Physics Laboratory Report

Lab number and Title: Lab 103 - Translational Static Equilibrium - Force Table

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Course & Section Number: PHYS111A 011 **Instructor's Name: Professor Nguyen**

Partners' Names: Logan Chappel, Jose Tabuena, Connor Nguyen

INTRODUCTION

The purpose of this experiment was to determine the mass and angle of strings attached to a ring so that the ring would have a net force of zero. Lab 103 was split between three cases, each of which had different values given, and using our knowledge of the kinematics formulas, had to solve for unknown variables which would result in the zero net force.

Case one gives us the mass of strings two and three, along with the angle at which they are connected to the ring. We need to determine the weight of the first string so that the ring remains suspended. Case two gives us the mass of strings one and two, and the angles of strings two and three. From this our group must figure out the angle and mass of string three. Lastly, case three provides us with the of all strings and the angle of string one, leaving the angles of strings two and three for us to solve.

From our classes, we know that the force of the string is the Tension Force (Ft = mg), and that when at equilibrium, the sum of the forces is equal to 0. When the ring is suspended without touching the pole in the middle of the force table, we know that T1 + T2 + T3 (the three strings) = 0. Our group applied this formula in determining the unknown variables from each of the three cases, and then used the given tools to find the measured values.

EXPERIMENTAL PROCEDURE

For all the cases, we used the three strings connected to a ring, weights provided by the instructor, and a force table. Strings A, B, and C represent the strings.

Case 1

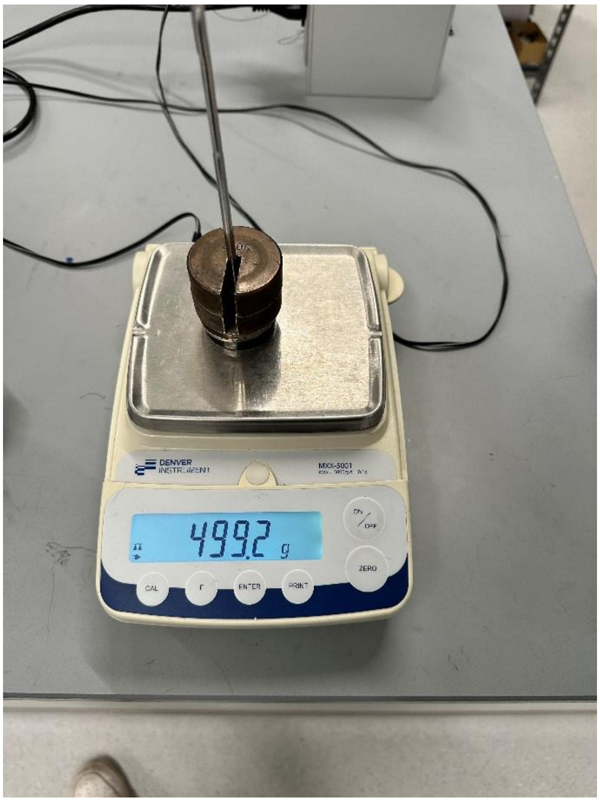
Variables

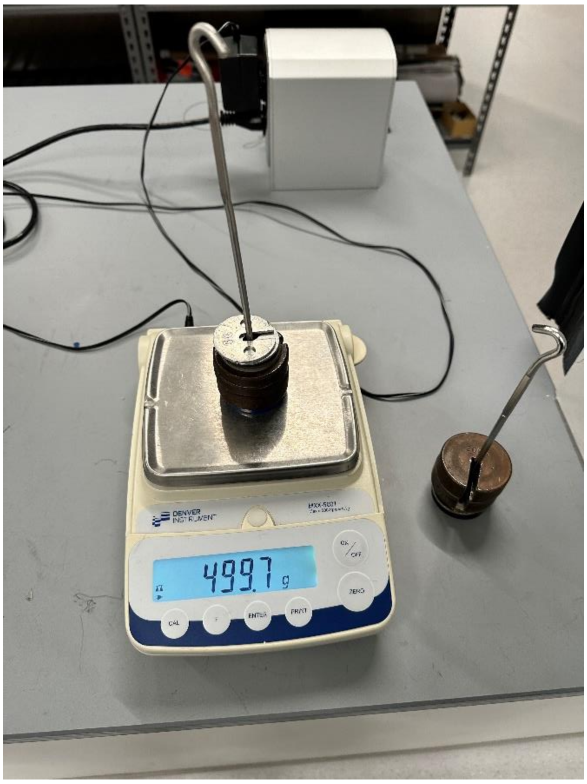
	Tension Force (N)	Mass (g)	Angle (°)
String A	500	500	120
String B	?	?	120
String C	?	?	120

For case 1, we were aware of the angle at which the strings were located and the mass of String A, which was 500 grams. The first step of the process was to put the strings at 120-degree intervals which could be checked by the equal distance between each piece of string. Using the degree values of the force table (specifically the values on the inside on the white background) we placed the strings. String A was put at 0 degrees, String B was placed at 120 degrees, and String C was put at 240 degrees. For the next step, we had to put the weight for String A. For the weight of String A, we were provided with 50 grams and were required to place a total of 500 grams, which was added using two 200-gram weights and one 50-gram weight.

