3

Vector Addition
Put Force On the Table

Purpose

To find the sum of two or more vectors graphically and analytically.

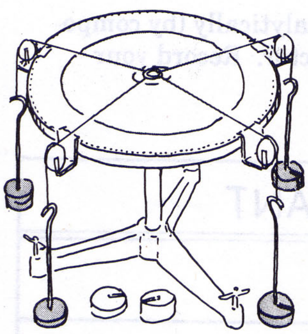
Required Equipment and Supplies

force table apparatus, including 4 pulleys, strong string, center ring and pin
variety of slotted weights
4 weight hangers
bubble level
Vector Laboratory from SciMaTech (optional)

Discussion

Hit a ball with a bat and the ball exerts the same amount of force against the bat as the bat exerts against the ball. Push against a wall and it exerts the same amount of force against you. When the earth pulls down on a body, the body simultaneously pulls up on the earth. If a body is securely suspended by a string, the downward pull of the earth does not move the body, because the string pulls upward on the body with just as much force. The upward force supplied by the string is equal in magnitude to the weight of the body. Even if the string is over an ideal pulley, the string tension is the same—as much as the weight of the suspended body.

For purposes of this lab, let's define a new unit of force called the Bonker (B). The Bonker is not a S.I. unit, but it will be useful here. The Bonker will be defined as the force that the earth exerts on a 1 gram mass. In other words, a 75 gram mass weighs 75 Bonkers.



If two people each pull on a strong rope in a tug-of-war with a force of 100,000 B, what would be the tension in the rope? Or what force and direction would be necessary to balance a 200 B weight hung from a pulley on a force table?

For any system in *equilibrium*, meaning any system that is not undergoing a change in motion (not accelerating), all the forces that act on it balance to zero. In this lab you will begin with a system not in equilibrium, predict the magnitude and direction of a force to place it in equilibrium, and check your prediction by experiment.

Pre-Lab

Practice adding two vectors graphically and then find the resultant analytically. If available, confirm your results using a Vector Laboratory. For example, what is the resultant if a vector 25 cm long at 0° is added to a second vector 25 cm at 90°? What is the resultant if the second vector is at 135°? 180°? 270°?

Now find the resultant of two unequal vectors. What is the resultant if the first vector is 25 cm long at 0° and the second is 35 cm long at 90°? What is the resultant if the second vector is at an angle of 135°? 180°? 270°?

Table 3.1

	A		B		C	
COMBINATION	FORCE (B)	ANGLE (°)	FORCE (B)	ANGLE (°)	FORCE (B)	ANGLE (°)
#1	150	0	110	70		
#2	200	0	100	90	150	135
#3	200	0	100	40	250	100

Procedure

Step 1. Using a bubble-type indicator, level the force table by adjusting the leveling screws on its feet. Table 3.1 has three different combinations of weights and angles. Position pulleys at the angles specified for each of the weights in the first combination. Check to see that the string does not bind on the pulleys. Arrange the strings so that they radiate from a common point in the center of the ring. Determine both the angle and the weight required to keep the center ring—called the *equilibrant*—in equilibrium. It is convenient to use the center pin to prevent the weights from falling while trying to adjust the equilibrant. Estimate the uncertainties by seeing how much you can vary the weight or the angle before the system is noticeably out of equilibrium. Record your results in Data Table 3.2.

Step 2. For each of the combinations of vectors, graphically add the vectors to determine the resultant vector. The equilibrant has the same magnitude as the resultant but is *oppositely directed.* If a Vector Laboratory is available, add the vectors on it first to confirm your analytical results. Record your results in Data Table 3.2.

Step 3. For each of the combinations of vectors, analytically (by components) add the vectors to determine the resultant vector. Record your results in Data Table 3.2.

Data Table 3.2

METHOD	EQUILIBRANT
FORCE TABLE	
GRAPHICAL	
ANALYTICAL	

Analysis

1. Why is it important to *do* the experiment in Step 1 before doing the calculations in Steps 2 and 3?

2. Why is it important to level the force table?

3. How do your calculations in Steps 2 and 3 compare to your experimental results in Step 1? Which method do you prefer?