Autonomous Vehicle Simulation (AVS) Laboratory, University of Colorado

Basilisk Technical Memorandum

Document ID: Basilisk-hingedRigidBodyStateEffector

HINGED RIGID BODY DYNAMICS MODEL

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Status: Initial document draft
Scope/Contents
The hinged rigid body class is an instantiation of the state effector abstract class. The integrated test is validating the interaction between the hinged rigid body module and the rigid body hub that it is attached to. In this case, a hinged rigid body has a diagonal inertia tensor and is attached to the hub by a single degree of freedom torsional hinged with a linear spring constant and linear damping term. The integrated tests has two scenarios it is testing: one with gravity and one without gravity. In both cases orbital energy, orbital momentum, rotational energy, and rotational angular momentum should all be conserved. This integrated test validates for both scenarios that all of these paramters are conserved.

Rev	Change Description	By	Date
1.0	Initial draft	C. Allard	20170705
1.1	Update to new format	C. Allard	20170714

Contents

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1 Model Description

The hinged rigid body class is an instantiation of the state effector abstract class. The state effector abstract class is a base class for modules that have dynamic states or degrees of freedom with respect to the rigid body hub. Examples of these would be reaction wheels, variable speed control moment gyroscopes, fuel slosh particles, etc. Since the state effectors are attached to the hub, the state effectors are directly affecting the hub as well as the hub is back affecting the state effectors.

Specifically, a hinged rigid body state effector is a rigid body that has a diagonal inertia with respect to its $\mathcal{S}_i$ frame as seen in Figure 1. It is attached to the hub through a hinge with a linear torsional spring and linear damping term. The dynamics of this multi-body problem have been derived

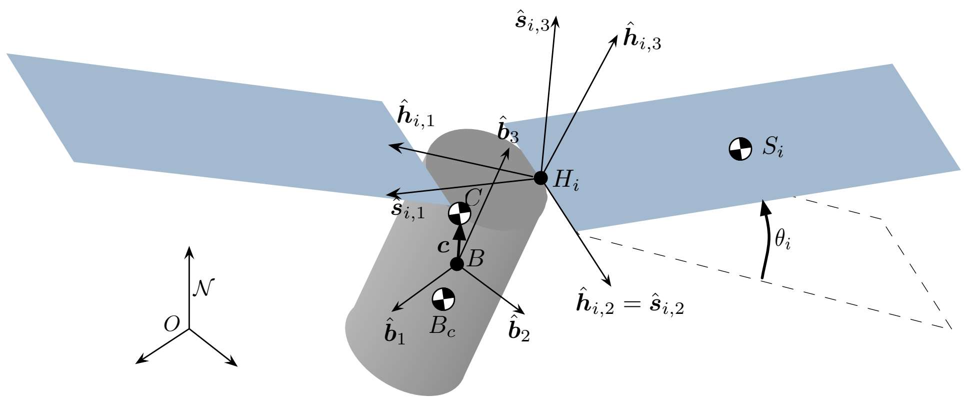

Fig. 1: Hinged rigid body frame and variable definitions

2 Model Functions

This module is intended to be used an approximation to a flexing body attached to the spacecraft. Examples include solar arrays, antennas, and other appended bodies that would exhibit flexing behavior.

3 Model Assumptions and Limitations

Below is a summary of the assumptions/limitations:

- The hinged rigid body must have a diagonal inertia tensor with respect the $\mathcal{S}_i$ frame as seen in Figure 1
- Only linear spring and linear damping terms
- Will only approximate one flexing mode at a time
- The hinged rigid will always stay attached to the hub (the hinge does not have torque limits)
- The hinge does not have travel limits, therefore if the spring is not stiff enough it will unrealistically travel through bounds such as running into the spacecraft hub
- The EOMs are nonlinear equations of motion, therefore there can be inaccuracies that result from integration. Having a time step of $<= 10$ sec is recommended.