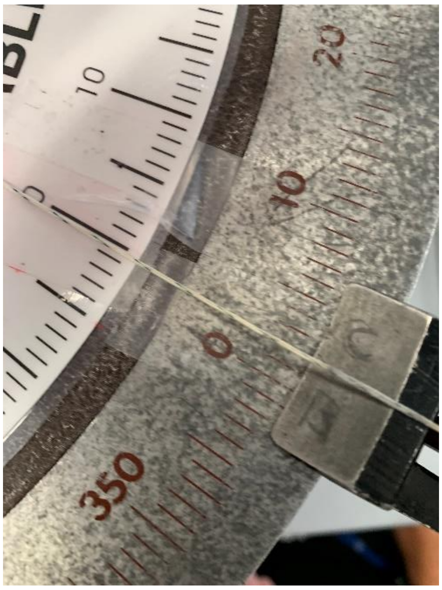
With the station set up, for step three we completed the calculations by hand and took photos of the angle / the weight on a scale to determine the accuracy. With the calculations completed, we would find the tension force of Strings B and C and derive the mass of both. From step three, we got that the mass of Strings B and C was 500 as well. For step four, we had to get the mass of Strings B and C to 500 grams, which was done by using the weights provided. For String B, we used two 200-gram weights, and one 50-gram weight. For String C, we used two 200-gram weights, two 20-gram weights, and a 10-gram weight since we ran out of 50-gram weights to use. For step five, we measure the weights to make sure that they are close to the theoretical value. Lastly, we attach the weight to the string, which should have the desired effect of the ring suspended in air.

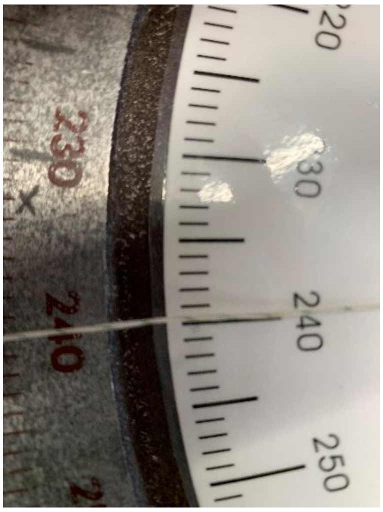
Weight of Ta, Tb, and Tc (Respectively)



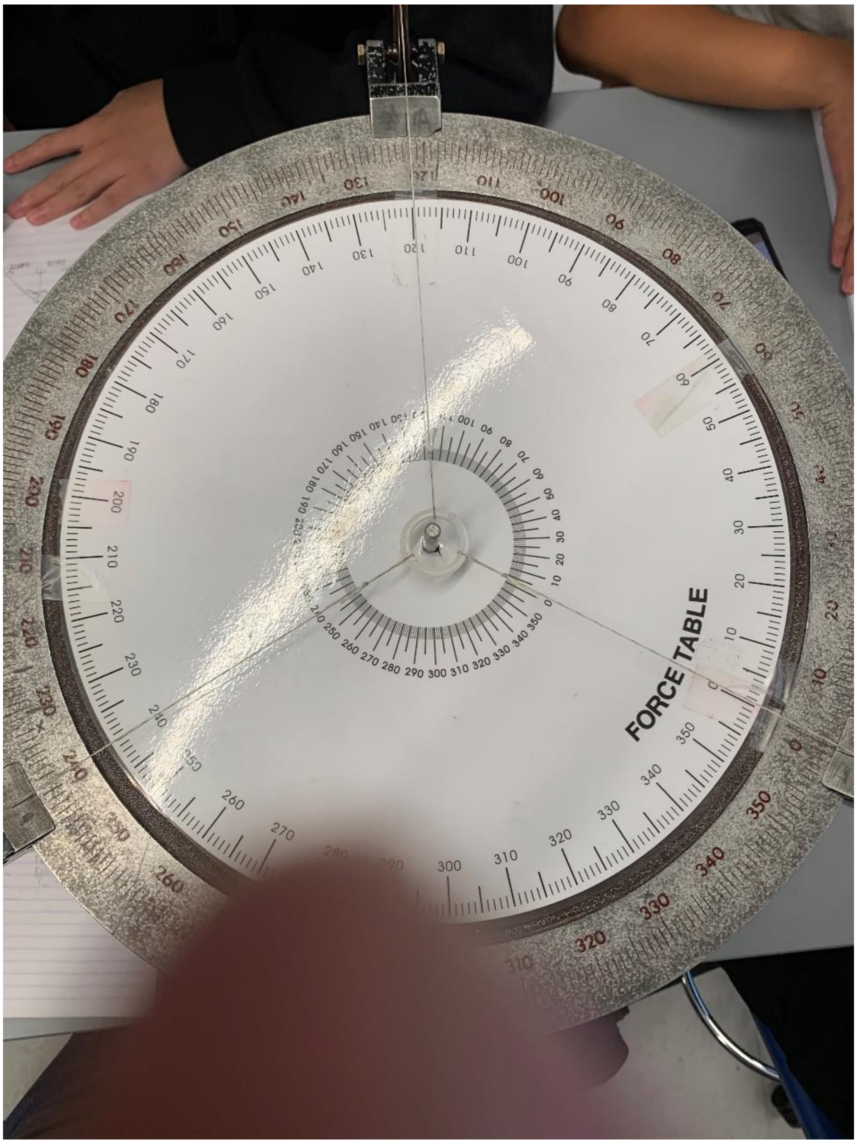


Angles of Θa, Θb, Θc (Respectively)





