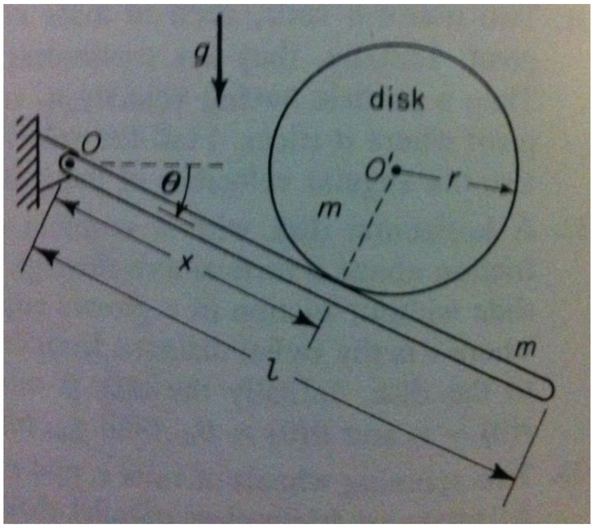
AA 242A Homework 8

Assigned: **Thursday, November 18th, 2021**

Due: **Thursday, December 3rd, 2021 at 5pm**

1. Greenwood 7-36

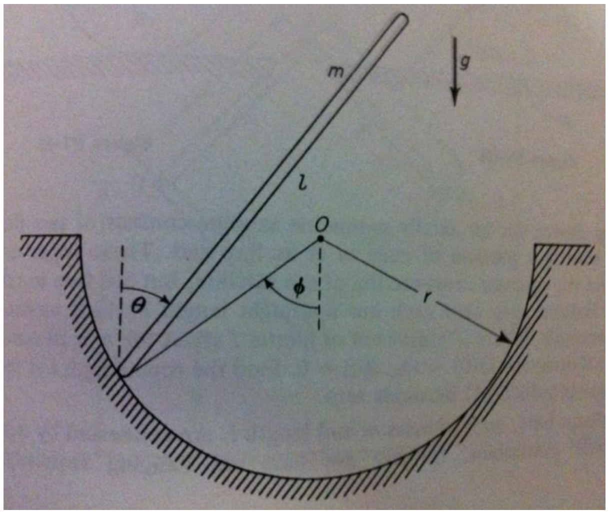


A disk of mass m and radius r can roll without slipping on a rod of mass m and length $l = 4r$ which is pivoted at one end.

a.) Using x and θ as generalized coordinates, obtain the differential equations of motion.

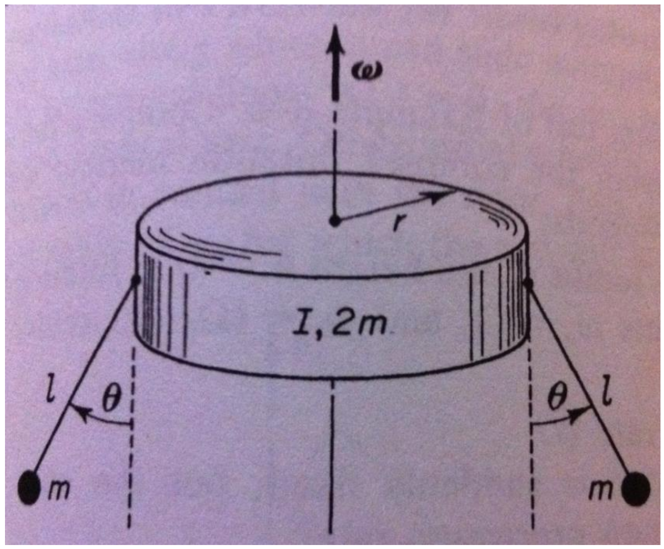
b.) Assuming that the system is released from rest with $\theta(0) = 0$, $x(0) = 2r$, solve for the initial force of the disk acting on the rod.

2. Greenwood 7-41



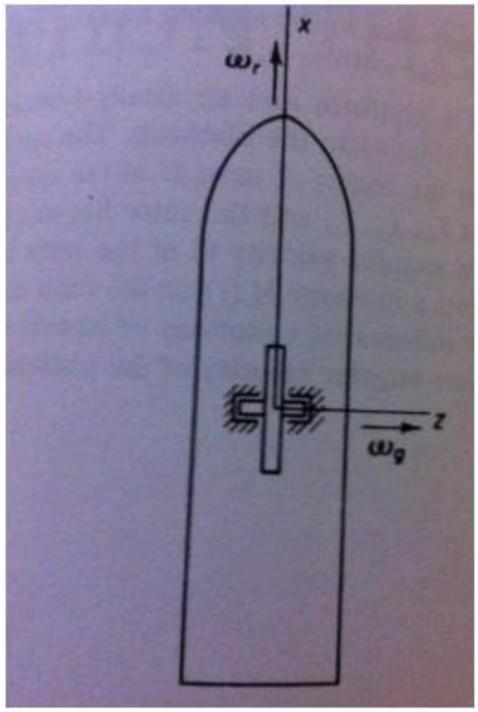
A thin uniform rod of mass m and length l undergoes planar motion on the smooth surface of a fixed hemispherical bowl of radius r. Using θ and ϕ as generalized coordinates, obtain the differential equations of motion.

