ASEN 3200 LAB A-1 BICYCLE WHEEL GYRO

Assigned: 10 March 2005
Report Due: 17 March 2005

OBJECTIVES

• Investigate gyro dynamics using a rim-loaded bicycle wheel.
• Observe and analyze precession of a gyroscope.
• Observe and analyze the use a control moment gyro to reorient an object.

PRELIMINARY QUESTIONS

1) Develop a model for the moment of inertia matrix of a rim loaded bicycle wheel. Assume that 60 percent of the weight of the wheel is concentrated in the rim and tire, and that the moment of inertia of the rim and tire about the center of mass constitute 95 percent of the total moment of inertia.

2) Develop an expression for the precession rate of the bicycle wheel gyroscope. Which of the following measurements do you need in order to predict the precession rate - mass of the wheel, moment of inertia of the wheel, distance from the center of mass to the point where the axle is attached to the support string, radius of the wheel, and speed of wheel rotation?

3) You are sitting on a stool, free to rotate about the vertical, holding the spinning bicycle wheel in front of you with the spin axis horizontal. Describe how the spin axis should be moved so that a torque is obtained about the vertical axis, i.e. so that you are rotated on the stool?

EQUIPMENT

Ruler, rim-loaded bicycle wheel, spin-up motor, bicycle wheel speed sensor, stopwatch, low-friction lab stool

PROCEDURE

There are two sets of hardware for this experiment. Groups will need to take turns observing and measuring data for each of the parts below.

A. Measure the precession rate of the bicycle wheel gyroscope.

   1) Measure the wheel diameter and axle length from center of mass to the support point. Predict the gyroscope precession rate as a function of wheel spin rate.
   2) Spin up the wheel using the motor, holding the spin axis horizontal. Note that the wheel speed sensor only works for spin in one direction.
   3) Hang the spinning wheel from the support string and measure the resulting precession rate by timing the period of precession over several full rotations.

B. Determine how to use a bicycle wheel as a control moment gyro to obtain pointing torque.

   1) Sit on the swivel stool with feet on the support rung. Hold the bicycle wheel in front of you with arms straight and axle horizontal. Have another group member spin up the wheel using the motor. Experiment with moving the spin axis. Try to obtain reaction torques that cause you to rotate about the stool vertical axis.
   2) Use the wheel to point your horizontal body axis (e.g. the axis described by our outstretched arms) to track a moving reference point (e.g. a walking group member).
   3) Try this with more than 1 group member and note any differences in performance.

ANALYSIS

A. Describe the method and assumptions used to develop the expression relating wheel speed to precession rate. Compare your predicted precession rate with the measured rate. What are the possible sources of error? How much could each contribute to the result?

B. Explain qualitatively how you were able to obtain pointing torque using the bicycle wheel as a control moment gyro. Use diagrams as appropriate.
REPORT OUTLINE & GRADING

Title Page (1 pt) – Lab, Course Number, Group Members, Date

Abstract (5 pts) – short summary of objectives, experiment, results, and analysis

A. Gyro Precession (20 pts)
   • Experiment – list equipment, detailed procedures
   • Results – give table of results (including units), observations made during the experiment
   • Analysis – present your computations of expected precession, compare with experimental results, describe and quantify possible sources of error

B. Control Moment Gyro (10 pts)
   • Experiment – list equipment, detailed procedures
   • Results – give qualitative results of this experiment, observations made during the experiment
   • Analysis – explain the results you obtained; use diagrams to show what results you expected compared to what was obtained

Conclusions and Recommendations (5 pts)
   • What did you learn from this experiment?
   • What would you recommend to improve the experiment or to extend it beyond the given objectives?

Acknowledgements (1 pt) Who did what in the group and what outside assistance you received

References

[Style & Clarity 8 pts]
Organization (2) – clear flow, follows required outline, numbered pages
Figures (2) – clear figures, appropriate axes, informative titles
Tables (2) – clear tables, significant figures, headings, informative titles
Spelling & Grammar (2)