Setup of Experiment



Case 2

Variables

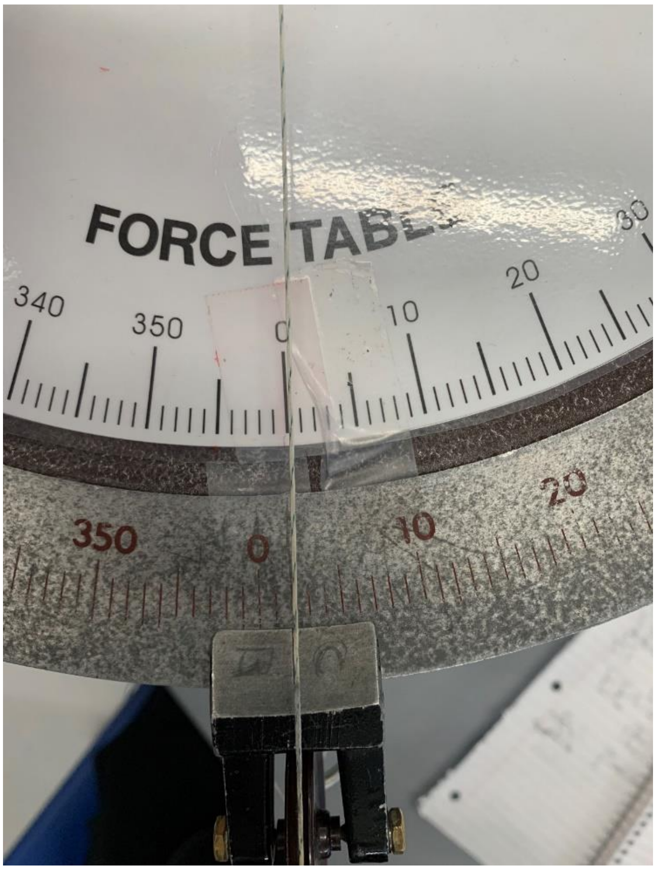
	Tension Force (N)	Mass (g)	Angle (°)
String A	200	200	150
String B	200	200	150
String C	?	?	?

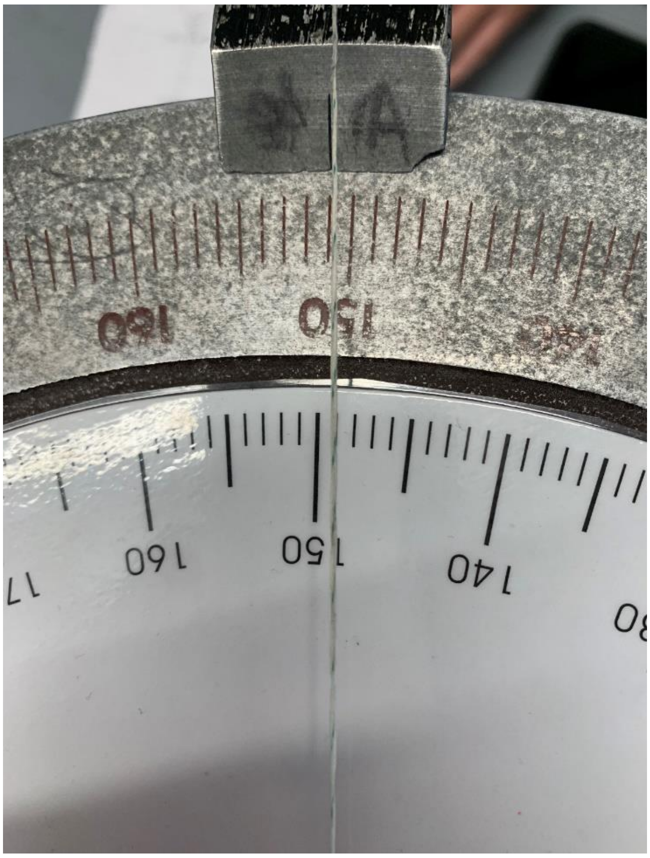
For case 2, we were given the tension force of Strings A and B, as well as the angles of A and B. We must find the Tension force and angle for String C. The first step was to figure out where the strings were supposed to go. Calculating that a circle has 360 degrees, and we already know two angles, we were able to determine that String C has an angle of 60 degrees. Once we knew the location of the strings, step two was to place them on the force table. String A was put at 90 degrees, String B was placed at 150 degrees, and String C was put at 300 degrees. With the strings in the correct location, we had to put the weights for String A and B. Both weights started with 50 grams and had to come to 200 grams, which was done by using a 100-gram weight and a 50-gram weight.