3. Greenwood 8-14



A satellite consists of a disk or radius r, mass $2m$, and moment of inertia I about the axis of symmetry. Two particles, each of mass m, are attached by rigid massless rods of length l to opposite points on the circumference. The frictionless pin joints are oriented so that the two rods always lie in a plane which contains the symmetry axis and rotates with the disk. Initially, the disk is spinning about its axis of symmetry at ω_0 rad/sec with $\theta(0) = 0$ and $\dot{\theta}(0) = 0$. For free motion, solve for the satellite rotation rate ω and also the value of $\dot{\theta}$ as functions of θ.

4. Greenwood 8-34



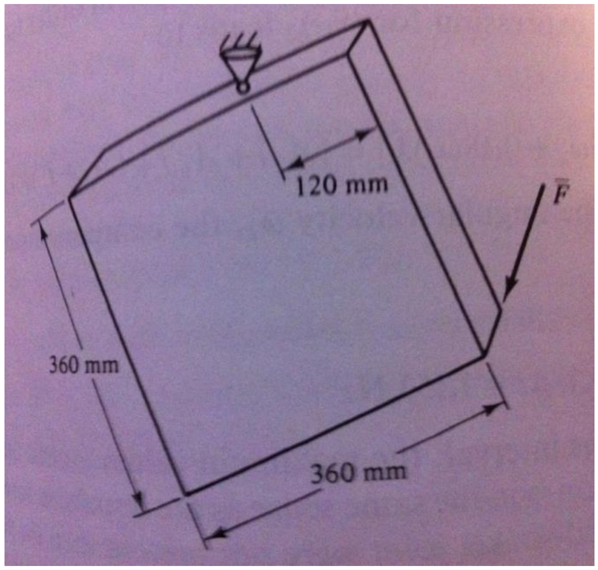
An axially symmetric rocket is spinning in free space about its axis of symmetry with an angular velocity ω_r = 10 rad/sec. Freely suspended at the mass center of the rocket by massless gimbals is a gyro rotor which is rotating at an absolute rate $\omega_g = 10^4$ rad/sec about its own axis of symmetry which is perpendicular to that of the rocket. Suddenly the gimbals are clamped and the rotor motion relative to the rocket is stopped. The gyro rotor has moments of inertia $I_a = 0.1$ kg·m^2 and $I_t = 0.05$ kg·m^2. The rocket, exclusive of the rotor, has moments of inertia $I_a = 10^3$ kg·m^2 and $I_t = 10^4$ kg·m^2. Solve for the following:

a.) The x, y, z components of the angular impulse applied to the rocket by the gyro at the instant the rotor is stopped

b.) The maximum angular deviation of the axis of symmetry of the rocket from its initial position. Note that approximate axial symmetry is maintained after the gimbals are clamped.

c.) Find the time required for a complete precession cycle of the rocket.

5.



A 10-kg square plate suspended by a ball-and-socket joint is at rest when it is struck by a hammer. The impulse force $\vec{F}$ generated by the hammer is normal to the surface of the plate, and its average value during the 4-ms interval that it acts is 5,000 N. Find:

a.) The angular velocity of the plate at the instant following the impact.

b.) The average reaction at the support.

6. For this last week on your creative dynamics problem, solve the problem using Force Balance OR Lagrange. Don't forget to draw your FBD and provide a short description of what you are trying to solve. Also please label your reference frame(s) and coordinate system(s) on your drawing.

   +5pts extra credit: Solve using both Force Balance AND Lagrange, and compare your answers. If they differ, try to explain why (i.e. different coordinate systems, Lagrange doesn't handle variable-mass systems well, etc.)

   Hint: use Euler angles as your generalized coordinates for 3D rigid body rotation.

7. EXTRA CREDIT (+10pts): Watch a dynamics related scene from a movie, TV show, video game, or YouTube video (how related is up to you) and use your newfound dynamics knowledge to critique its accuracy. Describe at least one aspect of the dynamics the producers got right, and at least one aspect they got wrong. In each case, draw a diagram to justify your explanation, and explain in words why the scenes are

correct/incorrect (e.g. momentum was not conserved). You should describe in enough detail that the grader can follow your explanation without having seen the movie/scene.