

Unit IV - Force Table Lab

Name(s)

Period:

Purpose:

To determine whether forces combine like *scalars* or like *vectors*. The *sum* or *resultant* of two forces acting at the same point on a body is that single force whose effect on the body is the same as the combined effects of the two forces. To solve the above problem, you are going to compare the resultant of two forces obtained by actual measurement with that obtained by treating the forces like vectors and combining them graphically.

Apparatus:

- One force table
- Three spring balances
- One ruler
- One protractor
- Pencil
- Blank paper



Background:

A scalar quantity, such as 3 kilometers, has only size or *magnitude*. On the other hand, vectors are quantities, such as 3 kilometers due North, that have both magnitude and direction. Vectors are typically drawn as arrows. The scaled length of the arrow represents the magnitude of the vector and the direction in which the arrow points represents the vector's direction.

To find the resultant of two forces acting at the same point, a third force is applied at the same point in such a direction and of such magnitude, so as to counterbalance the effects of the two original forces. Since this third force produces equilibrium, it is called the *equilibrant*.

We will use the force table to place three forces **a**, **b**, and **c** in equilibrium. The magnitude of each of the forces can be read on the spring scales and their directions measured with a protractor.

Hypothesis:

If forces combine or add like scalars than the sum of the forces would be independent of direction (i.e. $100\text{ g} + 200\text{ g} + 300\text{ g} = 600\text{ g}$). If forces combine or add like vectors, direction must also be taken into account.

The sum of two forces, **a** and **b**, is called the resultant. How do you think the magnitude and direction of the resultant will compare to the third force, **c**? (Remember that the ring these three forces are acting on is stationary.)

Do you think forces add like scalars or vector? Why?

Procedure:

1. To begin, place the ring that holds the scales together near the board's center. Evenly distribute the chains around the perimeter (edge) of the table (you don't want them all grouped on one side of the table). Make sure that none of the chains are crossed. Zero the spring scales when no force is applied by adjusting the face plate until the reading is zero.
2. Balance the force board by repositioning the chains in the slots around the perimeter. Increase or decrease the tension on the spring scales by pulling the chains tighter or releasing them by moving one link of chain at a time. For better results, adjust the balances so that they read 400 or more grams*. The final position of the ring does not need to be at the center of the force table.
3. Place a sheet of paper beneath the ring. Identify each of the spring balances as **a**, **b**, and **c** (your choice). Mark the center of the ring with a pencil and mark with a dot and the appropriate letter a, b, or c, the direction of each of the forces **a**, **b**, and **c**. Record the reading of each spring balance in Table I below as Trial 1.
4. Have each person in your group complete one trial. Reposition the chains so that each person has different data.

**NOTE – Forces are measured in Newtons, not grams, but for this lab we won't worry about that.*

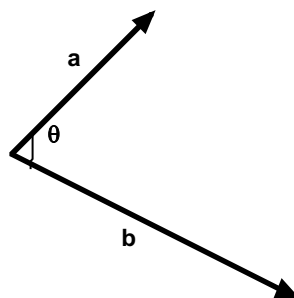
Data : (turn in one for the whole group)

TABLE 1

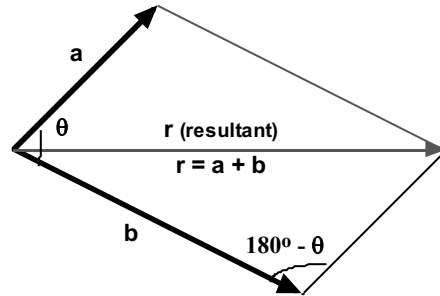
Trial	Force a (g)	Force b (g)	Force c (g) equilibrant	angle between a and b
1				
2				
3				
4				

Data Analysis: (each person in the group should complete this for his/her trial)

5. Pick a convenient scale (say 2 centimeters = 100 g) and, with a ruler, construct arrows of scaled lengths to represent vectors **a** and **b**. Put an arrowhead at the end of each vector to indicate a direction pointing away from the center ring dot. Label each vector with magnitude in grams. Measure the angle, θ , between **a** and **b** and record it in Table I.



6. To find the resultant of **a** and **b** graphically, use a protractor and ruler to construct a parallelogram with sides **a** and **b**. Make sure the other angle in the parallelogram is $180^\circ - \theta$ by measuring with a protractor. With a ruler, draw the resultant vector **r**, an arrow in the direction of the diagonal beginning at the point where **a** and **b** meet. With a ruler measure the length of the resultant. Use the scale that you set, determine its magnitude. Label the resultant **r** with its magnitude and also record it in Table II below. You have just added **a** and **b** according to the rules of vector addition.



7. Use a ruler to construct a scaled arrow to represent vector **c**. Put an arrowhead at of the vector to indicate a direction pointing away from the center ring dot. Label the vector with magnitude in grams. Measure the angle between **c** and **r**. Record the magnitude and angle in Table II.

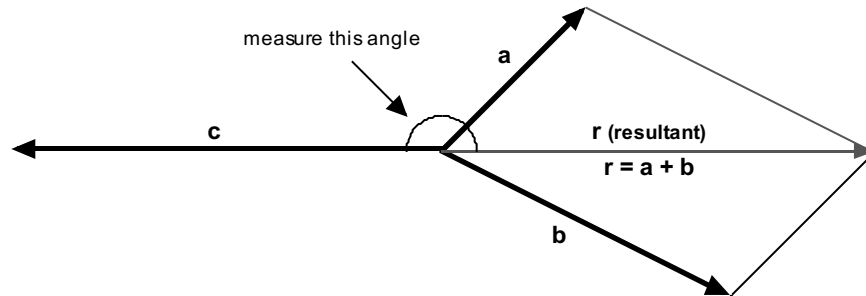


Table II	Trial 1	Trial 2	Trial 3	Trial 4
Force r (g) (predicted magnitude of resultant)				
Force c (g) (<u>measured magnitude of equilibrant</u>)				
angle (between force c and force r)				

Conclusion: (each person in the group must turn one in)

1. Compare the magnitude and direction of the resultant \mathbf{r} with the magnitude and direction of the equilibrant force \mathbf{c} .
2. From your data and data analysis, what would be the resultant of \mathbf{r} and \mathbf{c} ? Explain. Remember that the resultant \mathbf{r} equals $\mathbf{a} + \mathbf{b}$, so $\mathbf{r} + \mathbf{c}$ would equal $\mathbf{a} + \mathbf{b} + \mathbf{c}$.
3. Was your hypothesis correct? Do forces combine like vectors or scalars? Use the results of your experiment to determine your answer.
4. What are the sources of experimental error in this lab and how does this affect your results?
5. Under what circumstances will the three forces \mathbf{a} , \mathbf{b} , and \mathbf{c} be equal in magnitude? Explain.
6. Do you think that vector addition is commutative? In other words, is the resultant of $\mathbf{a} + \mathbf{b}$ the same vector as the resultant of $\mathbf{b} + \mathbf{a}$? Explain.

Staple together pages 1-4 (one copy for the whole group), the diagrams each person drew for their data analysis, and one conclusion for EACH group member and pass in. You do not need to write a formal lab report.