Balance of Forces (Vector Addition)

Do not print out the instruction page(s). Do not copy and paste the sentences on this page to your report.

Concepts and keywords

Vectors cannot be added with their magnitudes. The angles have to be considered to decompose the vectors into *x*- and *y*-components. The, each component is added separately to have the information of the resultant vector.

The equilibrium of multiple vectors, which forces are balanced, the sum of these vectors becomes zero.

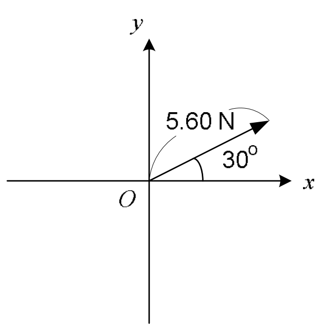
Objectives:

- To learn physical and mathematical properties of vector
- To learn how to add vectors
- To verify that a static equilibrium of vectors results in zero as the sum of these vectors

An example for obtaining the components of vectors

In a two-dimensional space, a vector can be expressed by its *x*- and *y*-components. The following method (angle taken from positive x-axis) is systematic; then, you can use cos and sin for *x*- and *y*-components always, respectively.

e.g.

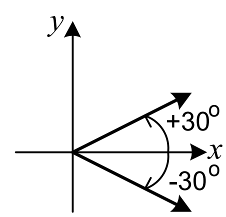


The vector has a magnitude, 5.60 N, and is directed 30^o from the positive *x*-axis. Therefore, each component of the vector will be:

x-component: $5.60\ \text{N} \times \cos 30^o$ = <u>4.85 N</u>

y-component: $5.60\ \text{N} \times \sin 30^o$ = <u>2.80 N</u>

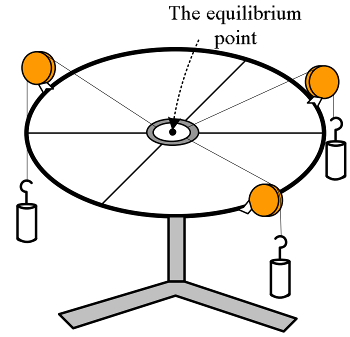
Note: The angle taken from the positive *x*-axis <u>counterclockwise</u> is positive, but when it is taken <u>clockwise</u>, it will be negative angle. Also, for sin or cos functions, -30^o gives an equal result with $+330^o$.



For the lab write up

- Write the introduction, conclusions and discussions.
- Answer the questions in the conclusion.
- Attach the data below and graph of addition of three vectors. (You can retype the results and use different graph papers for the vector addition.)

Static equilibrium with three forces



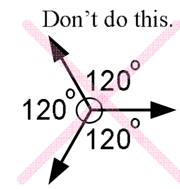
Name ____ Sign from instructor _________

Procedure:

① Use 3 <u>different</u> hanging masses as shown in the figure. (These are three vectors.)

② To make the equilibrium of three force vectors, adjust the angles so the center can be located in the middle of the force table.

③ Calculate each force and the net force by following the table below.



🛈 *Use different masses and angles for each hanging mass.*

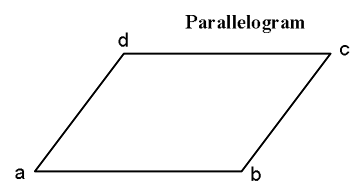
	Mass (kg)	Force (=9.8 $m/s^2 \times$Mass)	Angle	F_x (Go back to the first part.)	F_y (Go back to the first part.)
Force 1					
Force 2					
Force 3					
Sum of *x*- and *y*- components of each force ⇒					

Question:

Do the force components add up to zero? Explain this in terms of the net force. *(You are supposed to obtain zero theoretically.)*

What is parallelogram?

Definition of parallelogram is that side $\overline{ab}$ must be parallel with side $\overline{dc}$ and the length has to also be equal. Likewise, sides $\overline{ad}$ and $\overline{bc}$ are equal and parallel.



For the last part of this lab, read the following instruction. Use the above data and add all of the vectors graphically.

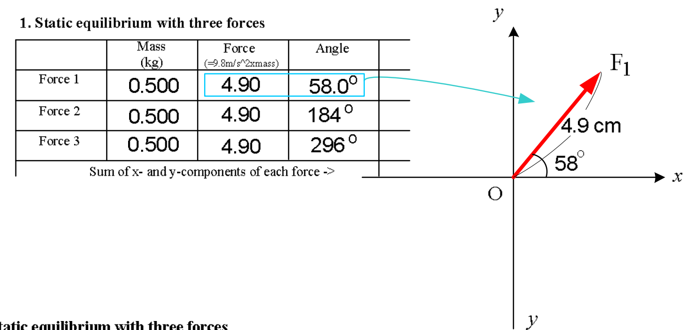
The data shown below are only for the explanation purpose. Please do not use this for your own results.

1. After taking data, you have the information of all of the vectors (the magnitudes and directions). The force column corresponds to the magnitude; and the angle column corresponds to the direction.

