EXPERIMENT 2

VECTORS ON A FORCE TABLE

PURPOSES:

1. To examine Newton's First Law.
2. Investigation of the concept of equilibrium.
3. Examination of Force-Angle Relationship.

THEORETICAL BACKGROUND

Force is an effect that causes an overall body movement, i.e. moving from a standing body, a body that stops moving, changing the direction and orientation.

Newton's 1st Law: An object at rest remains at rest, or if in motion, remains in motion at a constant velocity unless acted on by a net external force.

$$\vec{F} = m\vec{a} \qquad (1)$$

In this formula, "F" is the force,"m" is the mass, and "a" is the acceleration. As it can be seen from the formula, force is a vector. Therefore, it has a direction and magnitude.

If the net force acting on an object is zero, object will not move towards any direction. Then we can say that the object is at balance.

$$\sum_i \vec{F_i} = 0 \qquad (2)$$

$$\vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots = 0 \qquad (3)$$

The important thing here is; force is a vectorial quantity and its direction is very important. The addition of forces in opposite directions to one another actually means subtraction of the forces.

If we examine the concept of balance in one dimension;

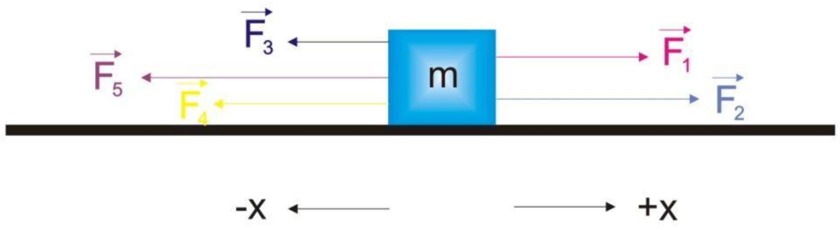

Figure 1. Forces acting on the body in 1D.

In Figure 1, we can see the forces acting on the mass, m on +x and -x direction. If the object is not moving; this means that the net force is zero.

$$\sum_i \vec{F_i} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4 + \vec{F}_5 = 0 \qquad (4)$$

If we take -x direction as negative, +x direction as positive;

$$F_1 + F_2 - (F_3 + F_4 + F_5) = 0 \qquad (5)$$

If we examine the concept of balance in 2D;

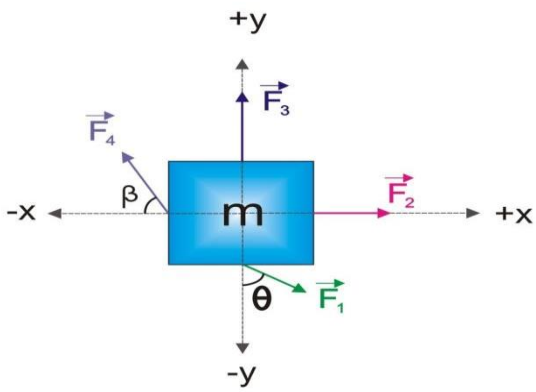

Figure 2. Forces acting on the body in 2(two) dimension

As it can be seen from Figure 2, forces on two dimensions can affect the mass too. If the object is not moving (at balance), the net force on the mass is zero. In other words, the net forces acting on the mass in both x and y direction is zero. In this case, it is necessary to examine the two axes separately;

x-axis:

$$\overrightarrow{F_2} + \overrightarrow{F_4}cos\beta + \overrightarrow{F_1}sin\theta = 0$$

$$F_2 + F_1 sin\theta - F_4 cos\beta = 0$$

y-axis:

$$\overrightarrow{F_3} + \overrightarrow{F_4}sin\beta + \overrightarrow{F_1}cos\theta = 0$$

$$F_3 + F_4 sin\beta - F_1 cos\theta = 0$$

In graphics, In order to see the angles and the forces better, we can take the mass as a point.

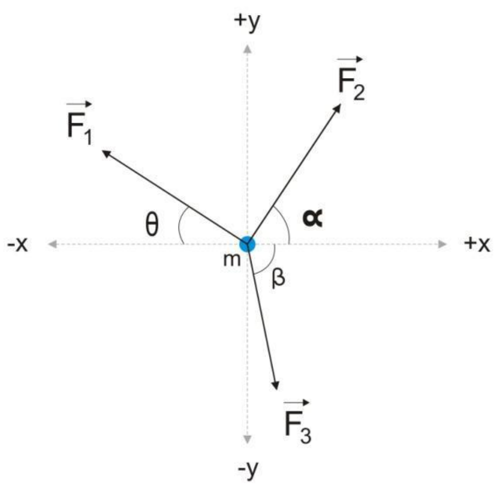

Figure 3. The forces acting on an object x-y plan**e**

If the object in Figure 3 is in equilibrium (balance) under the influence of three forces,

$$F_2 sin\alpha + F_1 sin\theta = F_3 sin\beta$$

it can be expressed as;

$$F_2 cos\alpha + F_3 cos\beta = F_1 cos\theta$$

There is also an easier way to find the forces acting on a body in equilibrium and it is known as the law of sines.

