4

VECTOR ADDITION
ON THE FORCE TABLE

OBJECTIVE

To study vector addition and resolution using forces.

INTRODUCTION

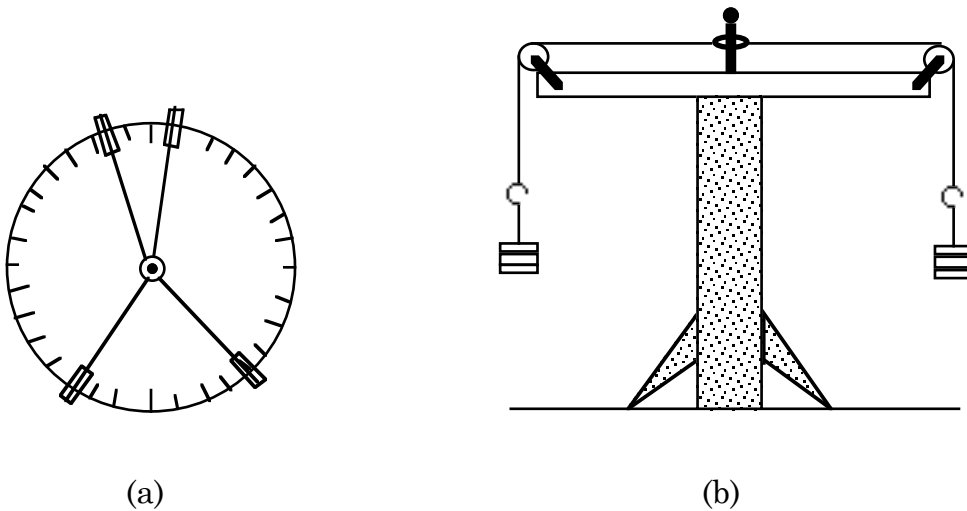(a)   (b)

Figure 1. (a) Top view and (b) side view of a force table.

Notice that the rim of the force table is ruled in degrees and that there are clamps with pulleys that can be set at various angles around the table. Masses can be hung on cords that pass over the pulleys and connect to a small ring in the center of the table. The gravitational force on the masses (their weight) is applied to the ring by the cords passing over the pulleys. The pulleys can be repositioned around the force table and the masses changed until the system is balanced (i.e., in equilibrium). Then the angle between pulleys can be read directly from the calibrated table edge.

A pin is supplied with the table to hold the ring near the center of the table while different weights and angles are tried for balance. When the forces are in balance, the ring will be centered around the pin; a small displacement will result in the

ring oscillating about but it will settle around the pin. In this state the pin can be removed and larger amplitude oscillations tried; the ring will come to rest over the position of the pin if the system is in equilibrium.

The forces acting on the ring have directions as well as magnitudes. Such quantities are called **vectors**. We represent a vector in a diagram by drawing an arrow that points in the direction of the vector and that has a length proportional the magnitude of the vector. For example, a force on the ring due to the weight of a 100-g mass suspended over the pulley aligned at the 0° mark could be represented by a 10-cm-long arrow drawn along the *x*-axis. On the same drawing, a force due to a 50-g mass suspended over a pulley at the 90° position would then be shown as a 5-cm-long arrow in the *y*-direction. Similarly, any other force would be drawn proportionately and in the proper direction. Drawings of this sort are known as *vector diagrams.*

ACTIVITY 1

1. Place two pulleys opposite each other and place the ring above the pin in the center of the table.

2. Load the two weight holders with unequal masses, such as 100 grams on one and 150 grams on the other. *Don't forget that the weight holder also has mass.* Remove the pin. **What do you observe?**

3. Increase the 100-gram mass to equal the companion mass of 150 grams. **How does this change your observations from step number 2?**

ACTIVITY 2

4. Replace the pin in the center of the table. Suspend two equal masses; position one at 0 degrees and the other at 90 degrees. Choose the appropriate mass so that for each the sum of the hanger and the added mass is 100 g. Add a third pulley to the table and pass a string and weight hanger over this pulley.

5. Find the third weight (*angle* and *size*) that will balance the two 100-g masses. When you think you have a balance, test it by removing the pin. Then lift the ring slightly and let go. It will oscillate and allow the weights to move. If you have achieved equilibrium, the ring should return to its position centered over the pin location. **Record the masses (including hangers) and position values.**

6. Before changing the configuration, use a protractor and ruler to **make a scale drawing of the force vector diagram representing the equilibrium. Also indicate the resultant vector from the combination of the two 100-g masses.** (*Hint*: When making your drawing, position the origin of your coordinate system near the center of your sheet of paper. Then represent each of the force vectors as an arrow with the tail, or origin, of the arrow at the zero of the coordinate system.)

ACTIVITY 3

7. Place 75 and 100 gram masses 90 degrees apart (these masses include the hangers). **Record the positions on the force table.** Find the third mass that will balance these two. **Record the mass needed and the angular position.**

8. **Make a scale drawing for the situation above**. Also **show the resultant vector formed by the two forces at 90 degrees.**

ACTIVITY 4

9. Pick two different masses and arrange them at an angle between 90 and 180 degrees (example: one mass set at 0 degrees and the other set at 100 degrees). **Record the masses used and their positions on the force table. What is the angle between the two masses?**

10. **Make a scale drawing for the previous arrangement**. **Find the resultant vector and use it predict the mass and angle for a third mass to just balance the other two.** Attach the third mass to the force table and verify that it brings the system into equilibrium.

SUMMARY

Discuss the following concepts that you have encountered in this lab: **equilibrium, resultant vectors in vector addition, and the resolution of a vector into its components**.

Hand in data sheets.   Name _____

VECTOR ADDITION
DATA SHEETS

ACTIVITY 1

What do you observe for equal masses?

How do your observations change with equal masses?

ACTIVITY 2

Record the masses (including hangers) and position values.

Mass label	Mass (grams)	Position (degrees)
Mass one		
Mass two		
Mass three		

Make a scale drawing of the force vector diagram representing the equilibrium. Use graph paper from your *Science Notebook*. Label the drawing. Also indicate the resultant vector from the combination of the two 100-g masses.

ACTIVITY 3

Record the masses (including hangers) and position values.

Mass label	Mass (grams)	Position (degrees)
Mass one		
Mass two		
Mass three		

Make a scale drawing on graph paper of the force vector diagram representing the equilibrium. Label the drawing. Also indicate the resultant vector from the combination of the two 100-g masses.

ACTIVITY 4

Record the masses used and their positions on the force table.

Mass label	Mass (grams)	Position (degrees)
Mass one		
Mass two		
Mass three		

What is the angle between the two masses?

Make a scale drawing on graph paper of the forces associated with the masses. Find the resultant vector of the first two masses and predict the mass and angle for a third mass to just balance the other two.

How well does the predicted mass equal the experimental mass needed for balance?

SUMMARY

Discuss the following concepts that you have encountered in this lab: **equilibrium, resultant vectors in vector addition, and the resolution of a vector into its components**.