4 Test Description and Success Criteria

This test is located in `SimCode/dynamics/HingedRigidBodies/UnitTest/test_hingedRigidBodyStateEffector.py`

5 Test Parameters

`Test parameters and inputs go here. I think that success criteria would work better here than in the test description section.`

5.1 Test Results

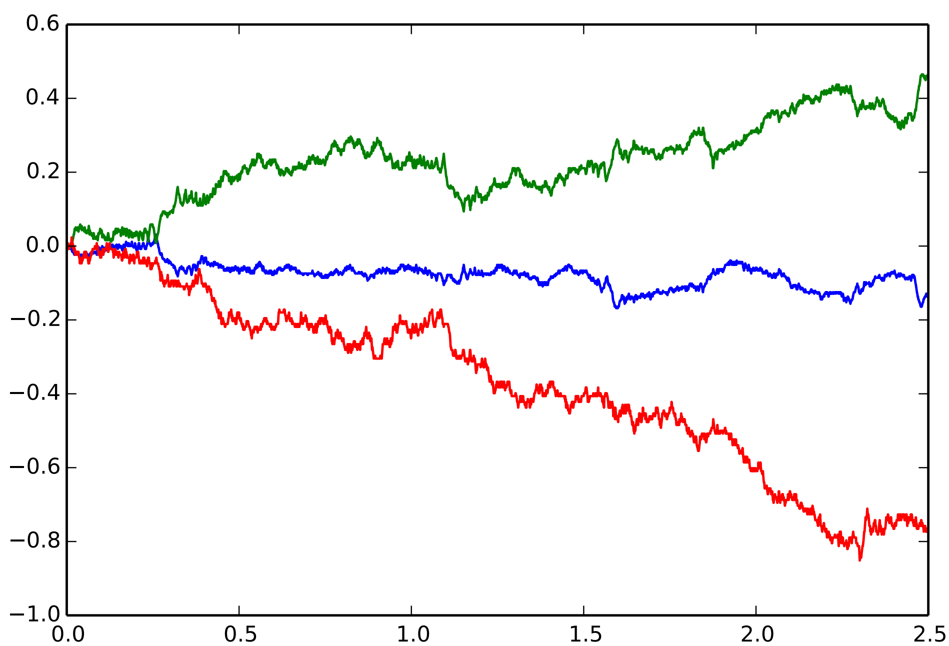

Fig. 2: Change in Orbital Angular Momentum with Gravity

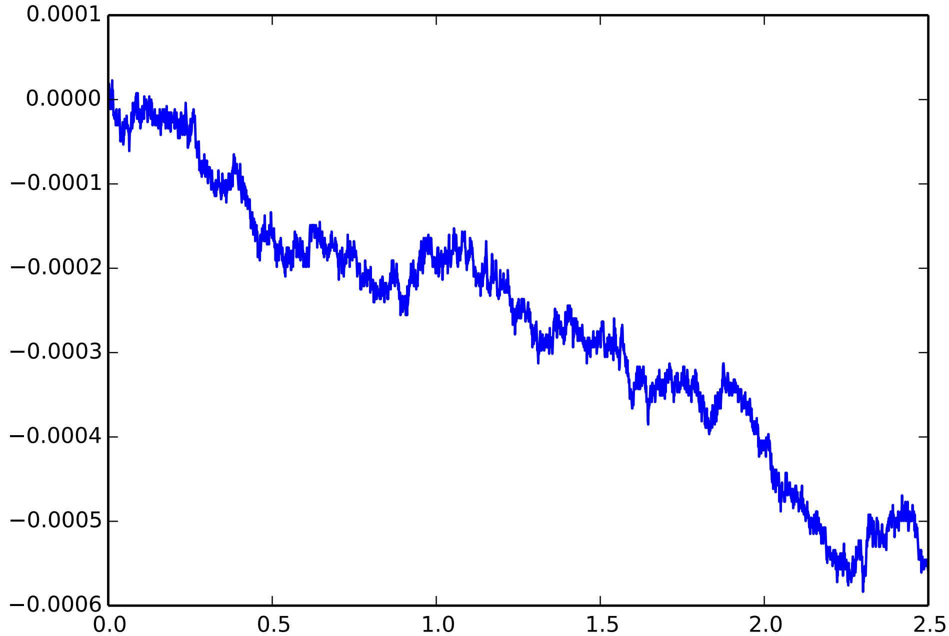

Fig. 3: Change in Orbital Energy with Gravity

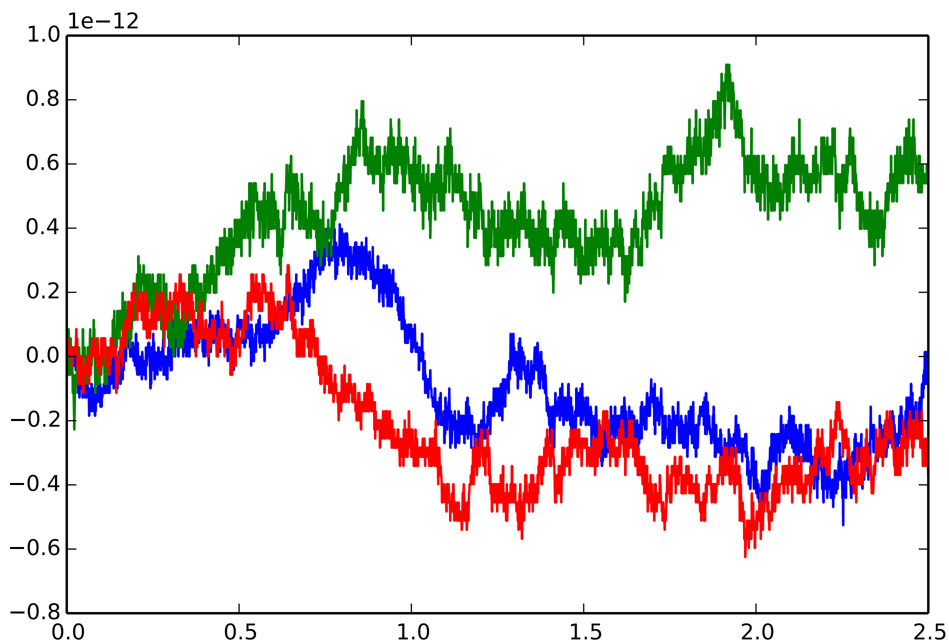

Fig. 4: Change In Rotational Angular Momentum with Gravity

