**EQUILIBRIUM OF FORCES**

**LAB MECH 13**

*From Laboratory of Elementary Physics, Westminster College*

# INTRODUCTION

Forces are a very prominent reality of our physical world and of living. They are a very significant entity from the perspective of physics. Force is recognized and treated as a fundamental phenomena involved is various physics behavior and outcomes. With the concept of equilibrium, that is, the condition when forces are in balance or no net force; a resultant force, magnitude and direction, can be experimentally determined for such as two specific unknown forces acting in known directions. The approach is to provide an arrangement such that the two unknown forces acting in their respective specified directions are then balanced by placing a third force with magnitude and direction so as to achieve equilibrium. This added force or “equilibrant” would be equal in magnitude and opposite in direction to the resultant force of the two “unknowns,” that is, a force that could replace and have the same net affect as the two forces.

The proposition lends itself to a force table arrangement with the two unknown forces as hanging masses properly placed and a third balancing force also as a hanging mass, chosen and placed to achieve equilibrium.

Having determined the magnitude and direction of the equilibrant, the magnitudes of the unknown masses can by trigonometry and algebra be obtained.

The results obtained can be further collaborated graphically by vector diagram.

# PURPOSE

This experiment enables the determination of the magnitudes of two unknown forces acting in known directions.

# EQUIPMENT/MATERIALS

force table with ring, strings, and weight hangers scientific calculator

set of known masses balance and calibrated masses unknown masses

# PRELIMINARY QUESTIONS

From a force perspective, what are the conditions that a door does not open as you push on it?

Under what circumstances force-wise, do the two teams in a “tug-if-war” come to a stalemate?

What are the force conditions such that an inflated basketball retains its size and shape?

# PROCEDURE AND ANALYSIS

On the force table are placed two masses of unknown magnitudes, Ma and Mb, connected to a ring at the center by thin strings. Via the strings the masses apply forces of magnitudes Mag (forcea) and Mbg (forceb) on the ring, where g is the magnitude of the acceleration due to gravity. Consider as given, the configuration (directions) of these two forces acting at a point represented by the ring and do not in any way disturb them.

With the concept of equilibrium along with the set of known masses, the addition of a pulley and string; proceed by placing on the force table a third force so that the forces are in balance. Record the magnitude and direction of this equilibrant force and also that of the resultant ‘s direction of the two unknown forces.

With the data obtained for the equilibrant, an approximate sketch, trigonometry/algebraic equations; proceed to determine the magnitudes of the unknown forces. Weigh the unknown masses with a balance. Are the results satisfactory, comment? Enter the various values/determinations in the Data Table provided.

Now with the magnitudes and directions for the original unknown forces, graphically by vector diagram drawn to scale determine the magnitude and direction of the resultant. Assess the uncertainty of these values obtained.

# DATA TABLE

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Unknown forcea position Angle(deg) | Unknown forceb position Angle(deg) | Equilibrant ForceE(N) | Equilibrant ForceE position Angle(deg) | Resutlant ForceR(N) | Resultant forceR position angle(deg) | Weighed forcea(N) | Weighed forceb(N) |
|  |  |  |  |  |  |  |  |

# EXTENSION

1. Discuss, based on the approach of this experiment, the proposition of solving for the magnitudes of three unknown forces with directions given, having available the equipment/materials and techniques used for this two-unknown force problem.