Lab 3:
The Sum of Vectors

Goals

1. To become aware that at equilibrium, the sum of balanced forces is zero

2. To graphically find the sum of vectors

3. To find the vertical and horizontal components of vectors

4. To calculate the sum of vectors using the vertical and horizontal components

5. To gain a better understanding of mechanical equilibrium

Materials and Equipment

Two 250 g spring scales
String
Slotted mass set

Material Not Included

Graph paper
Protractor
Masking tape
Card Table or small table

Introduction

Scalar quantities are completely specified with only a number and a unit. I.e., scalars have magnitude but not direction. Examples are mass, volume, and area. Adding scalar quantities, assuming they are compatible, is simple. For example, two liters plus five liters gives seven liters.

A **vector** is a quantity that has both magnitude and direction. Examples are displacement, force, velocity, and magnetic fields. Since vectors have magnitude and direction, adding vectors is usually more complex than adding scalars. The sum of two vectors is the **resultant**.

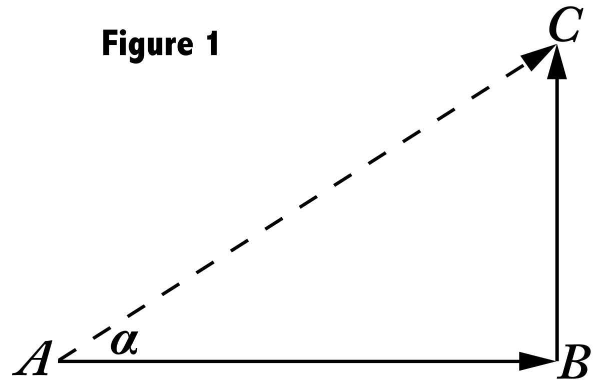


Figure 1

Displacement is the change in position. This is a vector since it has both magnitude and direction. If you walk three blocks east and then two blocks north, your displacement will be from your starting point to your ending point. The walk east and the walk north are two displacements that form the legs of a right angle triangle and the resultant is the hypotenuse. (You may need to go through some houses if you walk the resultant.) See Figure 1. Using trigonometry, angle α is:

(1) $\text{angle } \alpha = \text{tangent}^{-1}\ \frac{2}{3} = 33.7°$

The magnitude of the displacement can be found using trigonometry.