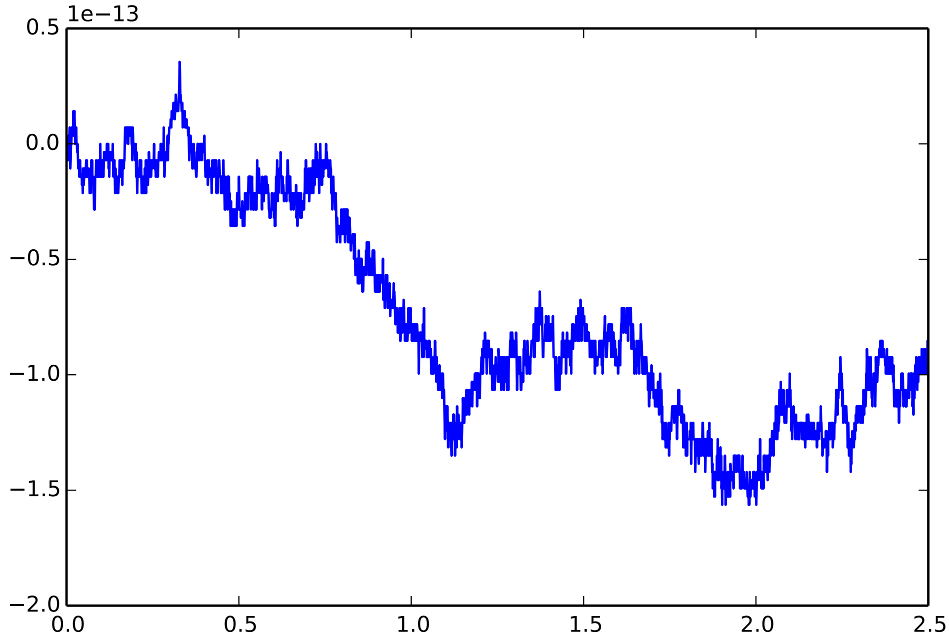

Fig. 5: Change In Rotational Energy with Gravity

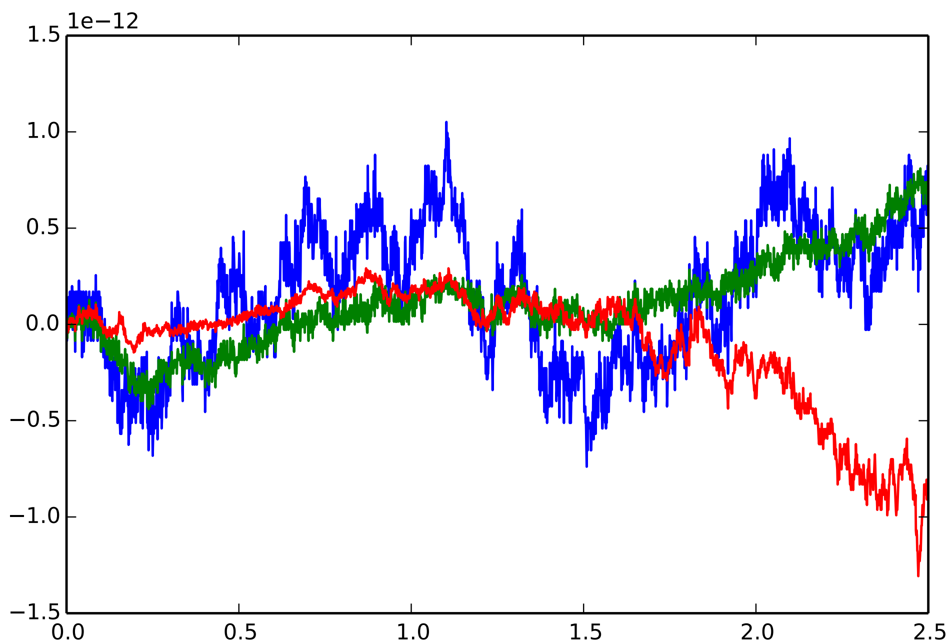

Fig. 6: Change in Orbital Angular Momentum No Gravity

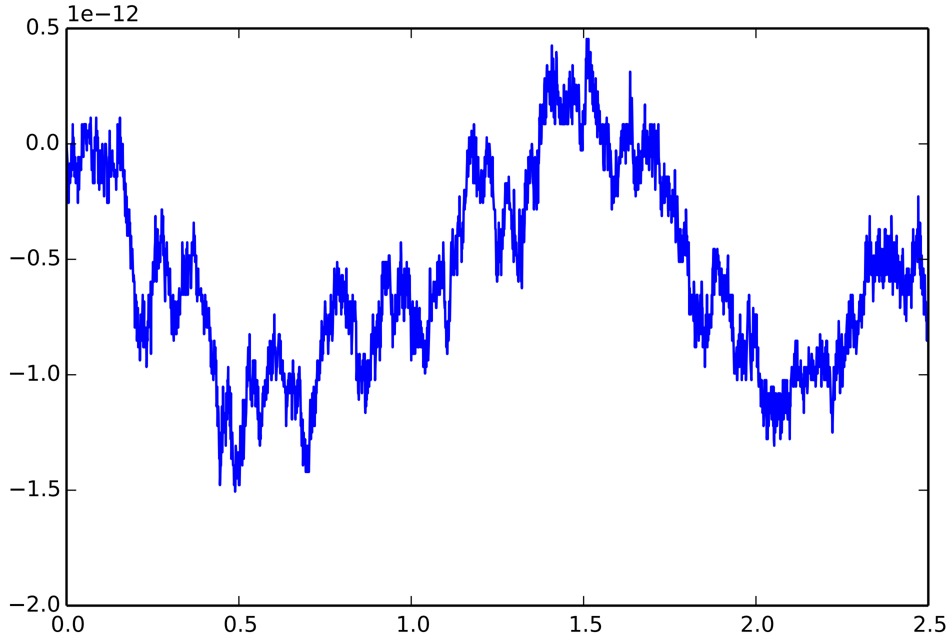

Fig. 7: Change in Orbital Energy No Gravity

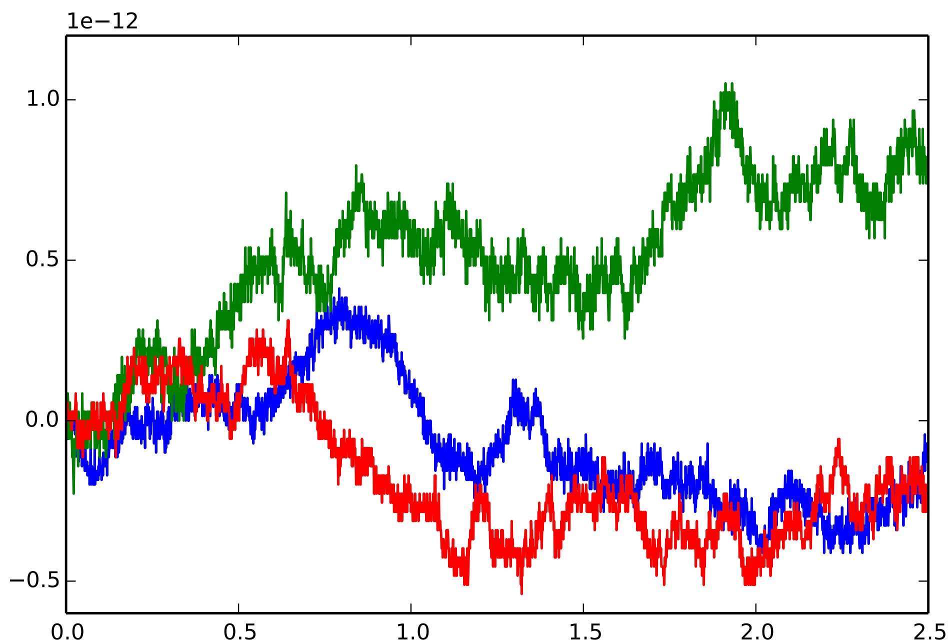

