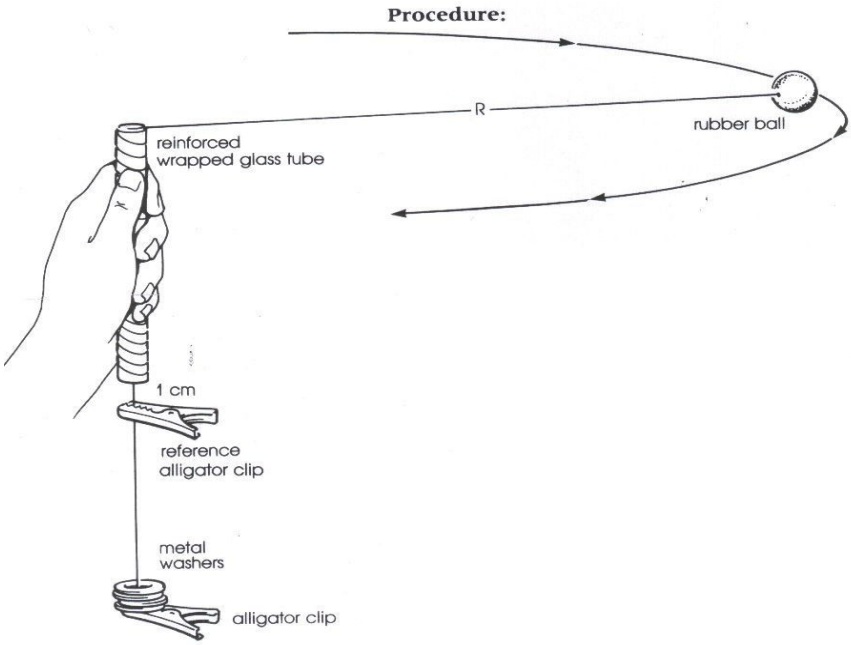
SPH4U Lab Activity: Centripetal Force **NAME:_____**

Purpose: What is the relationship between the centripetal force acting on an object undergoing uniform circular motion and the frequency, mass and radius of the motion?

Hypothesis: (state your own here AFTER reading the procedure) (2)

Materials:
2 identical rubber stoppers, 32 steel washers, 1 paper clip, fishing line (1.5 m), glass tube with smoothed ends, metre stick, stopwatch



Procedure:

Part A: Centripetal Force and Frequency.

1.Set up the apparatus as illustrated above. In place of the rubber ball use a rubber stopper. In place of the alligator clip, use the paper clip to suspend the washers. While holding the washers/clip, whirl the stopper in a horizontal circle above your head. Practice until you can keep the ball moving at a constant speed without moving your hand more than 3 cm to either side.
2. Place 8 washers on the end of the cord so that they are held suspended by the paper clip. Pull the cord so that the distance between the centre of the stopper and the glass tube is 100 cm. With the cord tight, attach a piece of tape (this is the reference tape) approximately 1 cm below the bottom of the glass tube. Throughout the experiment you should keep this piece of tape in the same position to ensure that the radius of motion is consistent.
3.While holding the paper clip/washers, whirl the stopper in a horizontal circle above your head. This time adjust the speed until you feel very little tension in the fishing line. Let go of the paper clip/washers and adjust the rotation rate so that the reference tape remains about 1 cm below the glass tube. Have your partner measure

the time to complete 15 rotations.
4.Use the following table to collect your data for part A.

# of Units of Force (# of washers)	# of Rotations	Time ( )	Frequency ( )	Frequency^2 ( )

**NOTE: The weight of the washers provides the centripetal force for the stopper.

5.Repeat this procedure, adding four washers each time until a total of 32 washers are used to generate the centripetal force on the stopper.
6.Complete the data table above by calculating frequency and frequency^2 for each trial. Show one sample calculation for each below. (6)

7.Plot a graph of (# of Units of Force) vs (Frequency). Include either a line or a curve of best fit. Staple your graph to this package. (5)
8.Plot a graph of (# of Units of Force) vs (Frequency^2). Include either a line or a curve of best fit. Staple your graph to this package. (5)

9.Does the shape of each graph make sense? Explain. (2)

10.Using your graph of (# of Units of Force) vs (Frequency^2), write a proportionality statement to describe the relationship between force and frequency for an object undergoing uniform circular motion. (1)

11.Calculate the slope of the graph of (# of Units of Force) vs (Frequency^2). What does this slope represent? Use this slope to write an equation for the relationship you described in step 10. (5)

12.Using this equation, determine the force (# of washers) required to maintain a stopper of the same mass in a circular path with the same radius you used and a frequency of 2.8 Hz. (3)

Part B: Centripetal Force and Mass.

13.Add an identical stopper to the one already attached to the fishing line, effectively doubling the mass.
14.With 32 washers still on the end of the fishing line (this is so that the F_c is also effectively doubled), whirl the two stoppers (making sure the reference tape is always 1 cm below the tube) and measure the time taken for 15 rotations.
15.Calculate the frequency for the motion in step 14. (3)

16.Compare the frequency you found in step 15 with the frequency for 16 washers in part A. What conclusion can you draw regarding the relationship between centripetal force and mass based on this result? Explain. (3)

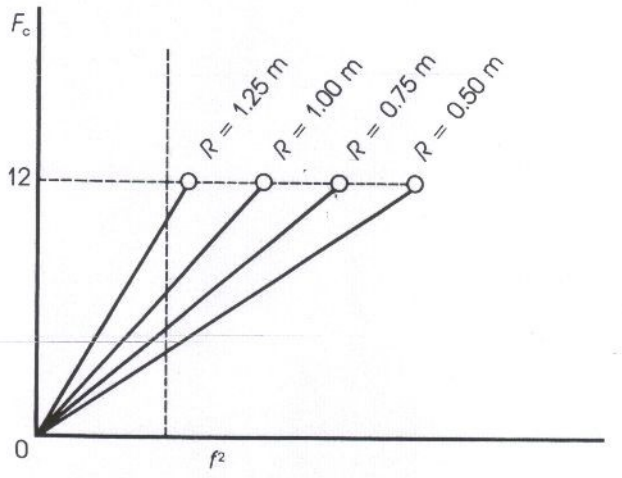
SPH4U Lab Activity: Centripetal Force **NAME:_____**

Part C: Centripetal Force and Radius.

17.Attach 12 washers to the end of the cord. Attach a new piece of reference tape such that the radius of motion is now 0.5 m. Rotate one stopper at a constant rate as you did previously, maintaining the reference tape 1 cm below the glass tube. Measure the time taken to complete 15 rotations.
18.Repeat step 17 for radii of 0.75 m, 1.00 m and 1.25 m. Record your data in the following table. (5)

Radius ( )	# of Rotations	Time ( )	Frequency ( )	Frequency^2 ( )

19.Calculate frequency^2 for each trial and complete the data table above.
20.Plot a graph of centripetal force vs. frequency^2. The graph should pass through the origin. Using the origin and the above data we can determine four values of f^2 for a constant F_c of 12 units. Plot four lines of F_c vs. f^2 on the same graph as shown below, one for each radius. (5)



21.Draw a dotted line parallel to the vertical axis of your graph, cutting each of the lines you've plotted. Using interpolation, find the force required for each radius to maintain the constant frequency^2 on the graph. Record your data in the following table. (2)

SPH4U Lab Activity: Centripetal Force **NAME:_____**

Radius ( )	Force (# of Washers)

22.Plot a graph of F_c vs. radius. (5)
23.Using the graph, determine the relationship between centripetal force and radius. (2)

Conclusion: (2 marks)

***** NOTE: All graphs should be stapled to this package.***