(2) $\sin \alpha = \frac{BC}{AC}$

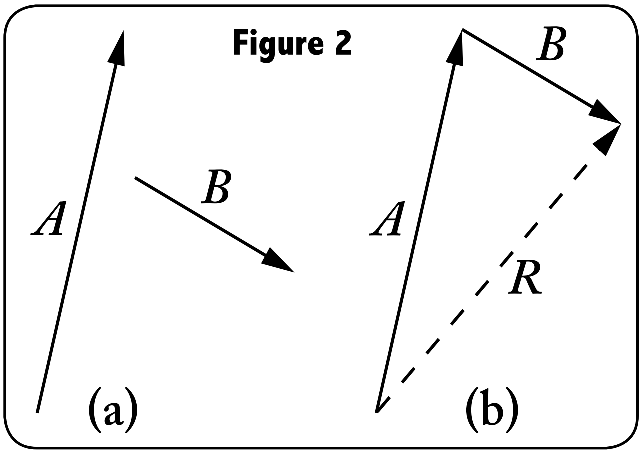
Rearranging this

(3) $AC = \frac{BC}{\sin \alpha} = \frac{2}{\sin 33.7°} = 3.6 \text{ blocks}$

A vector can be moved if the direction and magnitude are not changed. In

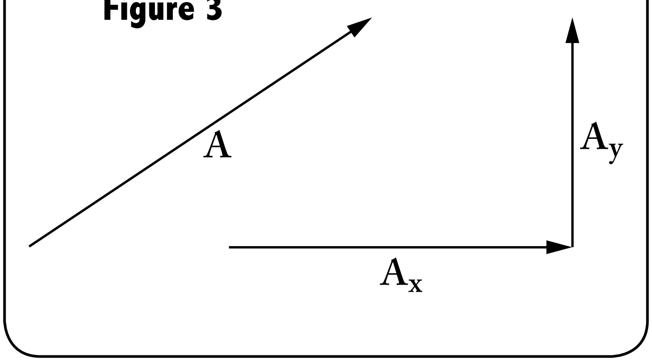
Figure 2(a) below, there are two vectors with different magnitudes and different directions. If they are moved so that the head of vector A is at the tail of vector B, the resultant, R, is from the tail of vector A to the head of vector B. See Figure 2(b). This method will be used to add vectors graphically. The addition process can also be reversed to find the vertical and horizontal components of vectors.

Figure 2



The addition process can also be reversed to find the vertical and horizontal components of vectors. See Figure 3. Vector A is equal to the sum of vectors A_X and A_Y. Therefore, vector A can be converted to horizontal component A_X and vertical component A_Y.

Figure 3



Note: Your spring scales correctly measure force in newtons, but also show the equivalent mass in grams.

Devotional

"Is any one of you in trouble? He should pray. Is anyone happy? Let him sing songs of praise. Is any one of you sick? He should call the elders of the church to pray over him and anoint him with oil in the name of the Lord. And the prayer offered in faith will make the sick person well; the Lord will raise him up. If he has sinned, he will be forgiven." James 5:13-16

"Come to me, all you who are wary and burdened, and I will give you rest. Take my yoke upon you and learn from me, for I am gentle and humble in heart, and you will find rest for your souls. For my yoke is easy and my burden is light." Matthew 11:28-30

Principle: Peace is not absence from pressure, it is pressure in balance.

The vector sum of the forces = (mass) x (acceleration)

Objects are accelerating when the sum of all forces is not zero. Objects are at rest when the sum of all forces is zero. Notice, this does not say that objects at rest experience no force. No, objects at rest do experience forces. In fact, engineering students will take a whole class called statics which analyzes the forces on an object at rest.

When we are at rest and doing well, it is not because we have no difficulties or conflicts. We will always have difficulties and conflicts in this life. When we are rest and doing well, it is because we have learned to balance and process the difficulties. We are confessing our sin and finding cleansing form God. We are gaining strength by proper rest for our body and soul. We are taking time with God, our refuge in storms. If out lives get out of balance, we must seek God and apply force against these unbalanced forces. This is how to be at rest. The reason Jesus "burden" is light is because the forces are in balance. While the tasks may be great, the burdens are largely carried by God himself.

Procedure

1. Use the slotted mass set to calibrate the two spring scales.

2. If using a card table, open up the

table legs. Place the table on end so that the legs are horizontal and the top is vertical.

Note: As an option, you could use suction cups on a smooth surface to support the scales. Position the suction cups about 1 m apart, attach the spring scales, then continue with Procedure 4.

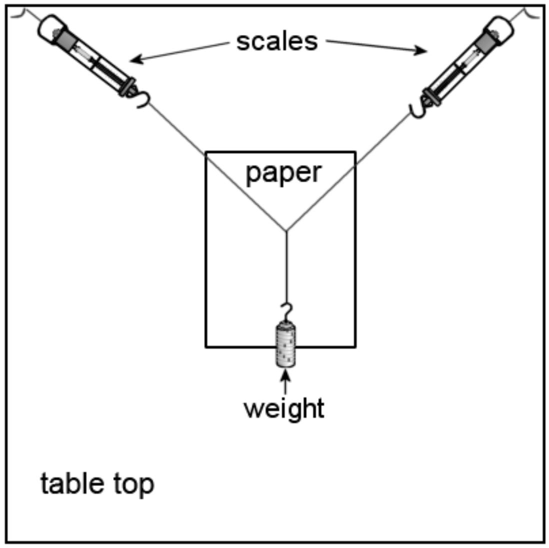
3. Fasten the scales to the right and left legs of the table with string. See Figure 4.