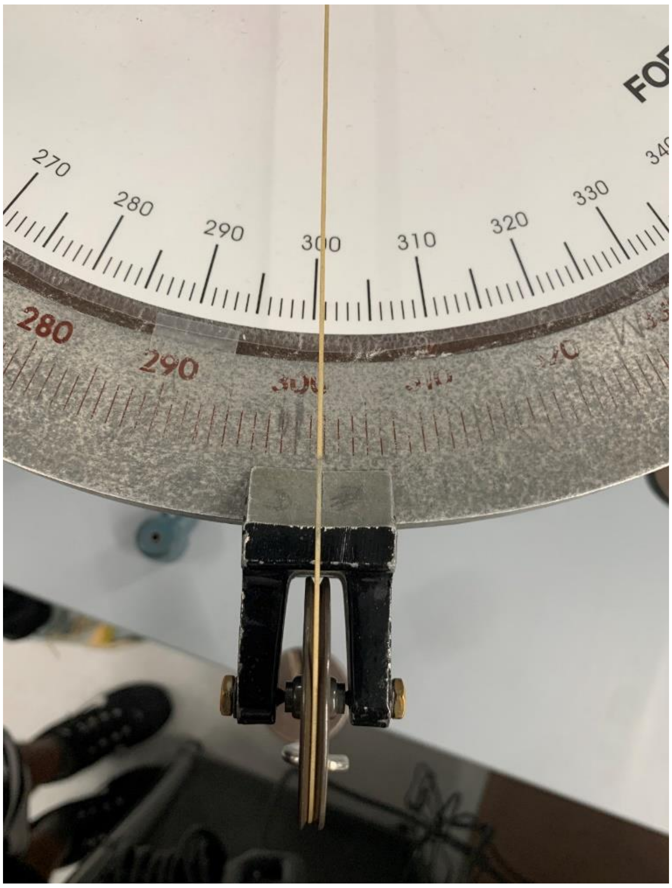
The last part (step four) missing from the equation was the value of Tc and then the mass derived from the tension force. Calculating using the formula Ta + Tb + Tc = 0, we were able to solve for Tc to be 350 grams. Step five had us use a 200-gram weight and a 100-gram weight to get to the desired weight for string C. After taking a photo of it on the scale, we placed the weight onto String C which had the intended effect of causing the ring to be suspended in air.

Weight of Ta, Tb, and Tc (Respectively)

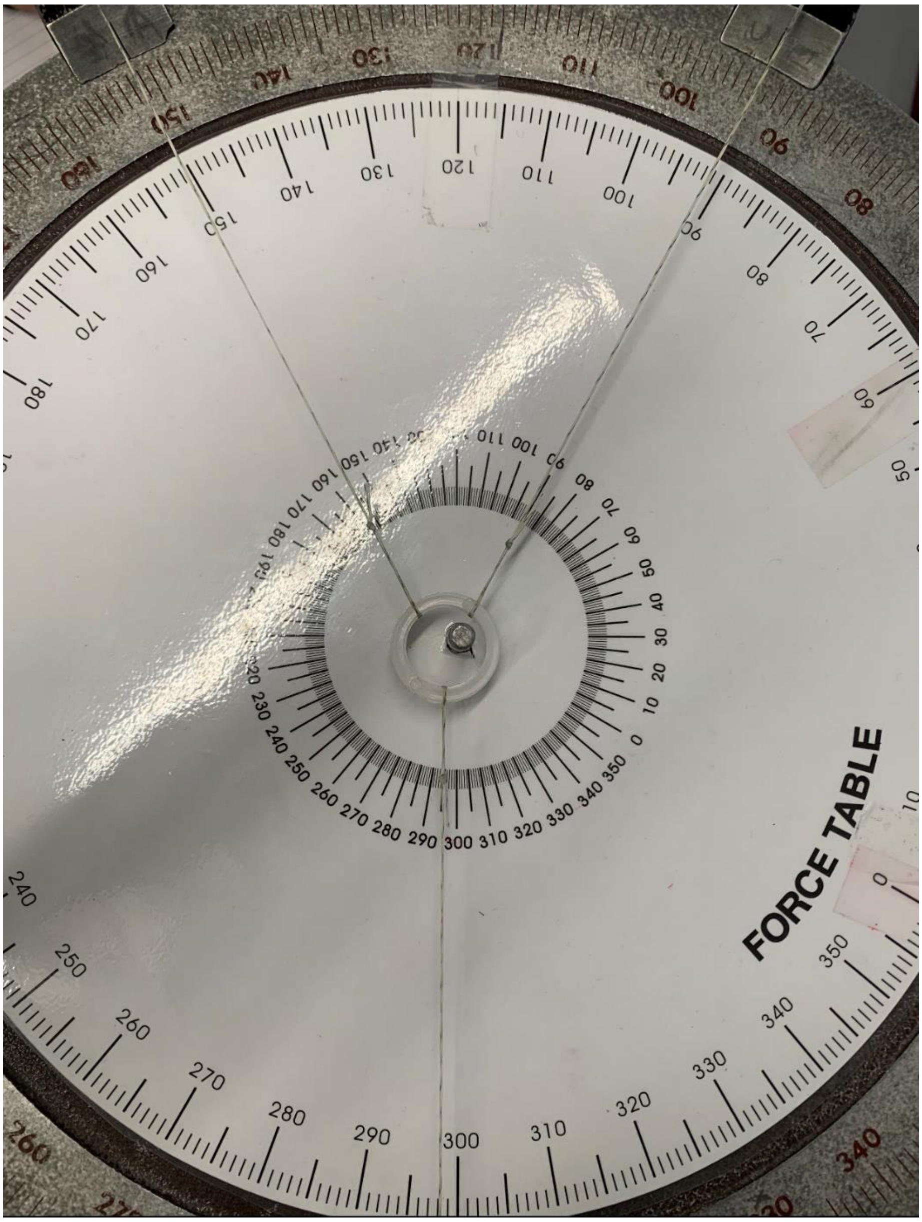
Angles of Θa, Θb, Θc (Respectively)


