Physics Laboratory Report

Lab number and Title: Lab 114 – Uniform Circular Motion

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Date of Experiment: 11/09/2023 | **Date of Report Submission: 11/23/2023**

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

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1. INTRODUCTION

1.1 Objectives

This lab was about learning about and understanding what rotational components are, and how they affect what we do when spinning. In class, we learned about angular velocity, angular acceleration, centripetal acceleration, period, and frequency. These components are all about using rotation and relating them to translational components, the things we had been doing for the past few weeks. In the experiments, we had a rotating beam that had a mass connected to a spring, from which we had to calculate a couple of important factors. Forces, time, and frequency were all variables we had to solve for. Our group also completed the extra credit experiment as instructed in class.

1.2 Theoretical background

There were a couple of new variables that were introduced in this class. We learned the formulas for angular velocity (ω), angular acceleration (α), and how they relate to one another and their translational counterparts. The formulas we have are $v_t = \omega r$, $\omega = 2n\pi$, $a = 4r\pi^2n^2$, $a_c = v^2/r$. These, using derivations and understanding of core concepts, allowed us to calculate for factors such as velocity and acceleration using the radius. There were also two new variables that were not introduced in our main physics class, period and frequency. The equation for period is 2π/ω, while the equation for frequency is n = 1/T, meaning that it is the inverse of period. Period represents the amount of time it takes for one revolution, while frequency is how often it occurs. The higher the time it takes for one revolution, the less frequency would be, and vice versa.

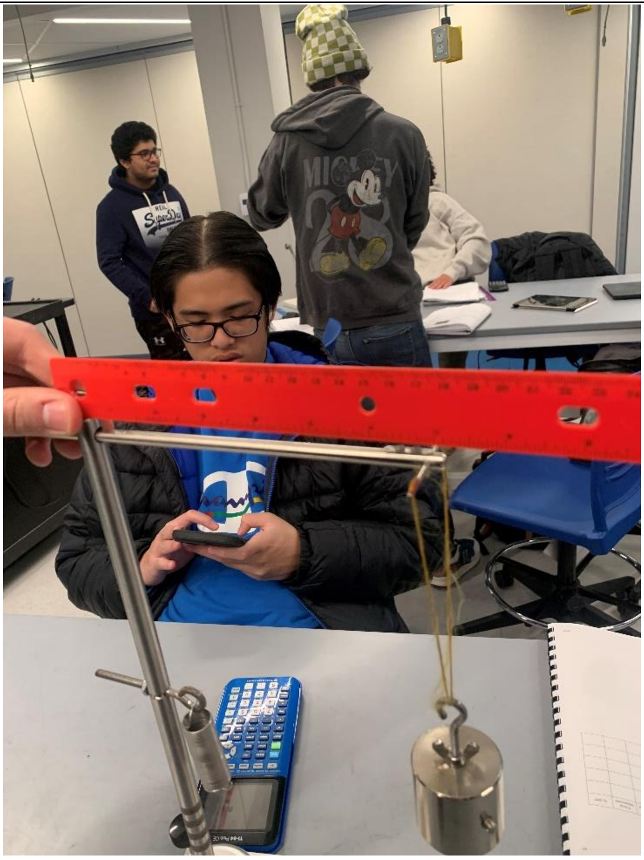
2 EXPERIMENTAL PROCEDURE

We followed the instructions for the experiment, as well as the instructions provided in class when doing the extra credit.

Experiment One

Hanging Mass Without Weight (0.4479kg)

Force Calculating Mass (0.745kg)



Radius from Center (0.16m)

Radius from Center - Closeup (0.16m)

Hanging Mass with Weight (0.4977kg)

Hanging Mass with Weight (0.5477kg)

Hanging Mass with Weight (0.4977kg)

Hanging Mass with Weight (0.647kg)

Mass of Counter balance (0.538kg)

Experimental Setup

Variables:

- Mass (m)
- Radius (r)
- Average Time for 50 Revolutions (t)
- Rotations per second (RTS)
- Force Computed (F_c)
- Force Measured (F_m)

