Respiratory Dynamics Project

ASE 330M

Note: All documents and files should also be turned in electronically. Place everything in a single zip file and submit via Canvas.

## Project Summary

A gyroscope is a 3-dimensional mechanical system designed to keep an inner axis pointed in a steady orientation independent of the overall motion of the system. Gyroscopes are used to measure angular motion or to enable ships or aircraft to navigate without known bearings. This project will focus on deriving the equations of motion of a gyroscope and explore those dynamics based on a given input to the overall system. The project will end with a closed loop controller driving a specific behavior of the system.

## Project Background

ECP's four axis Control Moment Gyroscope (shown in the picture below) is a dynamically rich system that provides superb demonstrations of multi-DOF rigid body control. Elementary experiments are readily performed that readily show the fascinating phenomenon of gyroscopic torque and its use in precision high authority control. More advanced topics range from MIMO linear control to fully general nonlinear control with singularity avoidance. Thus the system yields demonstrations that are intriguing to the layman and post-doctorate alike! In addition, the plant may be used to emulate the control of satellite attitude. Stimulating experiments first show the open loop nutation modes and then demonstrates their effective control.


The apparatus includes low friction slip rings at axes 3 and 4 for unlimited range of motion, and precision encoders for feedback of all position and velocity states. A host of safety features such as fail-safe brakes, inertial switches, and real-time watch-dog monitoring provide for safe operation of the apparatus.

## Analysis, Simulation and Animation

Use the Control Moment Gyroscope and information provided by the manufacturer to

1. Analyze the kinematics of the gyroscope for configuration 1, configuration 2, and configuration 3.
2. Show a free-body diagram for each of the first three conficurations.
3. Derive the equations of motion and represent in state-space format. Give expressions for the reaction forces/torques when appropriate. Consider configuration 1, configuration 2, and configuration 3.
4. For configuration 3, design an appropriate feedback control law for the input torque to force the gyroscope angular velocity $\omega_3$ to follow a desired profile.
5. Perform a dynamic simulation to steady-state for the apparatus in configuration 3 and create an animation of the motion of the device.

Advanced tasks:

1. Consider the above for configuration 4 and configuration 5.