2.032 DYNAMICS Fall 2004

Problem Set No. 8

Out: Wednesday, November 10, 2004

Due: Wednesday, November 17, 2004 *at the beginning of class*

Problem 1

Reconsider Problem 1 of Quiz No.1. As shown in the figure, the flywheel spins at a constant rate ω_2, and also rotates about z axis with angular velocity ω_1 that is a function of time. The center of mass of the flywheel is located on the z axis, and the centroidal moments of inertia are I_1 about the spin axis and I_2 transverse to that axis

(a) Derive the Lagrangian equations of motion.

(b) Find the generalized forces necessary to maintain the motion.

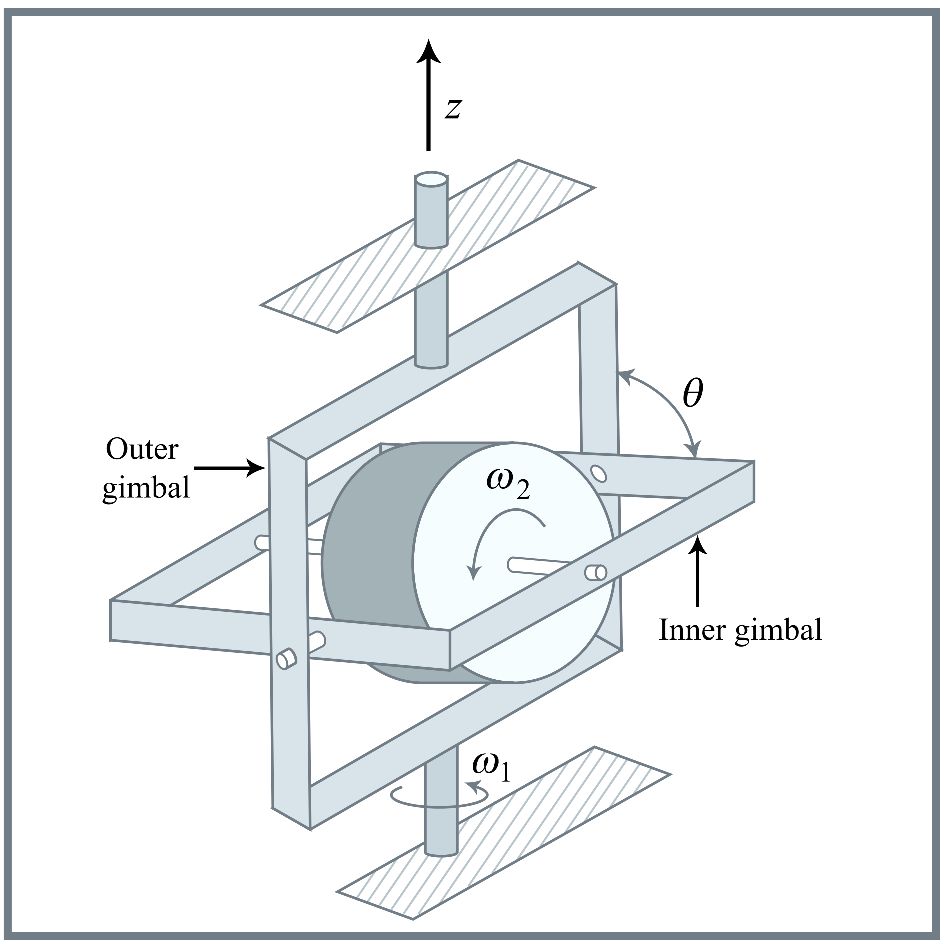
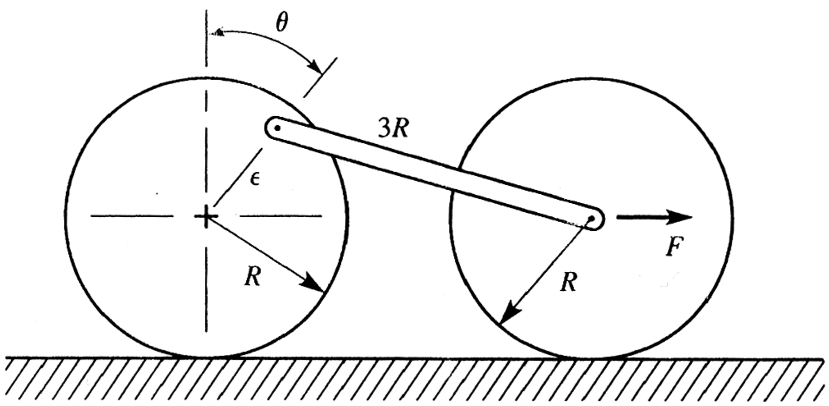


