PHY122 Lab # 3 NAME_______________

Force Table

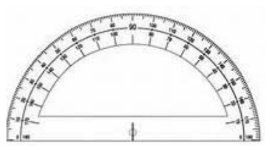
Lab Partners:

Purpose: The purpose of this lab is to study the equilibrium of a body acted on by concurrent forces, and to practice the addition of vectors.

Apparatus

Sharp Pencil

Protractor



Ruler marked off in metric increments

Force Table

Triple beam Balance

Assorted weights and hangers

Procedure Part A

1) Set up the force table and carefully level it.

2) Place the centering ring in the center of the force table and push the holding pin down through the hole in the centering ring and into the hole in the center of the force table.

3) Place one of the pulley clamps at the zero degree location on the force table.

4) Run one of the strings connected to the centering ring so that it runs over the pulley at the zero degree location and attach a weight hanger to the end of the string.

5) Place between 100.0 and 200.0 grams **on the weight hanger** at the zero degree location

6) Place a second pulley clamp at the 90 degree location on the force table.

7) Run one of the strings connected to the centering ring so that it runs over the pulley at

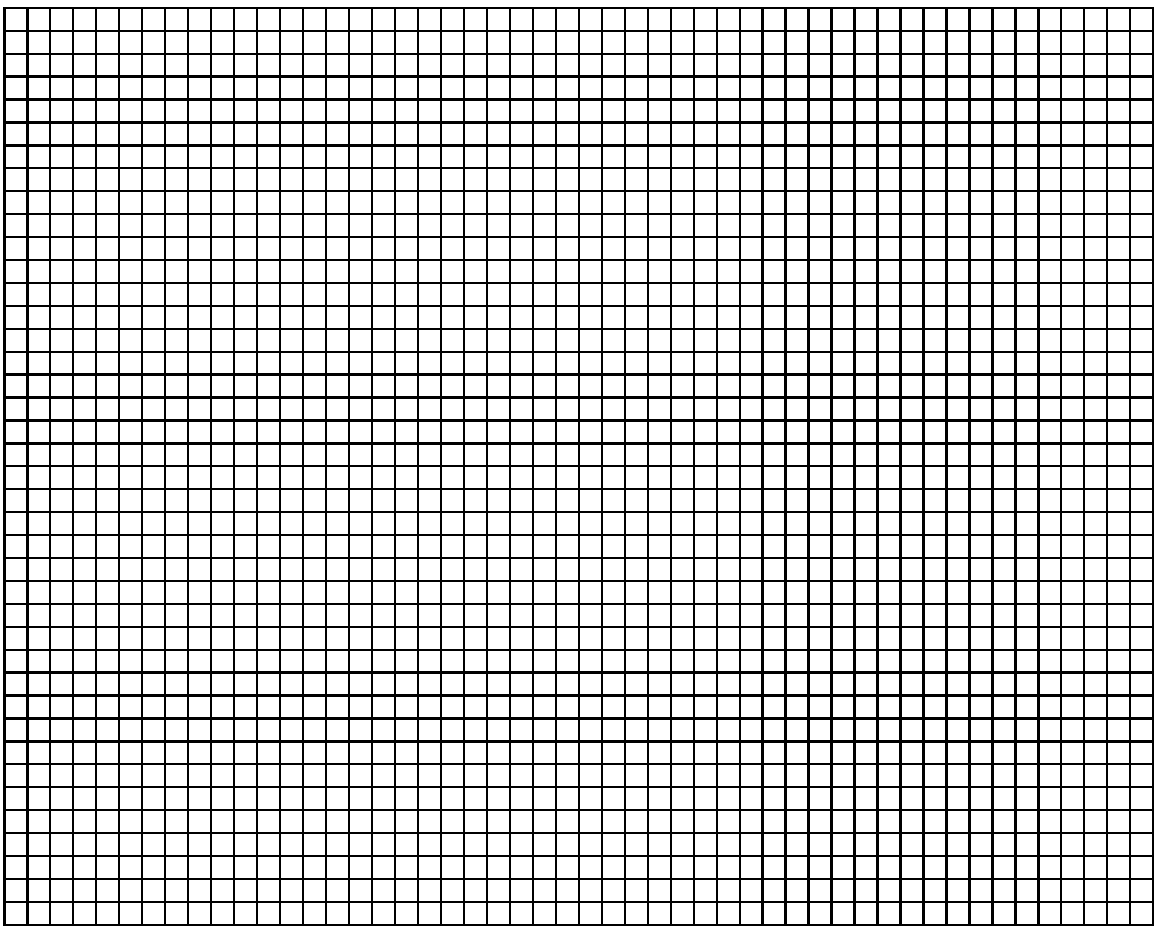
the 90 degree location and attach a weight hanger to the end of the string.