FORCE TABLE





Setup of Experiment



Case 3

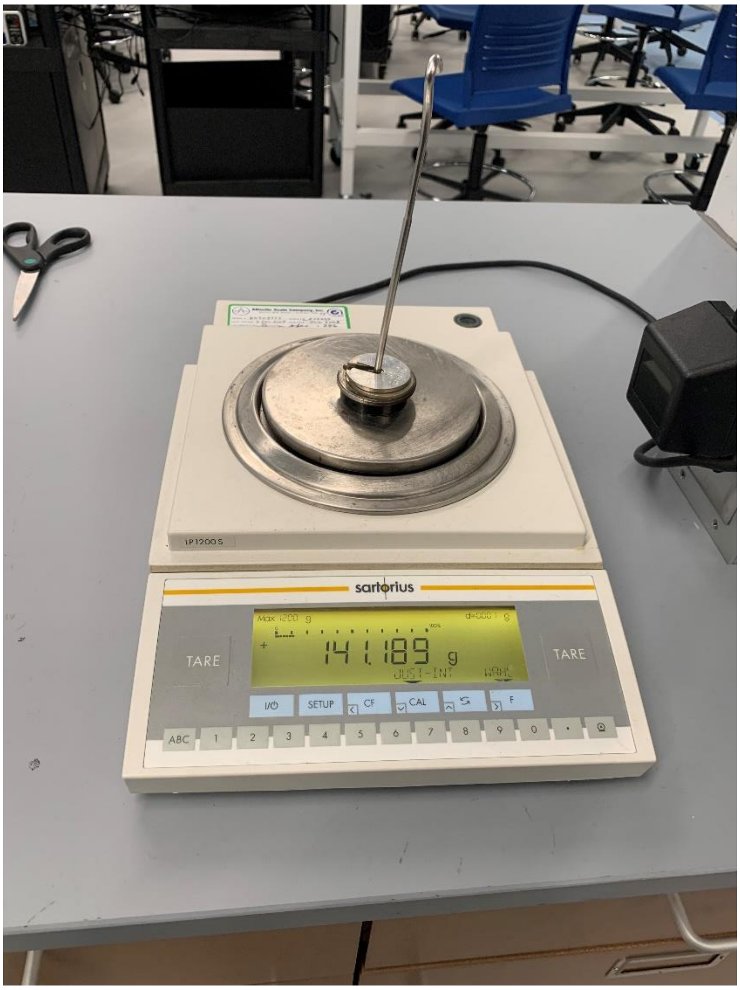
Variables

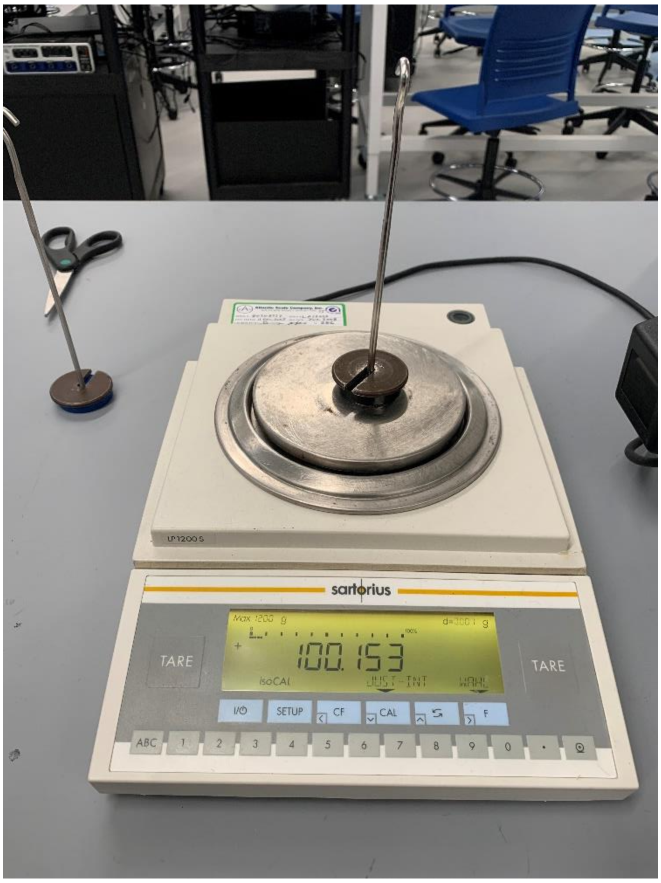
	Tension Force (N)	Mass (g)	Angle (°)
String A	141.42	141.42 (141)	90
String B	100	100	?
String C	100	100	?

For case three, we are given the tension force of all three strings, as well as the angle of theta A. We are required to solve for the angle of Strings B and C. To start off by setting up the station, we first can use the tension force to get the weights (which is equivalent from Newtons to grams in this case). For String A, we used two 50-gram weights, two 20-gram weights, and one 1-gram weight to reach as close to the theoretical value as possible. For string B and C, we used one 50-gram weight. After completing this step, step two was to measure all the masses to make sure that it matched up with the theoretical values.

