Principles of Flight

Lesson Plan: Gyrocopters – Describing Rotary Motion

Grade Level: 11-12

Subject Area: Physics

Time Required: ***Preparation:*** 30 minutes
Activity: One class period (50 minutes)

National Standards Correlation:

Science (grades 9-12)

- History and Nature of Science Standard: Nature of scientific knowledge.
- History and Nature of Science Standard: Science as a human endeavor.
- Unifying Concepts and Processes Standard: Evidence, models, explanation.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Unifying Concepts and Processes Standard: Systems, order, and organization.
- Science as Inquiry Standard: Understandings about scientific inquiry.
- Science as Inquiry Standard: Abilities necessary to do scientific inquiry.
- Physical Science Standard: Motions and forces.
- Science and Technology Standard: Understandings about science and technology.

Summary:

Students will work in cooperative teams of three, and use self-made gyrocopters from the previous lesson (Gyrocopters-Producing Rotary Motion) to examine rotary motion in terms of angular displacement, angular velocity, and angular acceleration. Teams will calculate the average angular velocities for each gyrocopter tested as it falls by collecting the appropriate data of angular displacement and time of rotation, and will express their calculated angular velocities in the following units: Revolutions per second, revolutions per minute, and radians per second. Students will apply the "right-hand rule" of angular velocity to determine the direction of the axis of rotation since vector quantities such as velocity require both magnitude and direction, and will explore how changes in the release height affects the average angular velocity calculations.

Objectives:

Students will:

- Conduct experiments and record measurements of angular displacement.
- Conduct experiments and record measurements of rotation time.
- Calculate angular velocity value by applying the equation for angular velocity.
- Perform unit conversions.
- Apply the "right-hand" rule of angular velocity.
- Determine if height variations affect angular velocities achieved.

Background:

There are various types of motion such as linear, free-fall, projectile, circular, and rotary. Though each is distinctively different, all can be described in terms of displacement, velocity, and acceleration. When it comes to rotary motion, it is described in terms of angular displacement, angular velocity, and angular acceleration. Angular displacement is the angle about the axis of rotation through which the object turns and can be expressed in the units of revolutions, degrees, or radians. Angular velocity is defined as the time rate change in angular displacement. Angular acceleration is the constant rate of change of angular velocity. Even though the equations for each type of motion are specific, the basic means of description remains the same.

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Materials: You will need:

- 3 gyrocopters made of different materials (see "Gyrocopters – Producing Rotary Motion" Extensions at http://www.nationalmuseum.af.mil/shared/media/document/AFD-090714-008.pdf)
- Pencils
- Paper
- Metersticks or metric tape measure
- Calculators
- Stopwatches

Safety Instructions: Follow all pre-established lab safety guidelines and expectations.

Procedure:

A. Warm-up

1. Review the equation for the calculation of angular velocity.

$$\overline{W} = \emptyset_1 - \emptyset_2 / t_1 - t_2 = \Delta\emptyset / \Delta t$$

2. Review unit conversion factors between revolutions, degrees, and radians.

3. Obtain the three gyrocopters from the previous lesson made of different materials, but of the same size.

4. Review the job of each member of the team. Timer, Recorder/Observer, Launcher.

B. Activity I

1. Teams select their own release height for the gyrocopters, and record it in meters on the Flight Data Log. The same release height will be used for all flight trials.

2. The Launcher releases the gyrocopter from the selected height and counts the number of revolutions or spins the gyrocopter undergoes as it "falls" to the floor. This is the angular displacement. The timer records the total time of the gyrocopter's descent from the moment it is released until it touches the floor. The Recorder/Observer notes the direction of spin.

3. Record all data in the Flight Data Log.

4. Test each gyrocopter three times at this height, and record all data.

5. Noting the direction of spin for each gyrocopter, apply the "right-hand" rule to determine the direction of the angular velocity.

6. Calculate and record the magnitude of the average angular velocity for each of the three gyrocopters.

7. Perform unit conversions from revolutions per second to revolutions per minute and radians per second.

8. Vary the release height for the gyrocopters at least twice, repeating steps 2-7 with each variation. Be sure to record the height chosen.

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C. Wrap-up

1. Analyze all recorded observations, collected data, and calculations.

2. Discuss and compare results with other lab groups.

3. Write a conclusion based on the analysis of your results. Within your conclusion compare and contrast calculated average angular accelerations for each gyrocopter. Formulate possible.

4. Explanations for how differences in construction material affect rates of rotation. Also formulate possible explanations for how differences in release height affect rates of rotation.

Assessment/ Evaluation:

Students should be evaluated on the collection and organization of data, calculation performances, and conclusion responses.

Resources/ References:

Trinklein, Frederick E. “Rotary Motion, ” Modern Physics,” Holt, Rhinehart and Winston. Austin TX 78741, 1990.

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Gyrocopters – Describing Rotary Motion

Name _____

Launch Height (m) _____

Gyrocopter	Modification /Description	Number of Revolutions (Angular Displacement) (sec)	Direction of Spin	Descent Time (sec)	Direction of Angular Velocity	Average Angular Velocity		
						Rev/ sec	Rev/ min	Rad/ sec
1								
2								
3								

Launch Height (m) _____

Gyrocopter	Modification /Description	Number of Revolutions (Angular Displacement) (sec)	Direction of Spin	Descent Time (sec)	Direction of Angular Velocity	Average Angular Velocity		
						Rev/ sec	Rev/ min	Rad/ sec
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2								
3								

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