

Disclaimer: This lab write-up is *not* to be copied, in whole or in part, unless a proper reference is made as to the source. (It is strongly recommended that you use this document *only* to generate ideas, or as a reference to explain complex physics necessary for completion of your work.) Copying of the contents of this web site and turning in the material as “original material” is *plagiarism* and will result in serious consequences as determined by your instructor. These consequences may include a failing grade for the particular lab write-up or a failing grade for the entire semester, at the discretion of your instructor.

Anything included in this report in RED (with the exception of the equations which are in black) was added by me (Bill) and represents the data obtained when the experiment was run. *Use your own data you collected and perform the calculations for your own data!*

Sample Only - Do Not Copy

Centripetal Force

Name:

PES 1150 Report

Lab Station: 005

Objective

The purpose of this experiment is to determine the relationships between radius, mass, linear velocity and centripetal force of a spinning body. We used logger pro to accurately measure the rotational velocity of and force exerted by a spinning mass and used these measurements to determine the interrelated interactions of the specified properties and viewed the results graphically.

Data and Calculations

Part B: Measure F vs. v^2

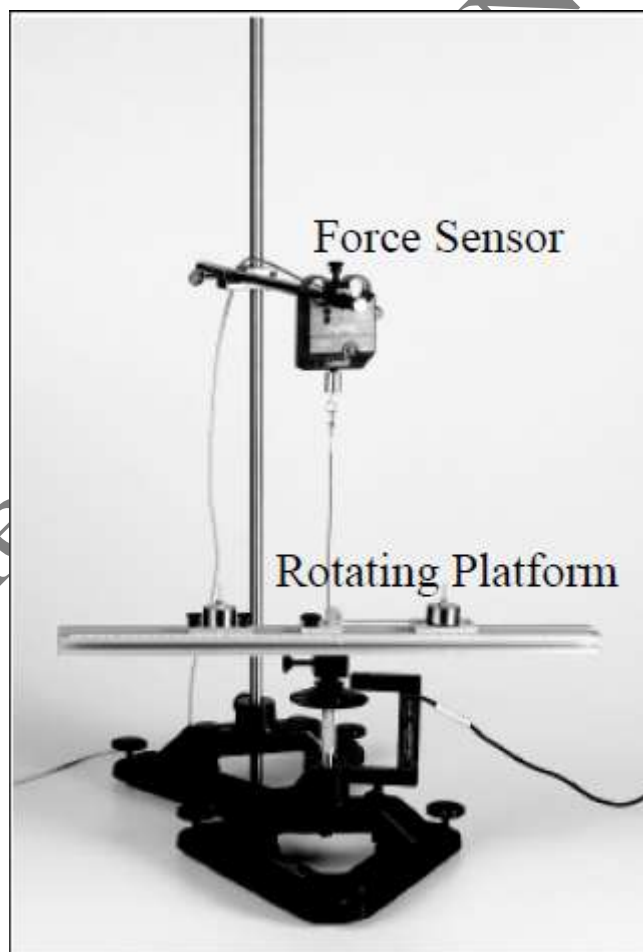


Figure 1: Experimental setup for the lab

To start the experiment, we first calibrated the force sensor. To do this, we entered a value of 0 when there was nothing hanging off the sensor and then we hung off a calibration mass of 295.0 g (which provided a force of 2.884 N).

We then began with using the 50g mass. We added one to each of the brackets that were on the rotating platform. We then measured the 50g mass with the screw, bolt and bracket to get the total mass of the sliding holder. We then reassembled everything and measured the distance where the string attached to the force sensor was tight. This was at 16.3 centimeters, so we positioned the fixed slider and mass to the same distance on the other side of the rotating arm.

The following table shows the data collection for run 1:

Mass of the sliding holder (kg)	101.7 g = 0.1017 kg
Radius m	16.3 cm = 0.163 m

Since Logger pro was collecting data in angular velocity, we needed to convert this to linear velocity to plot Force vs. Linear Velocity Squared.

To do this we used the relationship:

$$v_{Linear} = \omega_{Angular} R$$

That is “the linear velocity is equal to the angular velocity times the radius”.

