Principles of Flight

Lesson Plan: Gyrocopters – Producing Rotary Motion

Grade Level: 10-12

Subject Area: Physical Science/Physics

Time Required: ***Preparation:*** 30 minutes
Activity: 2 50-minute class periods

National Standards Correlation:

Science (grades 9-12)

- Science as Inquiry Standard: Ability Necessary to do scientific inquiry.
- Unifying Concepts and Processes Standard: Evidence, models and explanation.
- Unifying Concepts and Processes Standard: Form and function.
- Unifying Concepts and Processes Standard: Change, constancy, and measurement.
- Physical Science Standard: Motions and forces.

Summary:

Students will work in cooperative groups of three and use self-made gyrocopters to examine the production of rotary motion. Students will be instructed to experiment with different gyrocopter construction materials, blade orientations, blade lengths and mass distributions in order to determine how such variation effect torque (both clockwise and counterclockwise) and rotational inertia.

Objectives:

Students will:

- Construct gyrocopters following verbal, visual, and written instructions.
- Demonstrate rotary motion using the gyrocopters.
- Investigate how changing variables of blade orientation, blade length, and mass distribution affect rotary motion.
- Make and record observations.
- Determine the relationship existing between torque arm length and torque, and between mass distribution and rotational inertia.
- Explain why blade orientation determines whether applied torque will be clockwise or counterclockwise.

Background:

A gyrocopter is a simple device that, like a helicopter, operates using rotary motion. Helicopter rotors are, essentially, rotating wings. Rotary motion is defined as the spinning motion of a body about an internal axis. Newton's laws govern all forms of motion, including rotary. Newton's second law informs us that an object accelerates linearly (in as straight line) as a result of an applied force. If applied forces produce linear motion, what produces rotary motion? Torque is said to be to rotary motion what force is to linear motion. Commonly, torque is defined as the product of an applied force and the length of its torque arm, that is, the distance between the point of force application and the point of rotation or the spin axis. Therefore, any object that rotates or spins does so due to an applied torque. It is easy to observe that rotary motion can occur in either a clockwise or counterclockwise direction. As a result, torque is also designated as clockwise or counterclockwise. Newton's first law must also be considered when examining rotary motion. The first law implies that all objects possess inertia, which is defined as a resistance to a change in motion or position by an object. Inertia is directly related to mass, meaning that the more massive the object is the greater the inertia it possess. From this relationship, we know that

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objects with greater inertia require greater forces to be applied in order to change their states of motion or position linearly. When considering rotary motion, objects with the ability to spin possess rotational inertia. Rotational inertia not only depends upon the total mass of the object, but also the distribution of the mass within or upon the object. Therefore, the greater the rotational inertia, the more torque must be to produce to change the object's rotation.

Materials:

Each group will need:

- Gyrocopter template/pattern
- Pencil
- Paper
- Paper clips (for added weight)
- Scissors
- Metric rulers
- Construction materials such as construction paper, typing paper, poster board, paper bags, lightweight vinyl or plastic

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

Procedure:

A. Warm-up

1. Review Newton's three laws of motion.
2. Discuss rotary motion in terms of torque and rotational inertia.
3. Review the job of each member of the group: Pilot, Measurer, and Recorder.

B. Activity I

1. Choose a construction material from those provided.
2. Construct three gyrocopters from the same material using the master pattern sheet, but vary the blade length for each gyrocopter.
   - Cut on the solid black lines.
   - Fold on the dotted line at "A" so the fold does not cover the name.
   - Fold on the dotted line at "B" so the fold does not cover the name.
   - Fold on the dotted line at "C" so the fold does not cover the name.
   - Fold on the dotted line at "D" so the fold does not cover the name, and fold on the dotted line at "E" so the fold covers the name.
   - Bring the two "wings" up so they are perpendicular to the ABC section

C. Activity II

1. Fly each gyrocopter by releasing it from overhead.
2. For each gyrocopter, observe the direction of spin.
3. Record spin direction on the Flight Data Log.
4. Switch blade orientation and observe and record resulting changes in the rotary motion of the gyrocopter.
5. Repeat steps 1-4 for each gyrocopter.
6. Measure and record the blade lengths of all three gyrocopters in centimeters.
7. Compare and contrast the rotary motion of all three and record your observations.

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8. Using the first gyrocopter constructed, vary mass distribution along the blades and rotational axis by adding more paper clips. Conduct at least three variations.

9. Repeat this step with the other two gyrocopters.

10. Compare and contrast the rotary motion when more weight is added, and record your observations.

11. Label and save all gyrocopters constructed during this activity for use in an additional lab on rotary motion.

D. Wrap-up

1. Analyze all recorded observations and collect data.

2. Discuss and compare results with other lab groups.

3. Write a conclusion based on the analysis of your results. Within your conclusion explain the relationship you observed to exist between blade length and torque, and mass distribution and torque.

Assessment/ Evaluation:

Students will be evaluated on the accuracy of observations, collection and organization of data, and conclusion responses.

Extension:

Choose two different construction materials and construct two additional gyrocopters the same size as the first. Repeat the experiment. Record, compare, and contrast the rotary motion of these three different gyrocopters. These gyrocopters of different materials will be used in the next activity: "Gyrocopters – Describing Rotary Motion" (see http://www.nationalmuseum.af.mil/shared/media/document/AFD-090714-010.pdf)

Resources/ References:

Hixson, B.K. "Tubular Copters." The Wild Goose Company, Salt Lake City, UT 84115, 1991.

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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
1								
2								
3								

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GYROCOPTER PATTERN Cut on solid lines, fold on dotted lines