Forces in Equilibrium Teacher's Notes

Main Topic	Forces
Subtopic	Equilibrium, Vectors
Learning Level	High
Technology Level	Low
Activity Type	Student

Description: Use a simple force table to analyze the arrangement of three forces that produce equilibrium. Draw force diagrams.

Required Equipment	Round table or stool, Table Clamp Pulleys (3), Spring Scale Set, Hooked Masses, String, Washer.
Optional Equipment	

Educational Objectives

- Analyze the arrangement of three forces that produce equilibrium. Draw force diagrams.

Concept Overview

Equilibrium is a condition in which the net force is zero. A net force of zero can mean that the object in question is at rest, or is traveling at a constant velocity.

In this case, students will place three different forces on a washer, and then arrange the forces so that the washer is in stable equilibrium in the center of the table.

A situation where two forces create equilibrium is simple to understand. Imagine a book on a table. Gravity causes a downward force, and the table causes an upward force. If these forces are equal in magnitude and opposite in direction, the book remains stationary.

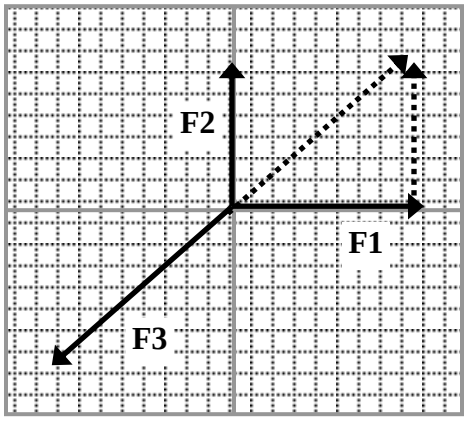
This lab adds a second dimension, allowing students to arrange a system of three forces. The forces must be visualized as vectors to understand how they can combine to produce a net force of zero.

Lab Tips

Any round, level surface can be made into a force table. There should be an easy way to identify the center, and the edge should fit in the clamp of the pulley.

Spring scales may be unnecessary if students are very comfortable with the relationships between mass, force, and string tension. The tension in the string, and thus the force on the washer, is simply the weight of the hooked mass.

The analysis portion of the lab, where students draw force diagrams and show that the net force is zero, can be directed by the teacher according to the desired focus and level of learning. Components can be used, or not. The simplest solution is to graphically vector-add two of the forces, and show that the third force opposes the result.



Forces in Equilibrium

Name: _____

Class: _____

Goal:

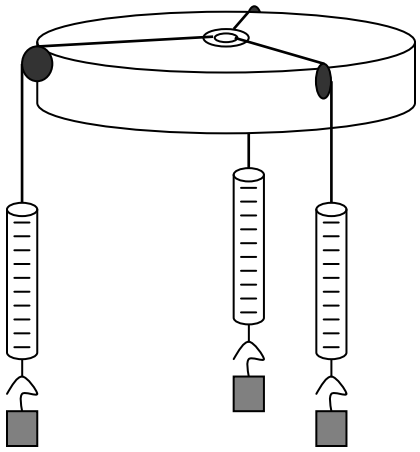
To analyze the arrangement of three forces in equilibrium.

Materials:

Round table or stool, Table Clamp Pulleys (3), Spring Scale Set, Hooked Masses, String, Washer.

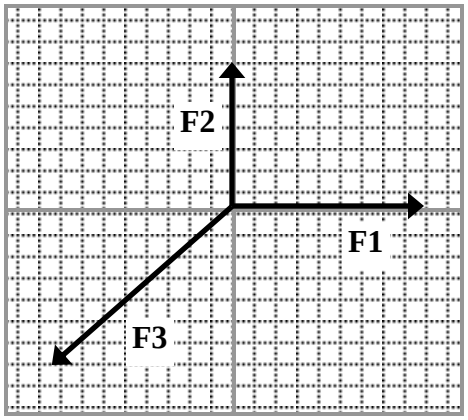
Procedure:

1. Tape a copy of the Force Table Guide to the top of the table, with the centers matching.
2. Fasten the three clamp pulleys around the edge of the table. Exact position is not important.
3. Tie three strings to the washer. Hold the washer steady in the center of the table as you hang each string over a pulley.
4. Attach a spring scale to each string. (You may use identical scales, or scales with similar but different ranges.) Hang a hooked mass on each scale. (Again, the masses can be the same or different.) Position the pulleys so that the washer is held exactly in the middle of the circle on the paper. Your table should look something like the figure.
5. Record the magnitude and direction of each force on the washer, for Trial 1.
6. Repeat for 2 more trials, changing the masses for each and moving the strings to create equilibrium.



	Trial 1		Trial 2		Trial 3	
	Magnitude (N)	**Direction (degrees)**	**Magnitude (N)**	**Direction (degrees)**	**Magnitude (N)**	**Direction (degrees)**
F1						
F2						
F3						

7. For each trial, on a separate sheet, construct a force diagram, as shown in the example. Be sure to draw lines proportional to the magnitude of the force.



	Example	
	Magnitude (N)	**Direction (degrees)**
F1	4.0	0
F2	3.0	90
F3	5.0	217

Questions

8. What is the net force on the washer in each trial? Explain how you know.

9. Use a different color (or dashed lines) on your force diagrams to find out if your trials demonstrate the net force you described in Question 7.

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Force Table Angle Guide