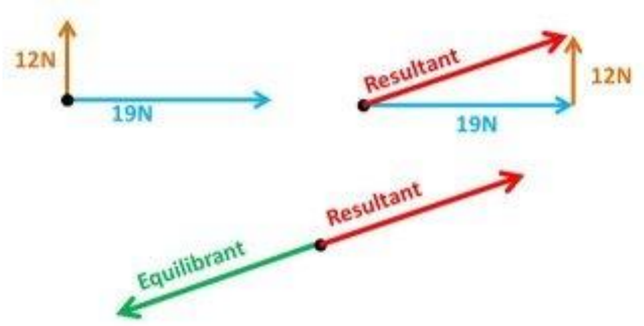
Part II: Exploring Two Dimensional Vectors

1. Click on ‘Explore 2D’ at bottom of page.
2. Check ‘values’, ‘angle θ’, ‘grid’, ‘components’.
3. Click and drag vectors a, b and c (you can also use: d, e and f) onto grid.
4. Click on vector ‘b’ to extend and rotate it until it is pointing into quadrant iv
5. Sum a_x, + b_x + $c_{x,}$ then get sum of a_y + b_y + c_y
6. Now click ‘sum’ on right hand side and see if your answers from (4) above are the same as those on grid for resultant vector labeled ‘s’.
7. As seen in (5) and (6) above, algebraic sum of components of parent vectors results in X and Y components of resultant vector. This method is very useful when summing three or more vectors.
8. Note when measuring angle for vector the X- axis is always used as the reference line, meaning X- axis is always one side enclosing angle (remember an angle always has two sides enclosing it).

Part III: Resultant Vs. Equilibrant

Equilibrant or balancing vector has same magnitude as resultant vector but points in direction opposite to resultant or 180^0 away from resultant. Another way to look at it is; equilibrant is the negative of resultant vector.

Figure 4: Illustration of relationship between Resultant and Equilibrant



1. Click on ‘Lab’ at base of simulation screen.

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2. Click on one vector and drag it into grid. This first vector is $\mathbf{V_1}$. Let magnitude of V_1 be: 5 units < $|V_1|$ < 10 units, and direction, θ be : $10^0 < \theta < 70^0$.. Record data in Table 1 below.
3. Click on the same color vector as in (2) above and drag another vector into grid. This second vector is $\mathbf{V_2}$. Let magnitude of $\mathbf{V_2}$ be: 10 units< $|V_2|$ < 20 units, and direction, θ be: $100^0 < \theta < 220^0$. Record data in Table 1.
4. Determine sum of vectors $V_1 + V_2$, this is resultant R. Record data in Table 1.
5. Determine magnitude and direction of equilibrant.
6. Record a screenshot or pic of your simulation grid for use in your lab report.

Table 1: Resultant vs. Equilibrant

Vector $\mathbf{V_1}$	Vector $\mathbf{V_2}$	Resultant **R**		Equilibrant
		Calculated	Observed	
$\|V_1\|$ =	$\|V_2\|$ =	$\|R\|$ =	$\|R\|$ =	$\|E\|$ =
Angle θ^0 =	Angle θ^0 =	Angle θ^0 =	Angle θ^0 =	Angle θ^0 =
V_{1X} =	V_{2X} =	R_x =	R_x =	E_x =
V_{1Y} =	V_{2Y} =	R_y =	R_y =	E_y =

7. Is there a difference between calculated and observed values for the resultant? What could possibly have contributed to this difference?

Part IV: Application in Life

A pilot is flying her Cessna aircraft at a speed of 210 km/h due north from Long Island MacArthur Airport, New York to Sikorsky Memorial Airport, Connecticut. There is a strong 65 km/h wind blowing from west to east. The airstrip upon which she has been given clearance to land is orientated in a north south direction.

1. Make a scale of say 10 units on your grid equates to 100 km/h.
2. Draw vectors to represent her aircraft and the crosswind.

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3. Determine the resultant direction and speed of her aircraft.
4. Give the direction θ^0 in which she should point her aircraft nose in order to remain on course to her destination (there may be potential for confusion here as navigation systems in aircraft use magnetic north as 0^0, while in our calculation here we use (east) the positive X- axis as 0^0. However, all angles are measured in a counterclockwise direction.).
   Draw this vector on your grid.
   Record a screenshot or pic of your simulation grid for your lab report.
5. Considering, to land her aircraft, she must slow down/decrease her speed, how will this affect her ability to stay on course for the north-south aligned runway? What corrective action can she take to compensate and ensure she remains on course as she slows down to land?