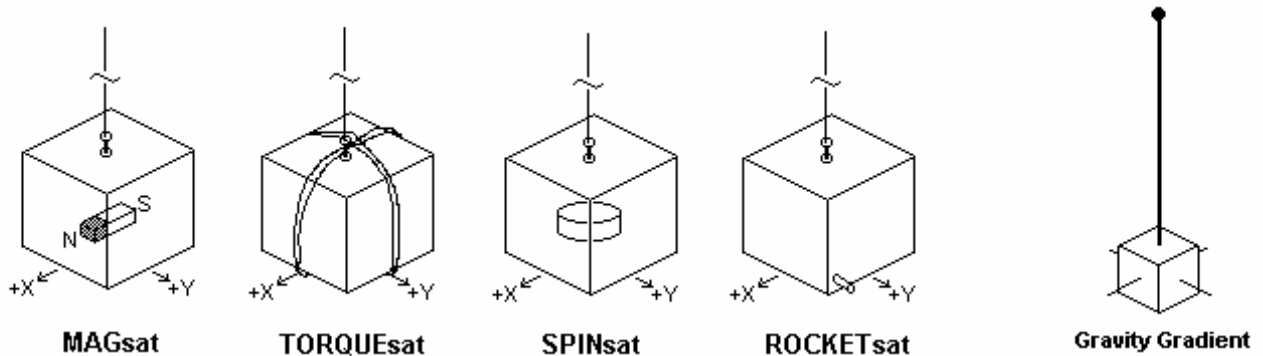


Introduction: This lab is a short demonstration of a more detail Attitude Control lab you will do in your first class year. Even though we are in a lab on the ground, in air and in a 1 G environment, we can still demonstrate most of the attitude control mechanisms that are used in space (except gravity gradient).

The forces needed to change the attitude of a spacecraft are extremely small in space, but are effective because all other forces acting on the spacecraft in the vacuum and microgravity of space are even smaller. Although it is difficult to achieve these minute forces in the lab, we can get close enough in one dimension by hanging our four models on a thin string as follows.



Passive Alignment Active Control Momentum Wheel Hot Gas Thruster Can't Do in Lab

COMMAND LINK: The USNA LABsats have 5 channels of analog telemetry and two ON/OFF circuits called CTRL-A and CTRL-B that can be initiated under a secure control link from the ground. You will use these commands to activate the momentum wheel and the torque coils or thrusters. But note, that there are significant delays in the exchange of data and acknowledgments like the internet or any other packet-switched network, so precise timing is not possible with this manual command system. Anticipate a second or more delays between command and response..

Part A: The Earth's Magnetic Field:

Look at your compass to see the direction of the Earth's magnetic field in this room. Visualize parallel magnetic flux lines permeating the volume of this lab and imagine how the magnets on the spacecraft will interact with this field.

Part B: MAGsat Passive Magnetic Stabilization:

Passive magnetic stabilization (as used on PCSAT-1) is one of the easiest stabilization methods for spacecraft. It will keep one axis of the satellite aligned with the Earth's magnetic field. MAGsat has a bar magnet attached to its payload plate. By the time you get to the lab, this satellite will have stabilized so that the +X face of the satellite will have aligned with the white north-seeking pole of the magnet to point North.

To verify that the satellite can easily align with the earths magnetic field, hold the satellite and carefully move the magnet to any other face you want to align to north. Then carefully release the satellite and watch as the satellite will realign in the given direction. Without damping, this can take some time.

Part C: TORQUEsat Torquing Coils:

TORQUEsat has two orthogonal coils wound from 205 turns of wire operated from 7 volts. These two coils may be individually activated using the commands CTRL A ON or CTRL B ON. The North seeking pole of the coils is marked on the satellite. Maximum torque is achieved when the coil is energized when its vector is perpendicular to the magnetic field.

- 1) Choose the A or B axis that is closer to being orthogonal to the Earth's field and note closely its exact orientation. Send the CTRL A ON or CTRL B ON command to energize the proper coil. Observe the spacecraft begin to change its orientation.
- 2) Next, observe the orientation of the other coil with respect to the Earth's magnetic field. We will be looking for the right point to activate this coil to continue turning the spacecraft. By proper on/off pulsing of the two coils, we should be able to spin up the spacecraft.

Part D: SPINsat Momentum Wheel:

SPINsat has a small 2.5" diameter momentum wheel disk connected to a motor. From rest, we will send commands to start the motor and observe the speed of rotation of both the momentum wheel and opposite reaction spin of the spacecraft. The motor will run at something around 9,000 RPM.

- 1) Command station sends CTRL A ON to spin the motor. Listen as it spins up to steady state. While it is accelerating to the final speed, it is exerting an equal and opposite torque on the spacecraft which will begin to spin in the opposite direction.
- 2) At steady state, both the wheel and the spacecraft are spinning at constant rates. This situation can remain indefinitely (though here in the lab, the string is being wound up and this begins to detract from the spin of the spacecraft as well as air friction).
- 3) At this time, we can send the command to turn off the momentum wheel and the reactive friction of the slowing motor will also cause an opposite countertorque on the spacecraft. In fact, as the motor returns to zero speed, so to will the spacecraft.

Part E: ROCKETsat Thrusters:

ROCKETsat has two small model rocket thrusters that can impart a torque on the spacecraft about the Z axis. For safe operation and to avoid the noxious fumes, it is set up outside the window but clearly visible from inside. One thruster provides a clockwise rotation and the other provides a counter-clockwise rotation.

- 1) First we will send the ARM command which connects power to the firing circuits for both thrusters. There is an LED by each thruster which should light when armed *and* when the circuit through the thruster's igniter is properly connected.
- 2) If both ARM lamps are lit, then we will send the CTRL A ON command to fire the clockwise thruster. This should significantly spin up the spacecraft. Because the thrust is only applied on one side, there will also be some translational wobble as well as the spin.
- 3) Estimate the revolutions per second of the spacecraft.
- 4) Before it begins to slow down due to counter-torque from the string, fire the opposite CCW thruster. If this thrust is identical to the original thruster, it should counter all the angular momentum applied by the first thruster and the satellite should stop spinning (at least to the degree of equality between the two thrusters).