PHYS 1401
General Physics I

EXPERIMENT 6
CENTRIPETAL FORCE

I. INTRODUCTION

The objective of this experiment is to measure the force needed to keep a mass rotating around in a circular path. In this experiment this force will be provided by a spring which stretches to allow the mass to rotate in a circle of known radius. Also the student will measure the period of rotation and from it calculate the centripetal force predicted by theory and compare it with the measured result.

II. APPARATUS

Beck's Centripetal Force apparatus, weight hanger and slotted weights, photogate, LabPro and a computer.

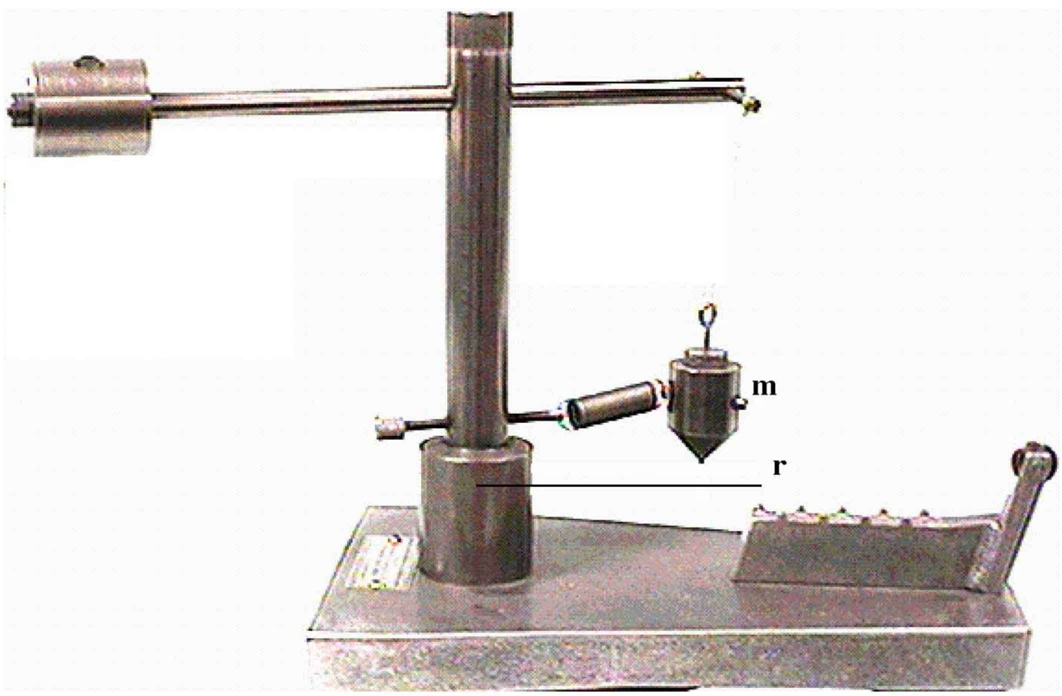

Figure 1: Beck's Centripetal Force Apparatus

III. EXPERIMENTAL PROCEDURE

1. Unhook the spring from the rotating mass and adjust the support bar until the rotating mass hangs directly above the $r = 0.14\,\text{m}$ mark. You will need about a 2 mm clearance. Tighten the screw securely.

2. Adjust the screw connected to one end of the spring to assure a reasonable amount of spring stretch when the apparatus is set in motion. Attach the hook on the other side of the spring to the rotating mass.

3. Rotating the apparatus at a constant speed and constant radius requires some practice so you may want to do several dry runs as practice runs. The idea here is to rotate the apparatus such that the tip of the rotating mass passes over the radius mark. This is an indication that the speed is constant. Practice doing this several times.

4. Now place the photogate such that the flag blocks and unblocks the beam as the mass rotates. Open the **Logger Pro** folder and open the **Centripetal Force** file. The computer will measure the period of rotation.

5. One of the lab partners will start the system rotating and when he/she feels that it is rotating with constant speed, another lab partner will start the timing process by clicking on the **start** button and time 10 rotations. Click on the **stop** button. The 10 periods measured by the computer should be very close to each other. If there is more than a 5% variation, the run should be repeated. Ask the computer to calculate the average period of rotation. Enter it in your data table.

6. Hook one end of the string to the rotating mass (when it is stationary) and run the string over the pulley with the hanger at the other end. Add masses to the hanger until the spring is stretched to the radius mark. This is the same amount of stretch it had when connected to the rotating mass and therefore the weight of this mass $W = m_{\mathrm{h}}g$ (including the hanger) is equal to the centripetal force for this run. Steps (5) and (6) must be done in succession for the same radius and identical spring conditions.

7. Adjust the support bar until the rotating mass hangs directly above the $r = 0.16\,\mathrm{m}$ mark. You *may* also have to adjust the screw holding the spring. Repeat steps (5) and (6) for the radii $r = 0.16\,\mathrm{m}, 0.18\,\mathrm{m}, 0.20\,\mathrm{m}$ and $0.22\,\mathrm{m}$ each time measuring the period of rotation and the hanging mass (not the rotating mass). Enter data in the data table.

8. Measure the mass M_{rot} of the rotating object using the digital balance.

9. You are done with the experimental procedure. Before you leave the lab, follow the steps in the analysis section and perform the required calculations to make sure your data are in agreement with the theory.

IV. ANALYSIS

1. Calculate the weight of the hanging mass for each run. This weight is equal to the centripetal force.

2. Calculate the speed of the rotating mass from the equation

$$v = \frac{2\pi r}{T} \tag{1}$$

3. Calculate the centripetal acceleration of the rotating mass from the equation

$$a_{\mathrm{c}} = \frac{v^2}{r} \tag{2}$$

4. Calculate the centripetal force using the equation

$$F_{\mathrm{c}} = M_{\mathrm{rot}} a_{\mathrm{c}} \tag{3}$$

5. Calculate the percent difference between the experimental and the theoretical centripetal force values

$$\%\,\text{difference} = \frac{|W - F_c|}{\left(\frac{W + F_c}{2}\right)} \times 100 \tag{4}$$

6. Write a conclusion summarizing your results. Comment on the success of this experiment. Explain any percent differences that are larger than 10%. If any of the percent differences you calculated are larger than 10%, you must come and see me before you turn in the lab report. What do you think are the two most important sources of error?

Experiment (8) Data Table			
Rotating Mass in (kg), $M_{\text{rot}} =$			
Circle Radius r (m)	Average Period T (s)	Hanging Mass m_{h} (kg)	Weight of Hanging Mass $W = m_{\text{h}}g$ (N)
0.140			
0.160			
0.180			
0.200			
0.220			

Circle Radius r (m)	$v = \frac{2\pi r}{T}$ (m/s)	$a_{\text{c}} = \frac{v^2}{r}$ m/s^2	$F_{\text{c}} = M_{\text{rot}}a_{\text{c}}$ (N)	Percent Difference
0.140				
0.160				
0.180				
0.200				
0.220				