LAB 5. FORCES IN EQUILIBRIUM

Supplies

Force table, mass hangers, disk masses, mystery mass, mass specification card

Introduction

The apparatus that you will be using is called the "Force Table". It is a circular platform ruled in degrees like a protractor. Three pulleys are clamped to the rim of the table; each can be set at any angle. Different masses hang from strings passing over the pulleys. The pulleys merely change the direction of the force exerted by the strings, from downward to outward over the surface of the table. These strings are tied to, and pull on, a central ring around a post. If the forces from the three strings balance (add to the zero vector), the ring will remain at rest in the center of the table, and in fact will return to the center if displaced. When the forces do not balance, the post in the center of the table holds the strings in place. When you believe that the tensions balance, lower the post by turning it clockwise to see if the ring remains centered.

Use the force table correctly. Be certain that all the strings point toward the center point of the table so the tensions on the ring are radially outward. You may have to adjust the attachment positions of the strings on the ring and you may have to adjust the pulley positions.

Lab activities

In some of these activities, all groups will use the same hanging masses. In others, each group will use its own individual masses. Your instructor will give you a card listing the masses for your group to use in the individual activities.

Activity 1. Three equal masses

Do hanging masses of equal weight always balance each other out?

1. Place equal masses (about 50 grams) on each hanger.
2. Experimentally determine whether or not hangers of equal mass balance each other regardless of their position. State your observations here.

Activity 2. Components

In this activity, you will show that a force is equivalent to the sum of its **components** in the directions of the principal axes. To do this, you will show that two axial tensions cancel the same tension cancelled by the force of interest.

1. Set up the force table so that the mass specified on the card is hanging from the table at the specified angle.
2. Use trigonometry to calculate the *x*- and *y*-components of this force vector. For simplicity, use units of gram-weights, so that you do not need to convert to and from newtons.

   Components: F_x: ___________________ F_y: ___________________

3. To balance a tension on the ring you need to apply a second tension in the opposite direction: $-\vec{F}$. To confirm this, attach an equal mass to another thread on the ring. Position its pulley so that the two tensions are in opposite directions. Is the ring in balance? Check and correct the setup if not.
4. The components of tension $\vec{F}$ acting together should be equivalent to force $\vec{F}$. To check this, remove the original tension and replace it with its two components F_x and F_y by hanging the appropriate masses along the x-axis (0°–180°) and y-axis (90°–270°).
5. If the tensions do not balance, find and correct your mistake. Show the balancing masses to your instructor for credit.

Activity 3. Equilibrant

In this activity, you will find a single tension, the **equilibrant**, that balances two other tensions.

1. Read the angles and masses for two of your hanging weights from the card.
2. Position two of the pulleys as directed and hang the directed masses from their threads. (Include the mass of the platform in the indicated masses.)
3. The vector sum of the two specified tensions is the **resultant** of the two vectors. The equilibrant vector is the negative of the resultant. Determine the equilibrant any way you like: graphically, by calculation, or by trial and error. Write it here.

   Equilibrant: Mass: ________________ Angle: ________________
4. Once you have determined the correct equilibrant, summon your instructor to witness that the two given vectors are correct and the equilibrant actually equilibrates. (If they aren't or if it doesn't, you get one more try.)

Activity 4: Mystery mass

In this activity, you will be given an unknown mass (the "mystery mass"), and directed which two other masses to use to equilibrate it. When you find the angles of the other two masses that equilibrate the mystery mass, you will use that information to deduce the mass of the mystery mass.

1. Receive the mystery mass from your instructor. Hang it on the force table at 0°.
2. Construct the other two hanging masses as specified on your card. Hang them from the other two threads on the ring.
3. Adjust the angles of the other hanging masses until the tensions equilibrate.
4. Complete the table below. Determine the mass of the mystery mass from the components, not from direct measurement.

Mass	m	θ	x	y
T_1				
T_2				
Mystery		0°		0 g

5. For credit, show your table and equilibrating masses to the instructor.