# Equilibrium of Linear Force

**Honors Physics**

(Force Board Lab)

If two forces act concurrently on an object and the same point, then a resultant force could be substituted for the force components without altering their total effect. A single force, when applied, would be the **equilibrant** if it puts that object at **equilibrium** (a state of balance).

**Objective:** 1. Calculate the equilibrant of a series of forces acting on an object.
2. Apply the calculations to the force board

**Materials:**

| | |
|---|---|
| force board | three spring scale apparatus |
| graph paper | tape |

**Procedures – Complete your data table as you work through the lab:**

1. Tape graph paper to the force board draw in the **x** axis and **y** axis centered on the graph paper.
2. Arrange the spring scale apparatus so the springs are attached around the force board at one third of the board's circumference and the springs are pulled out to the fifth chain link. The link on the scale is link one.
   Think of this as a three person tug-o-war between "The Rock," Rambo, and the Gubinator. Each is pulling with the same force and the center ring does not move.
3. On the graph paper, draw lines that show the direction and magnitude of the forces. Write next to the line the force and direction. For this lab the direction will start at **0°** on the right horizontal line and increase counter-clockwise. **Include** the units and scale on your graph paper. Record the group's names on the graph paper.
4. Problem 1: $\mathbf{F_1}$ is **2 N** positioned at **40°** and $\mathbf{F_2}$ is **4 N** positioned at **140°**. Calculate What $\mathbf{F_3}$ would be to place the system in equilibrium. **Hint:** Resolve each vector into its respective vertical and horizontal components and add them together. Solve the resultants magnitude with Pythagerum's theorem and direction with trig functions. Record your answer in the data table.
5. Trial and error, position $\mathbf{F_3}$ to bring the system into equilibrium. Record your answer in the data table. **Note:** You can determine the angle between forces from the force board.
6. Calculate the percent error between your calculated answer and the data from the force board.
7. Problem 2: $\mathbf{F_1}$ is **4.3 N** positioned at **20°** and $\mathbf{F_2}$ is **3 N** positioned at **180°**. Record in the data table $\mathbf{F_3}$. Record in the data table the angle between $\mathbf{F_1}$, $\mathbf{F_2}$ and $\mathbf{F_3}$.
8. Problem 3: $\mathbf{F_2}$ is **4.1 N** positioned at **160°** and $\mathbf{F_3}$ is **2.7 N** positioned at **270°**. Record in the data table $\mathbf{F_1}$. Record in the data table the angle between $\mathbf{F_1}$, $\mathbf{F_2}$, and $\mathbf{F_3}$.

Name _____ Date _____ Period _____
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Name _____

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Prelab Questions:

1. Define a scalar quantity. _____
   _____
   _____
2. Define a vector quantity. _____
   _____
   _____
3. If three forces are in equilibrium, what acceleration will be produced? _____
4. What is an equilibrant vector? _____
   _____
   _____

1. The separation in the slots of the force board is _____degrees (°).
2. The spacing between the springs is _____. The force on each spring is _____.
3. Is the ring in equilibrium? _____. Explain: _____
   _____
4. Redraw the vectors showing head to tail. Do not change the magnitude or direction, only the position. What is the new shape? _____
5. The sum of all the forces on an object in equilibrium is _____.
   **Note:** We do not expect the triangle to show perfect closure but we hope that the closure will be close.
6. Your calculated magnitude for problem 1 is _____ and your calculated direction is _____.
7. The percent error for the magnitude is _____.The percent error for the direction is _____.

| | $F_1$ | q $F_1$ « $F_2$* | $F_2$ | q $F_2$ « $F_3$ | $F_3$ | q $F_3$ « $F_1$ |
|---|---|---|---|---|---|---|
| Problem 1 | 4 N @ 40° | | 2 N @ 140° | | | |
| Problem 2 | 4.3 N @ 20° | | 3 N @ 180° | | | |
| Problem 3 | | | 4.1 @ 160° | | 2.7 N @ 270° | |

***Note:** Record the angle between the force vectors, not from the x or y axis.

Conclusions:

1. What accounts for the percent error in the calculated values and the measured values?
   _____
   _____
   _____
2. What could be done to the force board to produce a more accurate measurement? _
   _____
   _____
   _____