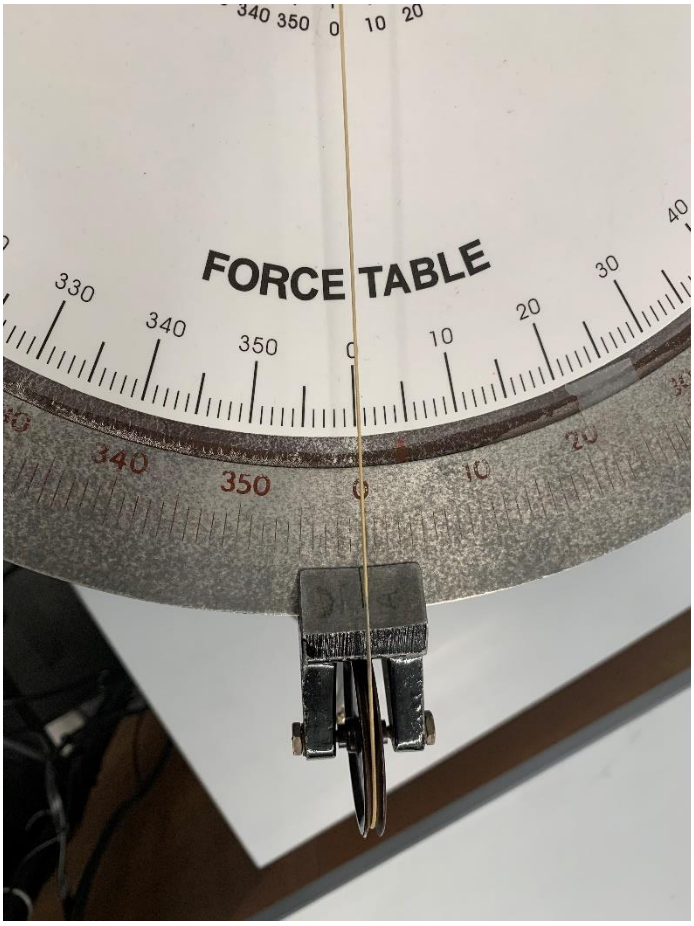
Our method to solve this problem used a trigonometric property whereby we used the graph to determine the angle of B is equal to the angle of C. With this information, we subtracted 90 from 360 and then divided that number by two, giving 135 for each side. Now that we have the values of Strings A, B, and C, we can put them onto the force table. For step three, we set up the strings so that they had the correct measurements. String A was placed at 0 degrees, String B was put at 135 degrees, and String C was at 225 degrees. Once the strings were at the accurate positions, step four was to put the weights that were set up in step two onto the strings. The 141-gram weight went to String A, while the other two went to Strings B and C (which had an equal mass). This had the desired effect of suspending the ring at the center of the force table.

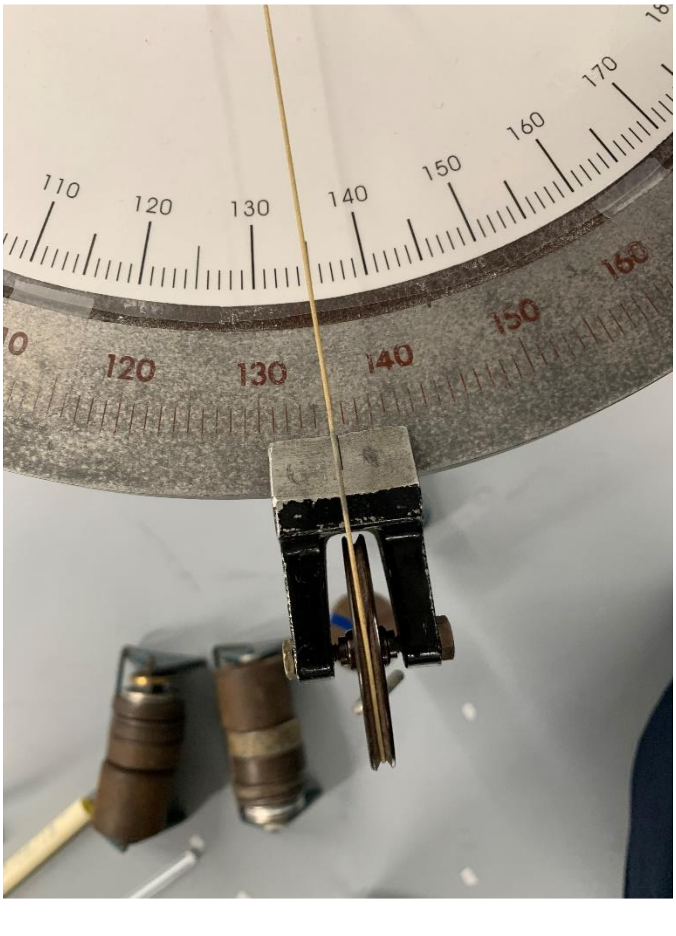
Weight of Ta, Tb, and Tc (Respectively)