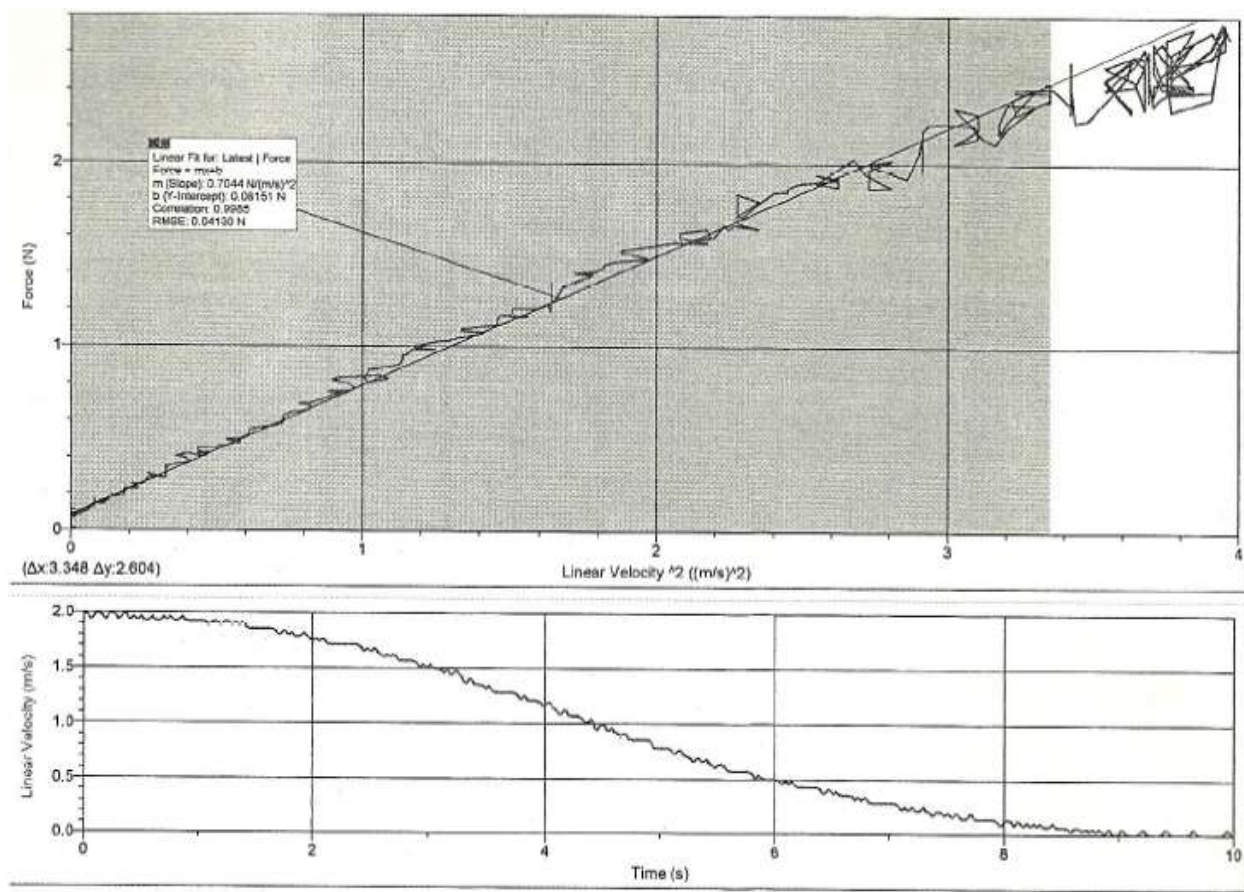


Figure 2: Experimental data of the 50g mass

By analyzing both the graphs above, we can see that as linear velocity increases, so does the centripetal force. This means that velocity and force are directly related. This is further reinforced by the equation of centripetal force:

$$\vec{F} = \frac{Mv^2}{R}(-\hat{r})$$

Notice that if we plot Force on the y-axis and linear velocity squared on the x-axis, this is effectively a straight line:

$$y = mx + b \text{ compared to } F = (\text{slope})v^2 + (y - \text{intercept})$$

The variance in the data is most likely due to a variable torque on the system.