Fig. 8: Change In Rotational Angular Momentum No Gravity

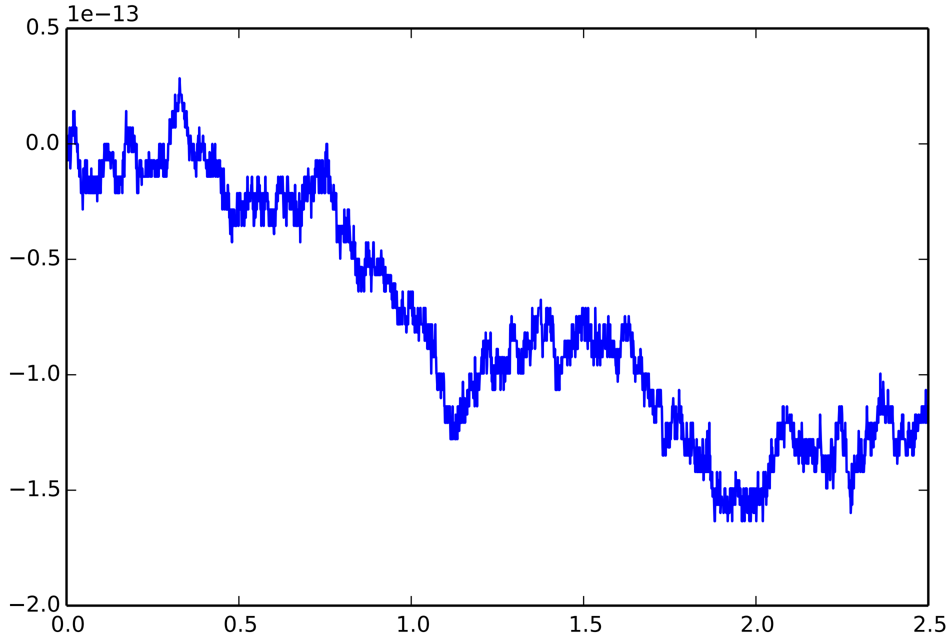

Fig. 9: Change In Rotational Energy No Gravity

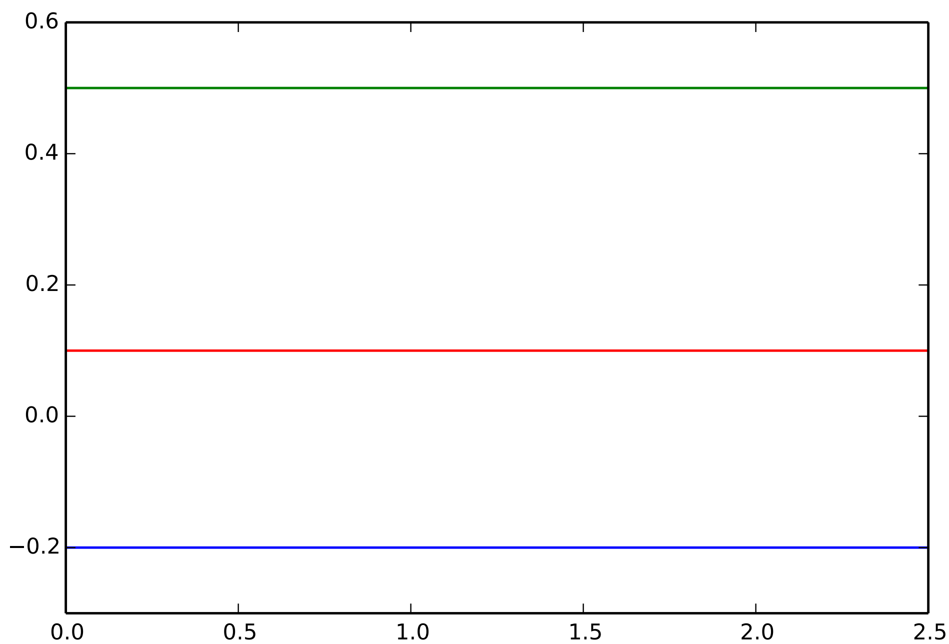

Fig. 10: Velocity Of Center Of Mass No Gravity

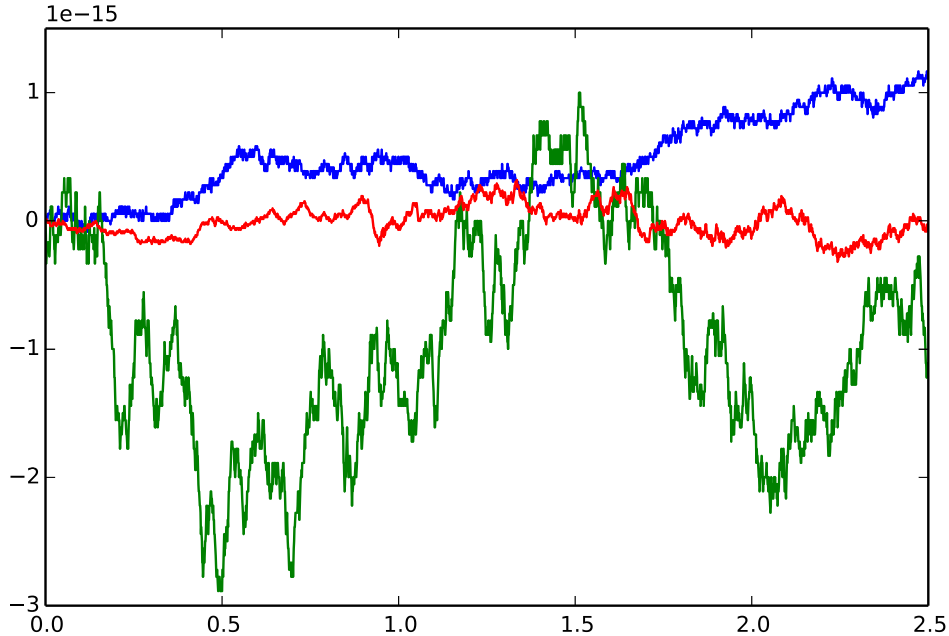

Fig. 11: Change In Velocity Of Center Of Mass No Gravity

6 User Guide

This section contains information directed specifically to users. It contains clear descriptions of what inputs are needed and what effect they have. It should also help the user be able to use the model for the first time.

REFERENCES