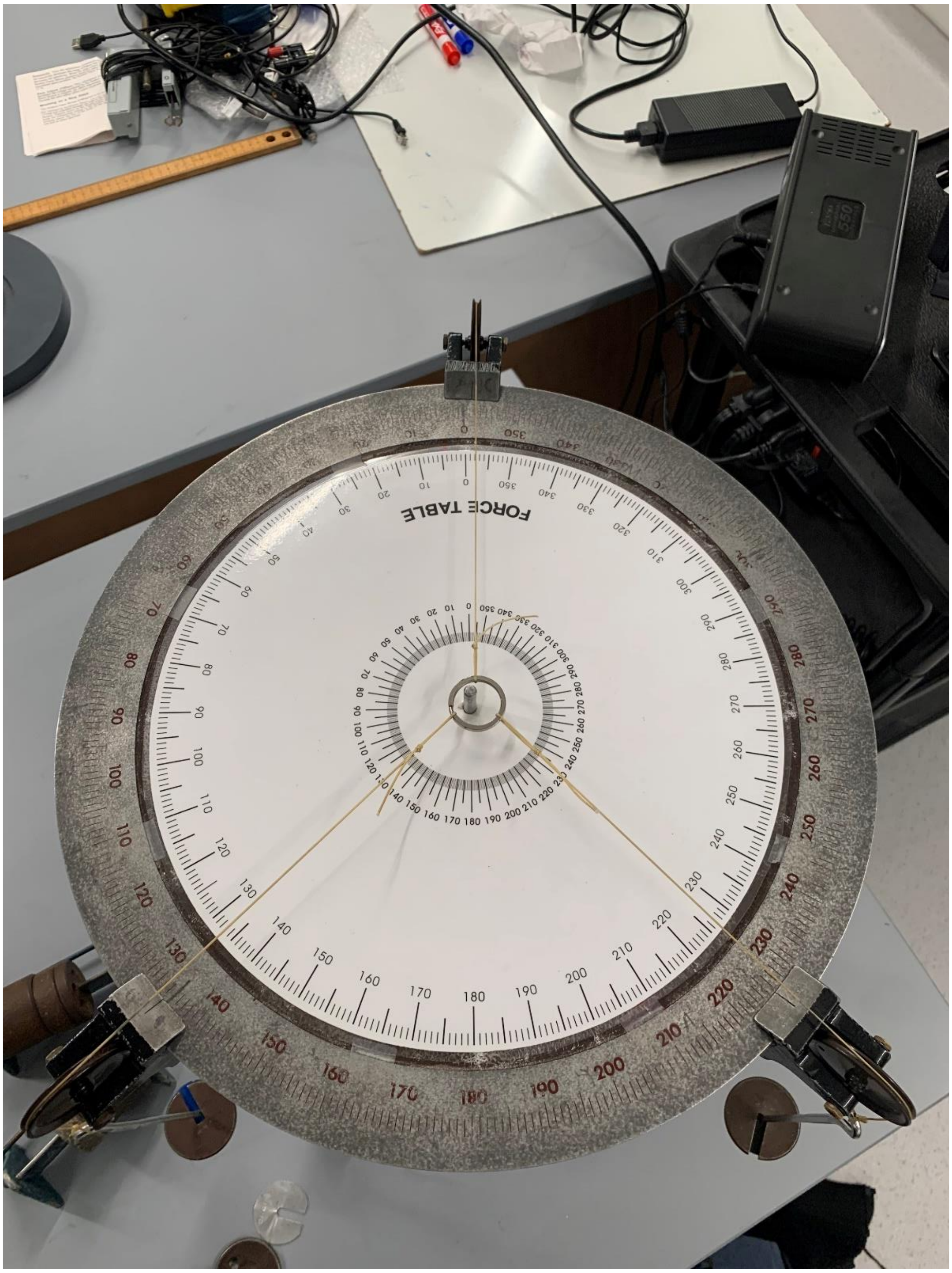


Angles of Θa, Θb, Θc (Respectively)


FORCE TABLE



Setup of Experiment



RESULTS

***1.1 Experimental Data* (15 points)**

Case	Quantity Given	Quantity to be Determined	Theoretical Answer	Measured Value	% Difference
1	Ta = 500N	Tb	500N	499.2N	0.2%

	Θa = 120 °				
	Θb = 120 °	Tc	500N	499.7N	0.06%
	Θc = 120 °				
2	Ta = 200N	Tc	350N	349.9N	0.03%
	Θa = 150°				
	Tb = 200N	Θc	60°	60°	0%
	Θb = 150°				
3	Ta = 141.5N	Θb	135°	135°	0%
	Θa = 90°				
	Tb = 100N	Θc	225°	225°	0%
	Tc = 100N				

