

LAB PARTNERS _____

NAME _____
 DATE _____ PERIOD _____

TITLE: Concurrent Forces in Equilibrium

PURPOSE/ABSTRACT: Three concurrent forces will be applied to produce a condition of static equilibrium. The parallelogram method of composition of forces will be used to find the resultant of two of the forces. This resultant force will then be compared with the third force, which is the equilibrant.

PROCEDURE: see separate sheet

DATA:

Scale: _____ cm = _____ N

	g	N	cm
FORCE 1			*
FORCE 2			#
HANGING WEIGHT (EQUILIBRANT)			•
RESULTANT	////////// //	@	

	g	N	cm	%
ERROR OF MAGNITUDE	////////// ////////// ////////// ////////// ////		////////// ////////// ////////// ////////// ////	

	g	N	deg	%
ERROR OF DIRECTION	////////// ////////// ////////// ////////// ////		////////// ////////// ////////// ////////// ////	

ANALYSIS: see separate sheet

CALCULATIONS:

Each of the calculations below is related to the item in the data table designated by a similar marker, i.e., *, #, •, or @. See steps 4 and 8 in Analysis section for instructions on calculations, and show a simple unit analysis calculation in each of the spaces provided.

* # •

@

PROCEDURE:

1. Arrange two identical spring balances and a hanging mass as shown in FIGURE (1). Details for hanging the spring balances and the mass will be discussed in class. Hang the weight so that it is noticeably "off center;" approximately 2/3 to 3/4 of the way between the balances, either left or right. If your spring balances are 250 gram capacity, use a 200 gram mass; if your spring balances are 2000 gram capacity, use a 500 gram mass.

2. Place an unruled sheet of paper (long side vertical) so that its center is directly under the junction where the strings meet, and use masking tape to fasten the paper to the masonite backing board (smooth side).

3. Gently press the string junction STRAIGHT BACK against the paper on the masonite backing board. DO NOT PUSH UP, DOWN OR SIDEWAYS, and BE SURE THE SPRING BALANCE READINGS DO NOT CHANGE AS YOU PRESS. With a pencil, carefully mark the location of the string junction on the paper. Also, carefully mark the three positions the edge of the paper where the strings leave the paper. Now gently release the push on the string junction in such a way that the SPRING BALANCE READINGS DO NOT CHANGE.

4. Record the readings of the two spring balances in grams as precisely as possible in the table provided. If the balance does not read zero when no load is applied, be sure to correct for this by adding or subtracting the appropriate value. Also record the value of the hanging mass in grams. Spring balance 1 will be the balance on your left, and spring balance 2 will be the balance on your right.

5. Remove the paper and either

- (a) slide the string from which the weight is hanging to a noticeably different location, and/or
- (b) change the location of the hanging point for one of the spring balances.

Then put a new paper in place and repeat steps 3 and 4. Continue this until each person in the lab group has his/her own unique data.

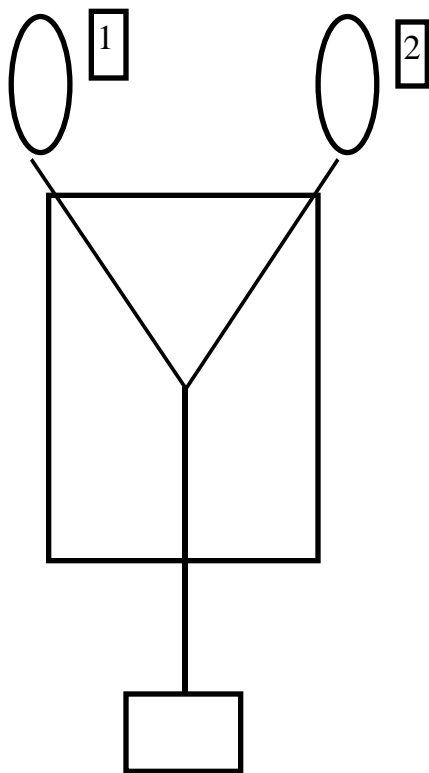


Figure 1

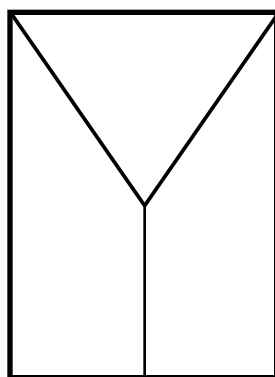


Figure 2

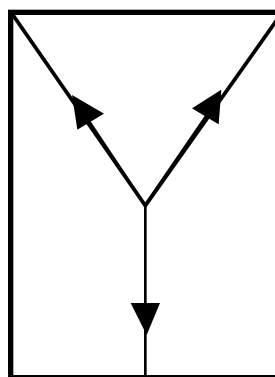


Figure 3

ANALYSIS:

