

## Chapter 3 Lab Activities

### Investigation 3.1.1 Analyzing Uniform Circular Motion

- This activity allows students to investigate uniform circular motion in terms of the centripetal force exerted on an object on the end of a string. The centripetal force is produced by the force of gravity acting on a suspended mass on the other end of the string.

#### BACKGROUND INFORMATION

A rubber stopper is tied to the end of a string that passes through a narrow glass tube and is tied at the other end to a known mass. The rubber stopper is then twirled around in uniform circular motion in a horizontal plane. As its speed of rotation increases, it moves in an ever-increasing radius. Gravity, acting on the suspended mass, produces the tension in the string. The force of gravity ( $F_g = Mg$ , where  $M$  is the mass of the suspended mass) provides the tension in the string and, thus, the centripetal force ( $4\pi^2 mrf^2$ , where  $m$  is the mass of the rubber stopper) that causes the acceleration of the rubber stopper in uniform circular motion. By twirling the rubber stopper with uniform circular motion at a constant radius, it is possible to calculate and compare the centripetal force acting on the stopper and the gravitational force acting on the suspended mass. These values should be equal.

#### Related Background Resources

- *Nelson Physics 12*, Section 3.1, pages 122–127

#### Teacher Preparation

**Time:** 10 min

#### Instructional Resources

- Textbook Investigation 3.1.1
- Lab and Study Master: Student Worksheet LSM 3.1-1 Investigation 3.1.1 Analyzing Uniform Circular Motion
- Appendix A1: Analyzing Experimental Data
- Appendix A1: Error Analysis in Experimentation
- Appendix A2: Planning an Investigation
- Appendix A5: Lab Reports

Material/Equipment	Quantity per station	Quantity for 16 stations
reinforced glass tube with smooth ends	1	16
1.5-m fishing line or strong, smooth string	1	16
one-holed rubber stoppers (equal size)	3	48
metal masses (50 g, 100 g, 200 g)	3	48
small paper clip or 2 cm length of masking tape	1	16
metre stick	1	16
graph paper	1 per student	1 per student
electronic balance	1 or 2 per class	2

**Materials and Equipment Notes**

- Wrap masking tape around the glass tubes for reinforcement. The ends of the glass tube must be smooth so that the string does not catch on anything.
- Students can work in groups of 3 or 4 to minimize the amount of equipment needed.

**Safety and Disposal**

- Students must exercise care when the rubber stoppers are whirling around at considerable speeds. It is suggested that students wear eye protection when working this lab.

**Assessment**

- Students can be assessed on their knowledge and understanding of uniform circular motion using Assessment Rubric 1: Knowledge/Understanding (Teacher's Resource).
- Students can be assessed on their inquiry skills and analysis of data using Assessment Rubric 2: Inquiry (Teacher's Resource).
- Students can be assessed on their communication skills if a lab report is required using Assessment Rubric 3: Communication (Teacher's Resource).
- Students can also be assessed on their ability to make connections using Assessment Rubric 4: Making Connections (Teacher's Resource).

**Student Preparation**

- Students should understand the concepts associated with uniform circular motion and centripetal force.
- Students should practice twirling the rubber stoppers so that they maintain the constant desired radius at a given rotational speed.
- Students should prepare data tables for this investigation before class.

**Pre-lab Discussions**

- A discussion of uniform circular motion and centripetal force is required before students attempt this investigation.
- Teachers should consider reading through the procedure step-by-step with the students to ensure a complete understanding of the analysis required in this investigation.
- Teachers should advise students of the necessary safety precautions.

**During the Lab**

- Teachers should monitor student progress as they perform this investigation.
- Teachers should alert the students of identifying systematic and random errors that they are likely to encounter.

**Post-lab Discussions**

- Teachers may want to discuss the results with the class. Students can identify sources of scientific error and suggest possible modifications to the procedure to minimize them.
- Students may want to refer to Appendix A1: on page 751, Error Analysis in Experimentation on page 755, Appendix A2: on page 764, and Appendix A5: on page 768.

**Extensions/Modifications**

- Ask students to calculate the radius of rotation to maintain uniform circular motion for a given frequency of rotation and masses. Students can attempt to verify their predictions with the materials used in this investigation.