Extra Credit

Force Mass for Extra Credit (0.7480kg)

Extra Credit Experiment Setup

Variables:

- Non-Stretched Spring Displacement (x_0)
- Stretched Spring Displacement (x)
- Spring constant (k)
- Hanging mass (m)
- Theoretical frequency (n)

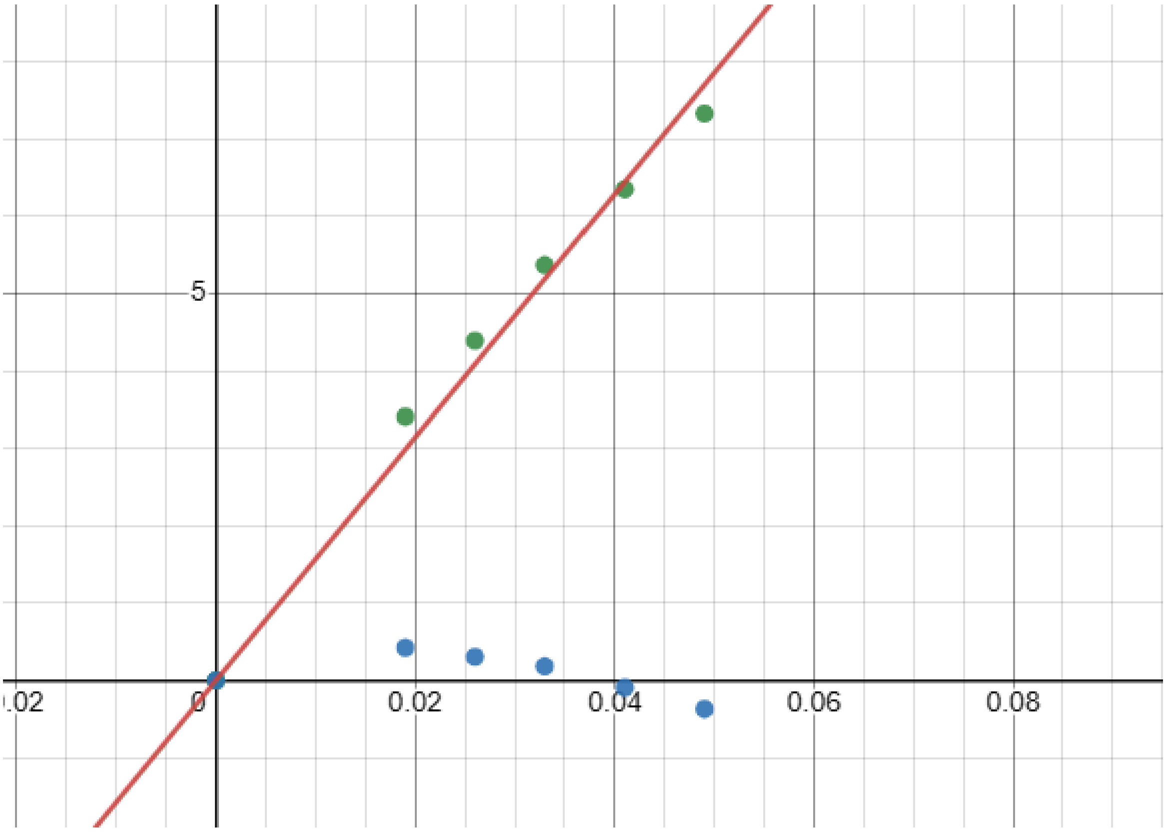
3 RESULTS

Experiment One

Trial	Mass (kg)	Radius (m)	Time for 50 Revs (s)	RPS (rev/s)	Force Computed (N)	Force Measured (N)	% Diff
1	0.4479	0.155	30.46	1.64	7.37	7.33	0.540%
2	0.4979	0.155	32.96	1.52	7.04	7.33	4.03%
3	0.5477	0.155	33.76	1.48	7.34	7.33	0.140%
4	0.5973	0.155	35.80	1.39	7.06	7.33	3.75%
5	0.6470	0.155	36.90	1.35	7.22	7.33	1.50%

We calculated the value for the time for 50 revolutions by setting up a timer and having two group members counting. We had to redo some trials (especially trial 5) several times to make it accurate since the weight moved away from the tape too much.