1.2 Calculation (15 points)

Case 1 Calculations

Case 1

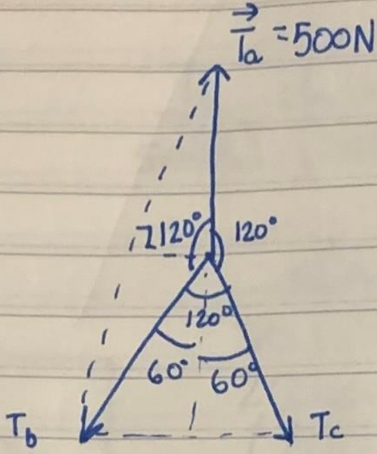
$T_a = 500N$

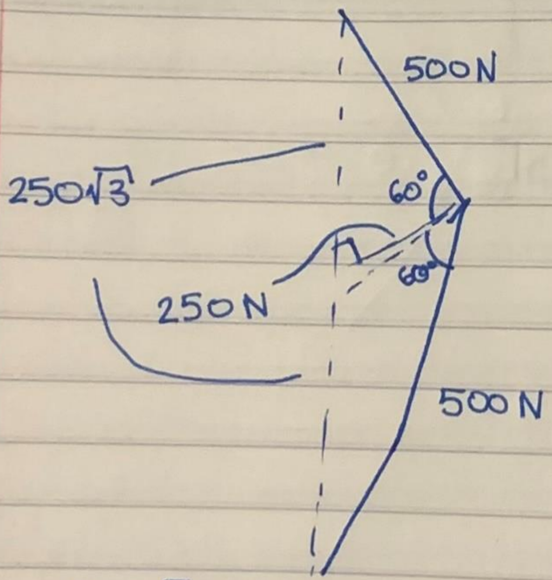
$\Theta_a = \Theta_b = \Theta_c = 120°$

$T_b = ?$

$T_c = ?$

(not drawn to scale)

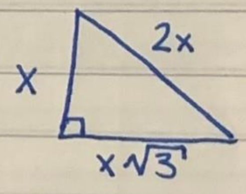




$T_b = 500N$

$T_c = 500N$

Forms a 90-60-30 triangle



By splitting the area in half, we find the length of the bisection as 250

Since T_b follows the same rule, it's $2(250) = 500$

Case 2 Calculations

Case 2

$T_a = 200$

$T_b = 200$

$\theta_a = 150°$

$\theta_b = 150°$

$T_c = ?$

$\theta_c = ?$

$$360 = \theta_a + \theta_b + \theta_c$$

$$360 = 300 + \theta_c$$

$$\theta_c = 60°$$

$$\frac{T_a}{\sin(\theta_a)} = \left(\frac{T_b}{\sin(\theta_b)} = \frac{T_c}{\sin(\theta_c)}\right)$$

$$\downarrow$$

$$\frac{200}{\sin(150°)} = \frac{T_c}{\sin(60°)}$$

$$200\sin(60°) = \sin(150°)\,T_c$$

$$\left(\frac{200\sin(60°)}{\sin(150°)}\right) = T_c$$

$$T_c = 200\sqrt{3} \text{ or } 346.4\text{N}$$

$$\boxed{\begin{array}{l}\theta_c = 60° \\ T_c = 346.4\text{N}\end{array}}$$

Case 3 Calculations

Case 3

$T_a = 141.5N$

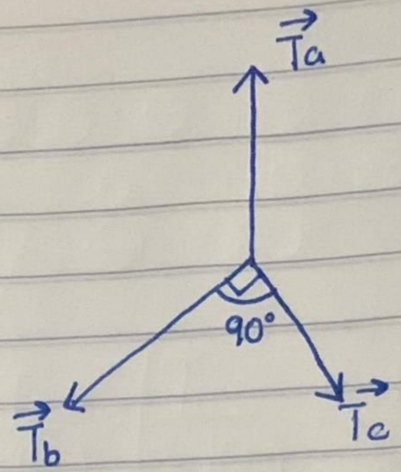
$T_b = 100N$

$T_c = 100N$

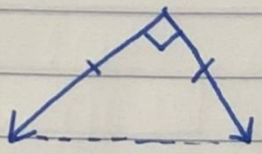
$\theta_a = 90^\circ$

$\theta_b = ?$

$\theta_c = ?$



$360 = \theta_a + \theta_b + \theta_c$ $\quad \theta_{bc} = 270^\circ$



Since it's a right triangle and it's an isosceles, we know the angles $\theta_b = \theta_c$

$\frac{270^\circ}{2} = 135^\circ$

$$\boxed{\begin{array}{l}\theta_b = 135^\circ \\ \theta_c = 135^\circ\end{array}}$$

ANALYSIS and DISCUSSION

Case 1

For case one and three, we used our knowledge of trigonometry to solve the equation. We used 90-60-30 triangles, which were created from bisecting the 120-degree triangle in half and then applying our knowledge of the special triangle to solve for the unknown. For case two, I used the formula $T_a/\sin\Theta_a = T_b/\sin\Theta_b = T_c/\sin\Theta_c$ which was able to solve what I was looking for. The results from the lab done in class matched closely with what we got in our calculations, but the weights had very small variations. We had originally got one of the answers wrong (case 2), which at the time lead to the experiment and theoretical being 12% away, but that was luckily corrected before the end of class. The highest error margin was under 1%, so I believe the theory and experiment did match up. These small error margins were caused by the scales we were using and that we didn’t have weights smaller than 1-gram to correct it.

CONCLUSIONS (10 points)

The experiment helped our group, and me personally, to understand how to apply the various physics functions that we were given in class. We were able to apply the tension force formulas and our prior learned trigonometric formulas in order to solve the problems. The experiment allowed us to fill in for two variables, but I would like to experiment in the future with more variables being left blank and allowing us to think further on the assignment. Lastly, if we were conducting the lab again, I would try to work with a larger array of weights and more accurate scales to lower the margin of error.