4. Tie a string between the scales so that the angle between them is about 100 to 130 degrees.

5. Tie a short string to the first string, but slightly off center.

6. Weigh the mass holder with all the masses (250 g total mass) in newtons and record this weight (force). Fasten the mass holder with all the masses to the string.

Figure 4



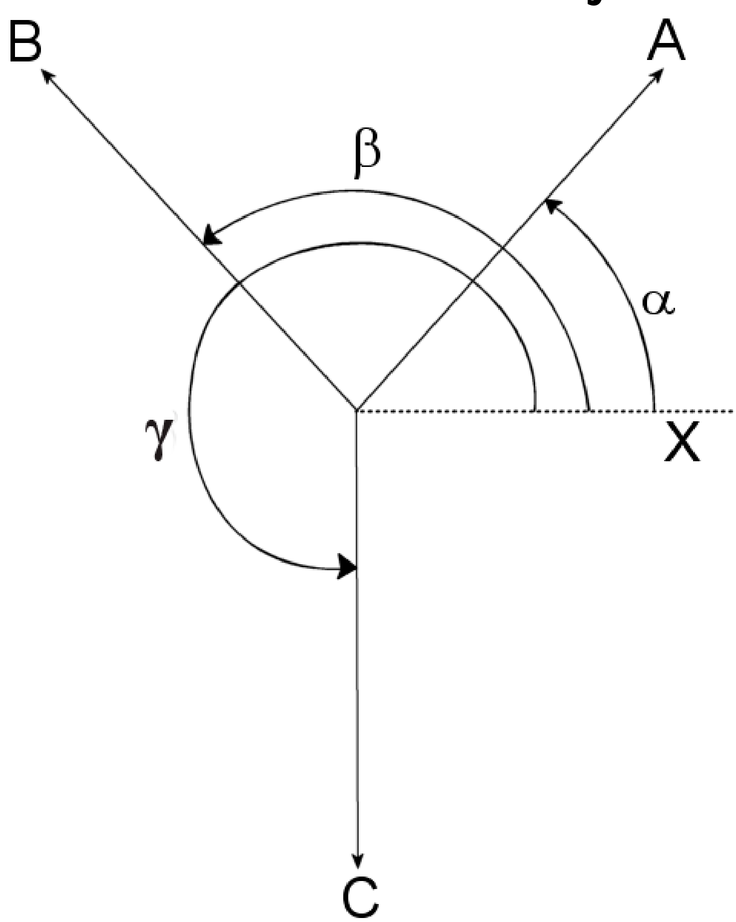
7. Tape a sheet of graph paper to the table under the strings so that the lower string is parallel to the graph lines.

8. Label the vector that points up and to the right A, the vector that points up and to the left B, and the vector that points down C. See Figure 5.

9. Mark the graph paper under the strings to indicate their directions. Be careful not to move the strings. Read the scales (in newtons). Record the forces in Table 1. ***Note: The weight of 1 g = 0.00981 N.***

10. Remove the graph paper from the table top. This will have some data that you will need.

Figure 5



Lab 3

Questions for the Sum of Vectors

Table 1

Vector	Magnitude, N	Direction, degrees	Horizontal component, N	Vertical component, N
A				
B				
C				
Sums	XXXX	XXXX		

1. The weight of the 250 g mass ______________ N.

2. Use the protractor to measure the angles between vectors A, B, and C and the x axis (horizontal axis). (See Figure 5.) Record these.

3. From the angles and the magnitudes of the angles, calculate the horizontal and vertical components of the three vectors. Record these data in the table. Consider up and right to be positive and left and down negative.

4. Add the horizontal and vertical components and record these sums in the table.

5. With perfect measurements, the sum of the vertical components in the table would be zero. What is the percent difference between the vertical components vectors of A and B and the weight of the 250 g mass?

6. Draw the sum of the vectors to scale on a piece of graph paper. Does the sum come to a point (i.e. is the sum zero)?