8) Place between 100.0 and 200.0 grams on the weight hanger at the 90 degree location. (Note: the amount used must be different from the amount on the first hanger.)

9) Using the included graph paper, a protractor, and a ruler, add the vectors graphically **using the polygon method** to calculate the resultant vector. NOTE: you must indicate the scale used in your vector diagram.

10) Using the calculated resultant vector, determine and then add the equilibrant vector to the force table. NOTE: the equilibrant vector will have the same magnitude as the resultant vector, but will act in the opposite direction.

Remember when graphing data that the scale used should make the graph as big as possible and still fit on the graph paper.



The scale used is: 1 cm = 10 g

The mass used at zero degrees is 150 g.

The mass used at 90 degrees is 200 g.

The resultant vector is 250 g at an angle of 53.5 deg.

The equilibrant vector is 250 g at an angle of 233.5 deg.

11) Make sure that the strings running from the centering ring to the pulleys are all pointed directly towards the pin at the center of the centering ring.

12) Pull the centering pin and answer question # 1 at the end of the lab.

Procedure Part B

13) Set up the force table and carefully level it.

14) Select two different size masses (between 100.0 and 200.0 grams) and set them up at right angles to each other on the force table. Use the centering pin to keep the ring in the middle of the force table. (These masses are to be added to the weight hangers and need to be different from those used in Part A of the lab.)

15) Using the algebraic method of vector addition, calculate the mass and location needed to produce the equilibrant force required to balance the force table. Then place this equilibrant force on the force table.

16) Pull the centering pin and note the results. **Is this system in equilibrium? How can you tell?**

Yes. The centering ring did not move therefore the forces are balanced.

DATA TABLE for Part B

Vectors for Part B	Vector (Magnitude & Angle)	(Calculated) X component of the vector	(Calculated) Y component of the vector
Vector # 1	160 g 0°	160 g	0 g
Vector # 2	130 g 90°	0 g	130 g
Resultant Vector	206 g 39°	160 g	130 g
Equilibrant Vector	206 g 219°	-160 g	-130 g

Procedure Part C

17) Select three different size masses and set them up on the force table so that they are not in equilibrium and are at random angles with respect to each other. (That is no two forces will be aligned either 90 or 180 degrees with each other.)

18) Calculate the mass and location needed to produce the equilibrant force and then set it up on the force table.

19) Pull the centering pin and note the results. **Is this system in equilibrium? How can you tell?**

Yes. The centering ring did not move therefore the forces are balanced.

DATA TABLE for Part C

Vectors for Part B	Vector (Magnitude & Angle)	(Calculated) X component of the vector	(Calculated) Y component of the vector
Vector # 1	110 g 90°	0 g	110 g
Vector # 2	170 g 0°	170 g	0 g
Vector # 3	105 g 315°	74 g	-74 g
Resultant Vector	247 g 8°	244 g	36 g
Equilibrant Vector	247 g 188°	-244 g	-36 g

Procedure Part D

20) Using the set-up from part C of the lab, make the equilibrant vector ½ a degree smaller. (That is, subtract 1/2 degree from the old equilibrant vector.)

21) Pull the centering pin and watch for movement of the centering ring. If there was no movement of the centering ring, change the location of the equilibrant vector so that it is ½ degree smaller than before.

22) Repeat step 21 until the centering ring shifts by an amount that will not allow the pin to be replaced without moving the centering ring.

23) Fill in the blanks below as to indicate how much you had to reduce the angle for the equilibrant vector to get a noticeable movement of the centering ring? (List all angles to the nearest ½ degree.)

The original angle for the equilibrant vector was 188 deg.

The new angle for the equilibrant vector is 186.5 deg.

The equilibrant angle was reduced by 1.5 deg.

24) Restore the set-up from part C of the lab, then make the equilibrant vector ½ a degree larger. (That is, add 1/2 degree to the old equilibrant vector.)

