Physics 12 /20 Name:____________________
Block: ____________________

Circular Orbits

Purpose: To investigate what factors are involved in the uniform circular motion of a mass revolving at the end of a string.

Materials:

- Glass or metal tube
- 1.5 m nylon thread
- Permanent marker or white out
- 12 metal washers
- Meter stick
- Timer (on cell phone)

Background:

A small mass, *m* (3 washers), orbits on the end of a string, as in Diagram 1, fast enough to support the force of gravity on the large mass, *M* (9 washers, or *3m*). The edge of the glass tube acts like a pulley, changing the direction of the force without changing its magnitude.

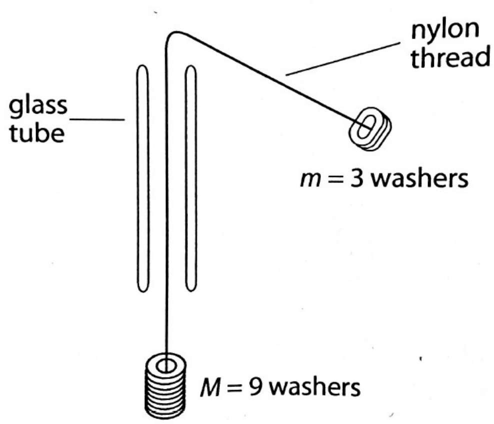

Diagram 1

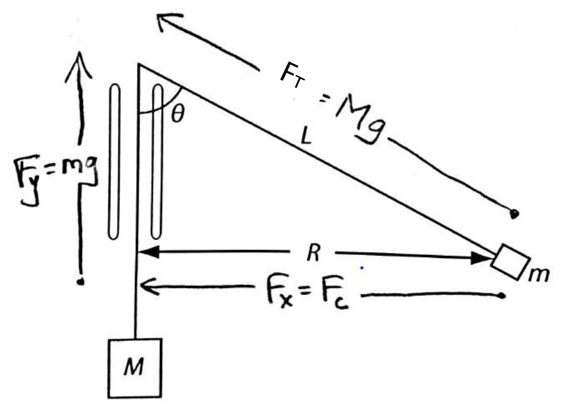

Diagram 2

When the small mass, *m*, is made to orbit around the top end of the glass tube, so that the large mass, *M*, remains stationary, the tension along the string is equal to the force of gravity on *M*. Thus, $F_T = Mg$.

If we consider the triangle made by the glass tube and the angled string with orbiting *m*, we can determine the components of F_T, as in Diagram 2. Note that the horizontal F_x is along the radius, *R*, of the orbit, and the hypotenuse of the triangle is *L* the length marked on the string from the glass tube to the small mass *m*. The F_y component of F_T supports mg of the small mass.

Procedure:

1. Set up the equipment as shown in Diagram 1. Tie with 3 knots. *Calculate* what angle θ, will be between the string and the vertical glass tube, when rotating and balanced. To find this theoretical angle, use trigonometry from Diagram 2.
2. In this lab you will vary *L* and measure the period of revolution *T* for each length *L*. Measure from the centre of gravity (middle of the washer hole) of the mass m along the string, and mark off distances of 20 cm, 40 cm, 60 cm, 80 cm, and 100 cm with a permanent marker or dab of white out.
3. Hold the glass tube vertically in your hand, and swing mass *m* until it achieves a stable orbit such that length *L* is 20 cm. While you keep *m* revolving, have your partners make the following measurements (as best as possible; it is difficult!):
    a. The radius of the orbit *R*: one partner hold a meter stick as near to the orbiting mass as possible (while avoiding decapitation) and estimate *R* (the horizontal distance) as closely as possible. Tilt metre stick so this partner can read it.
    b. The period of revolution *T*: other partner will time how long the mass takes to make 10 revolutions, then divide to determine time for each revolution.
4. Repeat step 3 for the other marked lengths. Record all your measurements into your lab in a table like the one below:

Length of String, *L* (cm)	Radius of Orbit, *R* (cm)	Period of Revolution, *T* (s)	sinθ = $\frac{R}{L}$	θ (°)	*T*□
20					
40					
60					
80					
100					

5. Plot a graph with *T* on the y-axis (since it is the dependent variable) and *L* on the x-axis (since it is the independent variable.) This will not be a straight line.
6. What power law will be needed to create a graph with a straight line? (T^n vs *L*, *n = ??*) Plot this graph (should be straight and through (0,0)).
7. Calculate the slope of the line with appropriate units.
8. Using the formula for centripetal force (with *T* in it) and trigonometry from Diagram 2, show that the theoretical slope of the line should be 1.34 s²/m.
   (Hints: F_c=F_x=Mgsin θ and r=Lsin θ and note the units you are looking for s²/m)
9. Calculate the percent difference between your measured slope and the theoretical one:

$$percent\ difference = \frac{|\,measured - theoretical\,|}{theoretical} \times 100\%$$

10. Calculate the percent difference between your theoretical angle (procedure 1) and experimental angle (average of 5 angle values in procedure 4).

Please return all lab equipment to the front of the class once you have completed the lab.

The Write-Up:

- Lab report with five sections 1. Title, 2. Purpose, 3. Materials, 4. Procedure, Data and Observations, (procedure **summarized** and insert data and observations into the flow of the procedure) and 5. Analysis/Conclusions.
- The lab should be in your own words, not simply a copy of a partner's lab!
- The write up should be very neat and organized – easy to read and interpret.

Hints for Analysis and Conclusions:

- Did you accomplish the purpose of the lab?
- Discuss what your results mean in terms of the physics concept being studied. Connection to formula/theory. What was learned through the lab? Did it prove a physics concept? Explain.
- Did the procedure lead to good results? Is there a better way to do the lab?
- List any inherent errors that affected the results like friction of… , reaction time of… , etc (NOT "human error").

Marking guide:

- Lab organized, all required sections (with diagrams in procedure) 4 marks
- Data table complete 3 marks
- Two graphs (by hand), slope calculation, theoretical angle and slope calculations, angle and slope % difference calculations 7 marks
- Analysis and Conclusion is complete (with at least 2 possible errors) 6 marks

Total: /20 marks

Due date:______________________________

Labs must be handed in on the due date. Your lab will not be accepted after others have been marked and returned. (*Personal Awareness and Responsibility Core Competency*)

If a student was away on the day of the lab, he/she can come to make up the lab, before it is handed back, immediately when he/she returns to school.