Extra Credit



Graph of values

X vector represents the distance between x and x_0

Y vector represents the force (mass*gravity) of the hanging mass to pull the spring

x_1	y_1	e_1
0	0	0
$.063 - .044$	3.41	0.42392719
$.07 - .044$	4.39	0.3037951
$.077 - .044$	5.37	0.18366302
$.085 - .044$	6.35	−0.093630799
$.093 - .044$	7.33	−0.37092461

$y_1 \sim mx_1$

STATISTICS

$R^2 = 0.9866$

RESIDUALS

e_1

PARAMETERS

$m = 157.162$

M represents the spring constant k. It is 157.162 N*m.

$$\sqrt{\frac{(157.162 \cdot .044)}{4\pi^2 \cdot .4479 \cdot .155}} = 1.58841457355$$

This is the value for n, the theoretical frequency. It's 1.588 s^{-1} or Hz.

The equation above represents the equation which was derived from setting the spring force (for which we found the spring constant for) equal to the net force of the rotational system.

4 ANALYSIS and DISCUSSION (20 points)

There was one experiment done for the lab, as well as the extra credit which was not part of the lab manual. For experiment one, we utilized our understanding of forces to determine the values which can be found in the chart. The formula for the computed force was by using the equation $F_c = 4\pi^2 mn^2 r$, for which we plugged in the values we found from the rest of the chart. For m, we used the hanging mass value, and the radius was measured from the axis of rotation to the center of mass of the hanging value. N was the value we found by doing the experiment for frequency. For the measured force, we used a hanging mass to determine the force in the spring, which would be equivalent. There is a error margin at the highest of 4%, which means that the value changes are very small. Some trials had a higher error percentage than others however, which likely means that were some small discrepancies in the force and if it was hitting the tape as instructed. These discrepancies, however, are minor.

There were some discussion questions in the manual that have to also be addressed. The first question asks us to see what is causing the centripetal force in the mass m. This is the string, which has a tension force going to the axis of rotation. If this string were not in place, there would be nothing holding the object in a circular path. The second question asks if the 5th and 6th equations are verified. The fifth equation represents the equation for centripetal acceleration. We know the original formula is $a_c = V_t^2/r$, but we know that V_t is equal to ω/r. Plugging that in, we do get an answer of $r^* \omega^2$, which can further be substituted for $r(2\pi n)^2$. This equation is verified. Equation six, the centripetal force is given as $4\pi^2 mn^2 r$. This similarly can be derived from the original equation F_c = ma, and plugging in for a using the same $a_c = V_t^2/r$. Doing this confirms the equation the manual gave is also verified.

Question three asks if the acceleration can exist if the velocity is constant, and the answer is yes because the direction of the object is changing. This constant turning requires an acceleration, which is centripetal. The translational acceleration however is 0. The same applies if the speed is constant. The fourth question asks if someone on the north pole, or the equator has a greater centripetal acceleration. Since the velocity is the same, it is dependent on the radius of where they are, which is why the person at the equator has a higher acceleration. Fifth, they give a diagram with two balls and ask which one is likely to break first. Considering all other factors are equal, the ball with the longer string has a higher centripetal acceleration, so it will break first. Lastly, it asks why the moon doesn’t fall to earth. The centripetal acceleration makes sure that it is coming towards the Earth, but its translational velocity pulls it away from being on a trajectory with Earth. This maintains the rotational movement of the Moon.

5 CONCLUSIONS

In summary, we learned to apply the fundamentals of rotational motion. It is a completely new sphere of study which adds onto our existing understanding of translational motion. I really enjoyed this lab and how it connects the current material to what we learned before. It does raise new questions about what other equations are interconnected, and how forces will be applied in the form of torque as learned in our main physics 1 class. Something thing I would like to change is the spring itself, so we can see changes to the force implemented to rotate. Overall, I found this lab very insightful.