We can see from Figure 2 that the slope of the line is simply the mass divided by the radius. This was a value of 0.7044 kg/m. To calculate the mass of the weight, we can simply multiply the slope by the spinning radius:

$$\underline{slope = \frac{M}{R}}$$

$$\underline{M = slope(R) = 0.7044 \frac{kg}{m} (0.163m) = 0.1148kg}$$

<u>Trial Number</u>	<u>Slope (units?)</u>	<u>Calculated Mass (kg)</u>
<u>1</u>	<u>0.7044 kg/m</u>	<u>0.1148 kg = 114.8 g</u>

$$\underline{\%diff = \left| \frac{0.1148kg - 0.1017kg}{0.1148kg} \right| \times 100 = 12.88\%}$$

We then exchanged the 50g mass for a 100g mass. We added one to each of the brackets that were on the rotating platform. We then measured the 100g mass with the screw, bolt and bracket to get the total mass of the sliding holder. We then reassembled everything and measured the distance where the string attached to the force sensor was tight. This was still at 16.3 centimeters, so we left the fixed slider and mass to the same distance on the other side of the rotating arm.

The following table shows the data collection for run 2:

<u>Mass of the sliding holder</u>	<u>(kg)</u>	<u>156.8 g = 0.1568 kg</u>
<u>Radius</u>	<u>m</u>	<u>16.3 cm = 0.163 m</u>