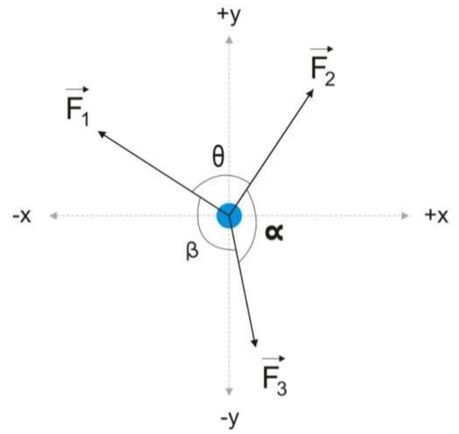

Figure 4. Finding the relationship between forces by law of sines.
at equilibrium

Sinus theorem can be used to determine the relationship between forces. This relationship;

$$\frac{F_1}{sin\alpha} = \frac{F_2}{sin\beta} = \frac{F_3}{sin\theta} \tag{6}$$

can be expressed as (6).

In our experimental setup, the balance of the forces is also provided as in Figure 3. In the setup, the cylindrical bar at the center of the table is concentric with the ring to which the threads are attached at the appropriate angle and force. This shows us that the forces are in balance. If the ring to which the threads are attached is in contact with the cylindrical bar in the center of the table, the force in the direction of contact is large.

TOOLS:

- ➢ Angled Table
- ➢ Three height adjustable legs
- ➢ masses Sets
- ➢ Connection Rods
- ➢ Frictionless Pulleys

THINGS TO BE CONSIDERED ON THIS EXPERIMENT

- ➢ With the aid of the water balance, make sure the table is flat.
- ➢ The ring in the center should not touch the surface of the table. For this reason, select the masses that are hanging heavy.
- ➢ Make sure that the studs are connected to the ring in such a way as to be 90º (check the angle between the rope and the ring as the positions of the pulleys are changed)

EXPERIMENTAL PROCEDURE:

Part I
Between Pulleys 120º Balance Condition

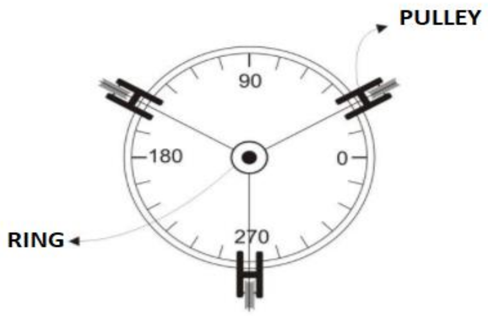

Figure 5. Mounting of the pulleys and the ropes on the table

1. Place the pulleys as shown in Fig.
2. Put the pulleys so that they are 120º apart.
3. Attach masses of the same size to the masses carriers.
4. Observe whether the system is in balance.
5. Calculate the equilibrium state by determining the components of the forces by using Equation 6.

PART II
Equilibrium State at Constant Angle Value

1. Place the pulleys on desired angles on the table. (α,θ β)
2. Connect one end of the ropes to the ring, which will be on the table, and the other end to the masses carrier.
3. Put the threads through the pulleys and set the system as shown in Figure 5.
4. Add masses to the carriers and keep the ring's balance.
5. Write down the angle values and masses attached to the carriage in Table 1.
6. Specify the x- and y- components of each force that is drawn.
7. Prove this equilibrium mathematically in both axes.

PART III
Equilibrium State at Constant Force Values with Additional Masses

1. Put the desired masses on the masses carriers.
2. Keep the position of a pulley stationary and change the positions of the other two pulleys so that the ring is centered with the rod on the table center.
3. Write down the masses and pulley positions attached to the carriage at equilibrium in Table 2.
4. Draw the forces acting on the ring on a piece of paper as shown in Figure 3.
5. Write down the components.
6. Prove the equilibrium position of the system using the components and by using the Equation 6.