25) Pull the centering pin and watch for movement of the centering ring. If there was no movement of the centering ring, change the location of the equilibrant vector so that it is ½ degree larger than before.

26) Repeat step 21 until the centering ring shifts by an amount that will not allow the pin to be replaced without moving the centering ring.

27) Fill in the blanks below as to indicate how much you had to increase the angle for the equilibrant vector to get a noticeable movement of the centering ring? (List all angles to the nearest ½ degree.)

The original angle for the equilibrant vector was 188 deg.

The new angle for the equilibrant vector is 190 deg.

The equilibrant angle was increased by 2 deg.

28) Using the same angle for the equilibrant vector as in part C of the lab, change the amount of mass hanging on the weight hanger to find out how much mass must be added to the weight hanger until a difference in the motion of the centering pin is noticed from its movement in part C? (Again, a “noticeable amount” means that the centering ring must be moved to replace the pin.)

27 g

29) Using the same angle for the equilibrant vector as in part C of the lab, change the amount of mass hanging on the weight hanger to find out how much mass must be removed from the weight hanger (from the amount used in part C) until a difference in motion of the centering pin is noticed from its movement in part C?

7 g

Questions for the Force Table Lab

1) What are some of the potential problems that can get in the way of getting a useable solution to a vector addition problem when adding vectors graphically?

   Not lining the protractor up correctly with the graph and not using a correct scale for the graph paper used or size of the vectors.

2) In Part D, why does the centering ring not start to shift as soon as you change the angle?

   The friction in the pulley is acting in the direction opposite the current direction of the motion in the mass hanging down giving you more leeway when you change angles as shown in part D of the data in the lab.

3) Typically in Part D the amount of mass that you have to add is more than what you have to subtract. What I want you to explain to me is why this tends to happen.

   The force of friction in the pulley increases as the mass increases. The more mass you add the more friction it will create causing you to add more mass to the hanger to overcome the force of friction.

4) Based upon what you have seen in this lab, give at least one good reason why it would be better to calculate the location of the equilibrant vector than to try to find it using trial and error.

   It is more accurate and efficient to calculate the equilibrant vector then it is to find it using trial and error.

Sample Calculations

To calculate the X_{comp}:

X_{comp}= mag(COS angle); X_{comp}= 160 g (COS 0°) = 160 g

To calculate the Y_{comp}:

Y_{comp}= mag(SIN angle); Y_{comp} = 130 g (SIN 90°) = 130 g

To find the resultant X_{comp} and resultant Y_{comp}:

ΣX_{comp} or ΣY_{comp} = resultant X_{comp} or resultant Y_{comp}:

160 g + 0 g = 160 g

To calculate the resultant and equilibrant magnitude:

mag = $\sqrt{(X_{comp})^2 + (Y_{comp})^2}$; mag = $\sqrt{(160\text{ g})^2 + (130\text{ g})^2}$ = 206 g

To calculate the resultant angle:

angle = $\tan^{-1}\left(\frac{Y_{comp}}{X_{comp}}\right)$; angle = $\tan^{-1}\left(\frac{130}{160}\right)$ = 39°

To calculate the equilibrant angle:

angle = $\tan^{-1}\left(\frac{Y_{comp}}{X_{comp}}\right)$+180°; angle = $\tan^{-1}\left(\frac{130}{160}\right)$+180° = 219°

Conclusion

In this lab we used quantities that have a direction as well as a magnitude called a vector quantity which is different from a scalar quantity because a scalar quantity only has a magnitude but no direction associated with it. The type of vector quantity we used in this lab is force. Force is a vector quantity because it has a mass and a direction it pulls towards. In parts A, B, and C of this lab we have different forces acting on the same object and to find the combined effects of those forces we must find the resultant vector. When you find the resultant vector by adding two or more vectors you can find the equilibrant vector by adding it to the resultant vector canceling each other out therefore producing a state of equilibrium.

In part A and D of the lab we should see that adding vectors graphically or by trial and error, as we did in part D, is much more difficult and inaccurate than doing them algebraically like we did in parts B and C.

One of the sources of error is not making sure the assorted weights and hangers are actually the weight they say they are. We need to make sure we are weighing every weight and hanger as precise as the machine we are using to weigh them. Another source of error is not having the force table as level as it should be. We should have taken more time to test the force table with marble and without the strings attached.