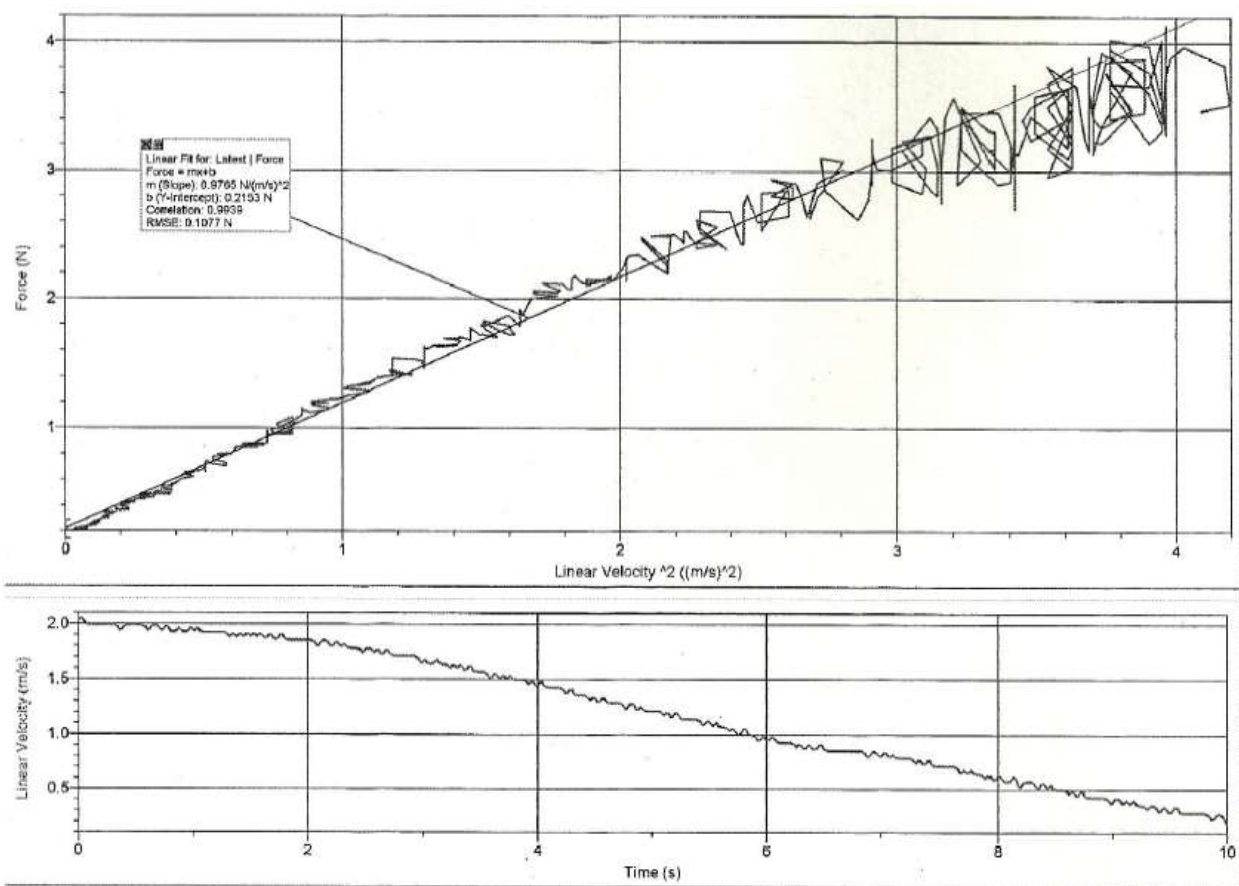


Figure 3: Experimental data of the 100g mass

We can see again from Figure 3 that the slope of the line is simply the mass divided by the radius. This was a value of 0.9765 kg/m. To calculate the mass of the weight, we can simply multiply the slope by the spinning radius:

$$\text{slope} = \frac{M}{R}$$

$$M = \text{slope}(R) = 0.9765 \frac{\text{kg}}{\text{m}} (0.163\text{m}) = 0.1592 \text{ kg}$$

<u>Trial Number</u>	<u>Slope (units?)</u>	<u>Calculated Mass (kg)</u>
<u>2</u>	<u>0.9765 kg/m</u>	<u>0.1592 kg = 159.2 g</u>

$$\% \text{diff} = \left| \frac{0.1592 \text{ kg} - 0.1568 \text{ kg}}{0.1592 \text{ kg}} \right| \times 100 = 1.479\%$$

We then added again an additional 50g mass. We added one to each of the brackets that were on the rotating platform. We then measured the 150g mass with the screw, bolt and bracket to get the total mass of the sliding holder. We then reassembled everything and measured the distance where the string attached to the force sensor was tight. This was still at 16.3 centimeters, so we left the fixed slider and mass to the same distance on the other side of the rotating arm.

The following table shows the data collection for run 3:

Mass of the sliding holder	(kg)	206.9 g = 0.2069 kg
Radius	m	16.3 cm = 0.163 m

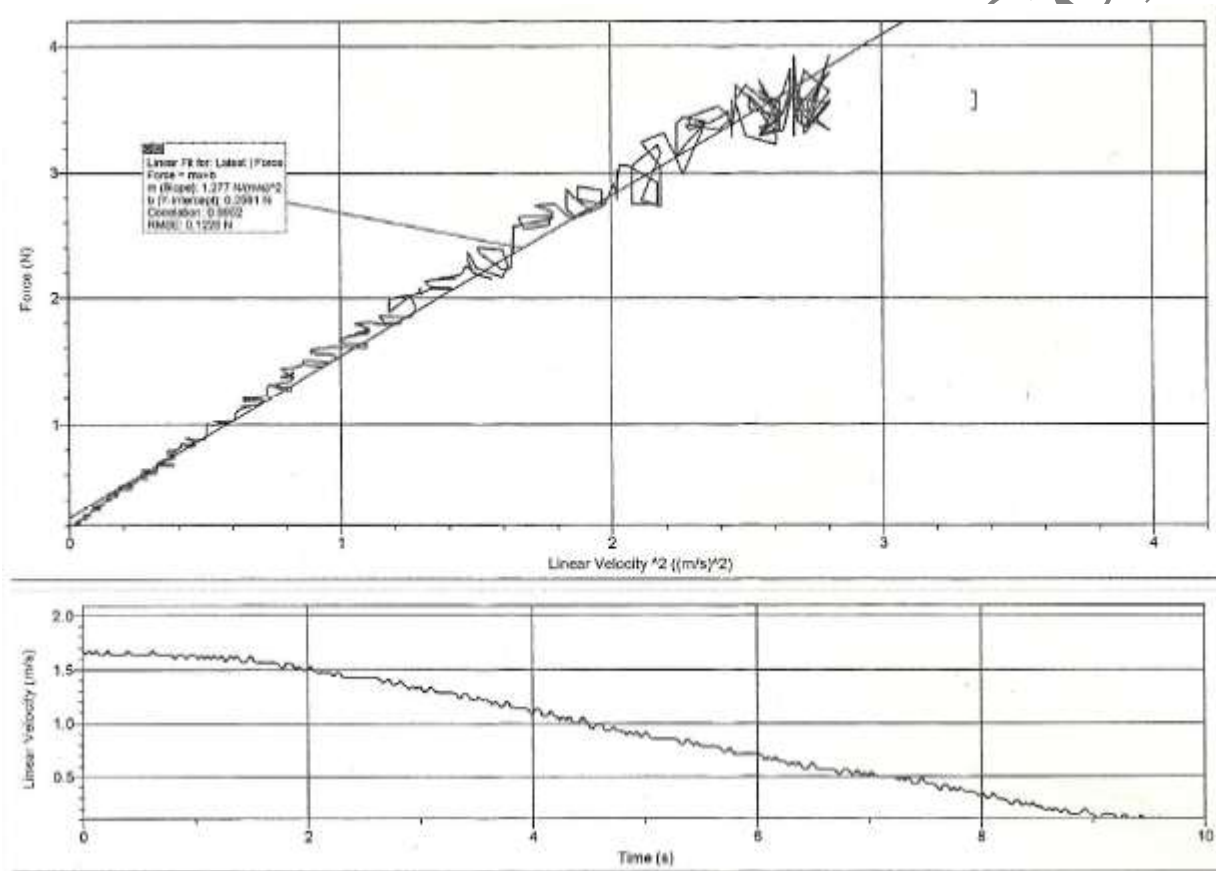


Figure 4: Experimental data of the 150g mass

Finally, we can see again from Figure 4 that the slope of the line is simply the mass divided by the radius. This was a value of 1.277 kg/m. To calculate the mass of the weight, we can simply multiply the slope by the spinning radius:

$$\text{slope} = \frac{M}{R}$$

$$M = \text{slope}(R) = 1.277 \frac{\text{kg}}{\text{m}} (0.163 \text{ m}) = 0.2081 \text{ kg}$$

<u>Trial Number</u>	<u>Slope (units?)</u>	<u>Calculated Mass (kg)</u>
<u>3</u>	<u>1.277 kg/m</u>	<u>0.2081 kg = 208.1 g</u>

$$\% \text{ diff} = \left| \frac{0.2081 \text{ kg} - 0.2069 \text{ kg}}{0.2081 \text{ kg}} \right| \times 100 = 0.58\%$$

Questions

1. What is the benefit of plotting F vs v² as opposed to F vs v? Does changing an axis change the data or the end results?

Plotting F vs v² is better, because then we get simply a linear relationship (instead of a quadratic relationship). This makes reading the Mass/Radius much simpler – since it was just the slope of the line.

2. How well does your experimental values match up with the theoretical values?

Surprisingly, we had VERY LOW percent differences, so the data was very good.

3. How does the statistical analysis affect your confidence in your final result?

Since the percent difference was very small for all the runs, my confidence in the final results is very high.

4. What are some of the possible sources of error associated with the apparatus and/or measurement technique?

A possible source of error included NOT weighing the weights plus the screw at the end of the apparatus. Also, starting the collection at a higher velocity than 10 rad/s may have maxed the force sensor.

Conclusion

You are intelligent scientists. Follow the guidelines provided and write an appropriate conclusion section based on your results and deductive reasoning. See if you can think of any possible causes of error.

** NOTE: There are several components of error which could significantly modify the results of this experiment. Some of these are listed below:

- Ignoring acceleration due to gravity on the spinning mass
- Tilt on the measured object
- Drag and air resistance
- Variable lengths of the radius
- Measurement of the markings on the string
- Snagging and catching
- Calibration
- Sensor limitation parameters
- Computer processor speed and reading registration
- Sensor Alignment
- Other ...

A few of the potential errors listed above may be applicable to YOUR experiment