1. Draw light lines from the center mark to each of the three marks at the edge of the paper. The lines thus draw indicate the DIRECTIONS of action of the three concurrent forces, but the lengths of the lines as yet provide NO INFORMATION about the MAGNITUDES of the forces. See FIGURE (2).
2. The spring balances and the hanging mass are calibrated in grams. Grams are a unit of mass, but not a unit of force. We shall have much more to say later about the critical difference between mass and force, but for now let it just be said that at the earth's surface a 1 kilogram mass experiences a gravitational force of about 10 newton which is called its weight. FOR EASE OF CALCULATION IN THIS LAB (AND IN MOST CASES FOR THE REST OF THIS COURSE) WE WILL ASSUME THAT 1 kg WEIGHS 10 N. THUS 100 g WOULD WEIGH 1 N. Using this conversion factor, convert mass in grams to force in newtons, TO THE NEAREST 0.1 N, and record in the table provided.
3. A suitable scale must be chosen for your vector drawing. If you are using a 5 N hanging weight, use a scale of $1 \text{ cm} = 0.5 \text{ N}$; for a 2 N hanging weight, use $1 \text{ cm} = 0.2 \text{ N}$. Record scale in space provided in Data section.
4. Using the scale chosen, and the force values in newtons from the table, show a unit analysis calculation to determine the length of each force vector in centimeters, TO THE NEAREST 0.1 cm. Show the unit analysis calculations in the appropriate spaces provided in the Calculation section, and record the lengths in the table provided. See comment at beginning of Calculation section.
5. Mark off the force magnitudes along the three lines (TO NEAREST 0.1 cm). Place an ARROWHEAD at the end each of the three vectors so that the TIP of the arrowhead precisely marks the end of the vector. **ON THE VECTOR DRAWING, CLEARLY LABEL EACH OF THE THREE VECTORS WITH ITS VALUE IN CENTIMETERS (TO NEAREST 0.1 cm), AND ITS VALUE IN NEWTONS (TO NEAREST 0.1 N).**
6. USE A PROTRACTOR to construct a force parallelogram for forces 1 and 2 as shown in FIGURE (3).
7. Draw the diagonal from the point of application of the forces to the opposite vertex of the parallelogram. This is the RESULTANT of forces 1 and 2. Place an ARROWHEAD at the end of this vector.
8. Measure the length of the resultant in cm (TO THE NEAREST 0.1 cm) and record in the table provided. Using your scale value and the value of the length in cm, show a unit analysis calculation to determine the magnitude of the resultant in newtons (TO NEAREST 0.1 N). Record in the table provided. **ON THE VECTOR DRAWING, CLEARLY LABEL THE RESULTANT WITH ITS VALUE IN CENTIMETERS (TO NEAREST 0.1 cm) AND ITS VALUE IN NEWTONS (TO NEAREST 0.1 N).**
9. Theoretically, the EQUILIBRANT should be equal in magnitude and opposite in direction to the RESULTANT if the system is in static equilibrium.
 - (a) Record the error in magnitude in newtons (TO NEAREST 0.1 N) in the table provided. Determine and record the percent error.
 - (b) Extend the equilibrant upward with a lightly drawn dashed line. Measure the angle between this line and the resultant. This is the error in direction. CLEARLY LABEL THE ANGLE WITH ITS VALUE (TO NEAREST WHOLE DEGREE), and then record the value in the table provided. Finally, determine the percent error, using 180 degrees as the comparison value, and record in the table provided.

LAB REPORT (assemble in following order):

Xerox Cover Sheet with Title, Purpose, Data, Calculations, Conclusion
Vector Drawing
Procedure & Analysis Instructions