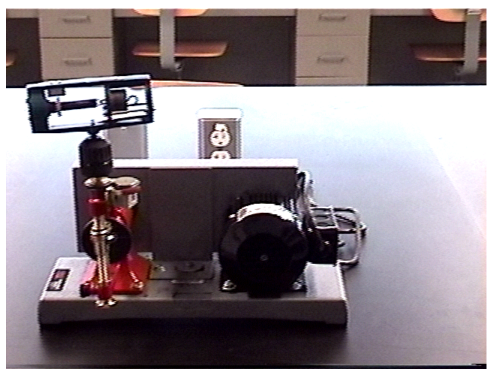
# PHYSICS LAB EXPERIMENT – 10

## UNIFORM CIRCULAR MOTION

**OBJECT**: The purpose of this lab is to study uniform circular motion, and to measure the centripetal force responsible for this motion.

**APPARATUS**: Centripetal acceleration machine, weights, stopwatch, ruler measuring down to 0.5 mm.

**INTRODUCTION**: The centripetal acceleration on a body in a uniform circular motion is: $\mathbf{a = V^2 / R}$, where R is the radius of the circle and V is the tangential velocity. Since V = R $\boldsymbol{\omega}$, the centripetal acceleration in terms of angular velocity is given by the equation a = $\mathbf{R\,\omega^2}$. However, $\boldsymbol{\omega = 2\pi\eta}$, where $\eta$ is the frequency of revolution or number of cycles per second (Hz), and so, $\mathbf{a = 4\,\pi^2\,\eta^2\,R}$. If m is the mass of the rotating object, the centripetal force responsible for a uniform circular motion is, $\mathbf{F = ma = 4\,\pi^2\,\eta^2\,R\,m}$.



**PROCEDURE**:

1. Set the tension of the centripetal machine on "very loose".
2. Run the machine and adjust the frequency until the spring is extended to the point where the needle attached to the lever is parallel to the frame.
3. Make note of the revolution counter reading and run the machine for 30 seconds. Note the final revolution counter reading. From the initial and final reading of the counter, calculate the number of revolutions (N) during this time period. Repeat this 5 times and record all data in the given table.
4. Calculate the average frequency ($\eta$) (average number of revolutions per second), and record in the table. Note the mass of the revolving weight (m), the extended radius of the spring (R), and record the values on the same page as the table. Make sure you do this *before* changing or readjusting the tension of the spring.
5. Calculate the centripetal force ($\mathbf{F_c = 4\,\pi^2\,\eta^2\,R\,m}$) from your data and record it in the table.
6. Now you will use the force of gravity on the spring to test the accuracy of the value you calculated in step 5. Hang the spring and the needle assembly from a rigid support. Start hanging weights from the lower end of the spring until the

needle flips again (i.e., spring is fully extended). This reproduces the same amount of extension in the spring as in the first part of the procedure.

7. Determine $F_g$. Record the value in the table. **Do not forget to add the weight of the rotating cylinder to the total weight**. Compare $F_c$ and $F_g$, and comment on the errors you observe.
8. Repeat the experiment with the tension of the machine spring set at the "medium" setting. Record the results and again consider what experimental errors might contribute to any discrepancy between $F_c$ and $F_g$.

**OBSERVATIONS**:

**Weight of cylinder m =______kg.**

**Radius of rotation of the cylinder in the extended position =_________m.**

| Spring Tension | Initial Reading | | Final Reading after 30 sec | N | $\eta = N/30$ | $F_c = 4\pi^2\eta^2Rm$ | $F_g = Mg$ | Abs. Error | % Error |
|---|---|---|---|---|---|---|---|---|---|
| **Loose** | $N_1$ | | | | | | | | |
| **M= (hanging mass+m)** | $N_2$ | | | | | | | | |
| | $N_3$ | | | | | | | | |
| | $N_4$ | | | | | | | | |
| | $N_5$ | | | | | | | | |
| **Average** | | | | | | | | | |
| | Initial Reading | | Final Reading after 30 sec | N | $\eta = N/30$ | $F_c = 4\pi^2\eta^2Rm$ | $F_g = Mg$ | Abs. Error | % Error |
| **medium** | $N_1$ | | | | | | | | |
| **M= (hanging mass+m)** | $N_2$ | | | | | | | | |
| | $N_3$ | | | | | | | | |
| | $N_4$ | | | | | | | | |
| | $N_5$ | | | | | | | | |
| **Average** | | | | | | | | | |

**QUESTIONS**:

1. How does the centripetal force on an object vary with the tangential speed of rotation (v) for a constant radius path? In other words, what must happen to the centripetal force as the velocity is raised or lowered?

2. How does the centripetal force vary with the radius of the path for a constant tangential speed of rotation?

3. The blades of a windshield wiper move through an angle of 120° in 0.34 s. The tips of the blades move on the arc of a circle that has a radius of 0.76 m.
   (a) What is the magnitude of the centripetal acceleration of the tip of the blade?

   (b) If a bug of mass 15.0 g is sitting on the tip of the blade, how much centripetal force is it experiencing?

4. Calculate at what speed the earth would have to rotate in order that an object at the equator would have no measured weight. Radius of the earth is about 6400 km.
   (a) What would be the tangential speed of a point at the equator?

   (b) What would be the length of the day (from sunrise to sunset) in hours?

5. How is the effective value of *g* affected due to the rotation of the Earth, (a) at the equator, and (b) at the poles? Explain briefly.