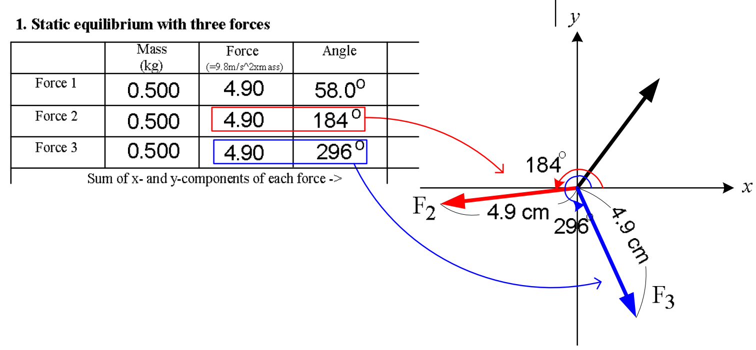
1. Static equilibrium with three forces

	Mass (kg)	Force (=9.8m/s^2xmass)	Angle	
Force 1	0.500	4.90	58.0°	
Force 2	0.500	4.90	184°	
Force 3	0.500	4.90	296°	
Sum of x- and y-components of each force ->				

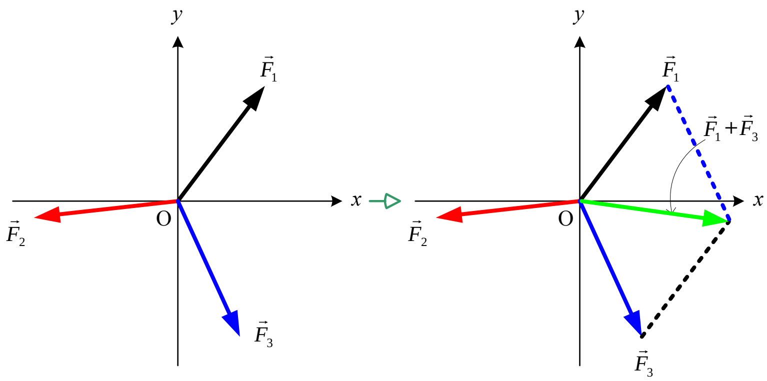
2. Draw each force vector as follows: Force 1 has magnitude, 4.9 N, and direction 58°. For convenience' sake, draw a vector on paper like 4.9 cm. (If it is too small to draw the vector, multiply the certain number by every magnitude of the force to magnify the lengths.)



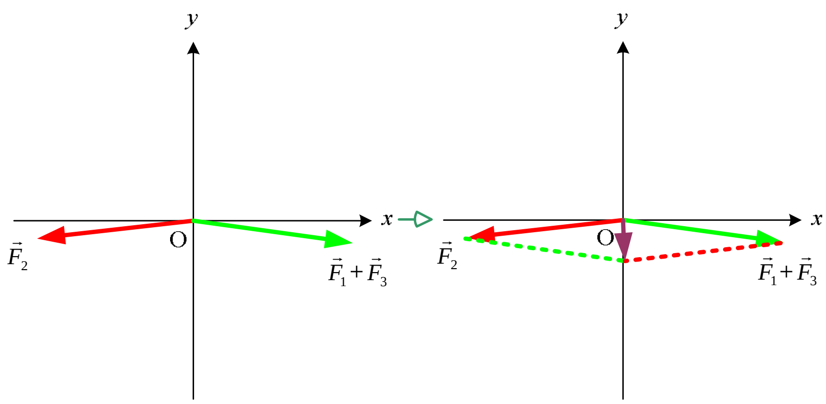
3. Perform the same procedure for the second and third vectors. The angles are always taken from the positive side of *x*-axis.



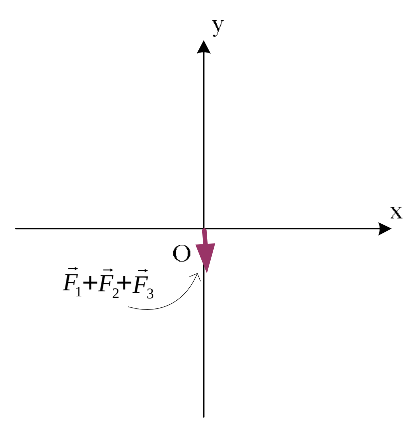
4. After you draw all of the vectors, pick out two vectors, such as $\vec{F}_1$ and $\vec{F}_3$. Then, make a parallelogram and draw the diagonal as shown.



5. The diagonal vector will be the sum of two vectors. (Note how you take the diagonal. The starting point of the vector is the origin.) Now, you have two vectors left, which are $\vec{F}_1+\vec{F}_3$ and $\vec{F}_2$. Perform the same procedure as above to obtain the sum of these vectors as shown below:



6. The sum of three vectors becomes close to zero vector as shown. The magnitude of this vector is the error from the experiment.



Use a graph paper to draw this part. A graph paper can be obtained at http://hirophysics.com/Physics165/Labs/graphpaper.pdf