Figure by OCW.

Problem 2 (from Doctoral Qualifying Exam 2002)

Two identical rigid cylinders, each having radius R and mass m, are linked by a connecting rod of length $3R$ and mass M as shown below. A horizontal force $F(t)$ is applied to the center of the right cylinder and neither cylinder slips in its rolling motion. In the initial position, the angle θ locating the connecting pin is zero. Derive the Lagrangian equations of motion for this system.



Problem 3 (from Ginsberg, Problem 6.41)

The slider, whose mass is m_1, oscillates within the groove in the housing. The moment of inertia of the housing about the axis of rotation is I. The spring restraining the slider is unstretched when $s = 0$. Derive differential equations for the distance s and spin angle ϕ resulting from application of a torque $M(t)$ to the shaft. Use the Lagrangian equations of motion.

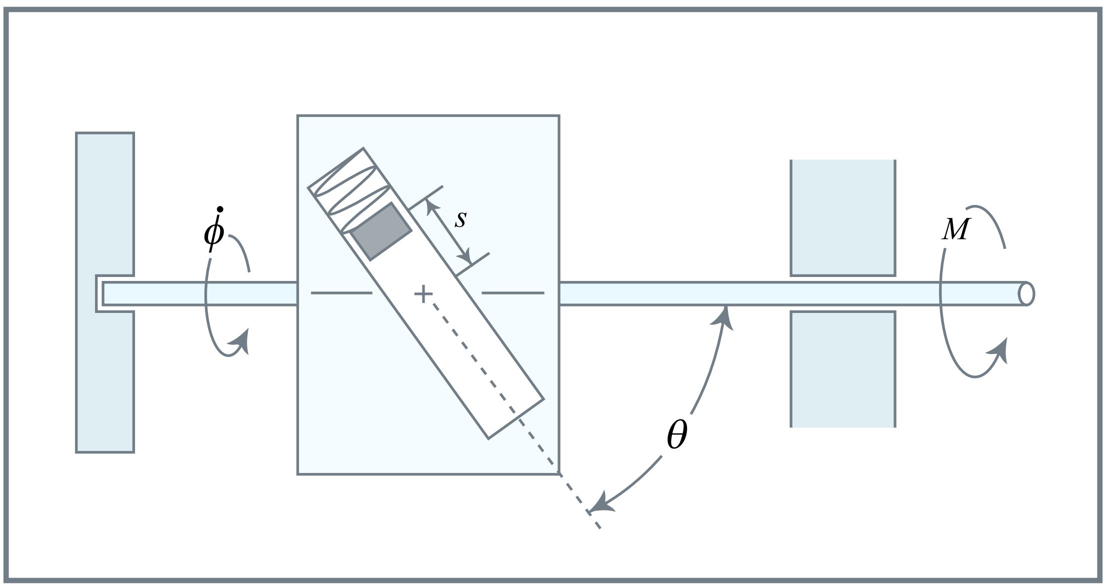


Figure by OCW. After problem 6.41 in Ginsberg, J. H. *Advanced Engineering Dynamics.* 2nd ed. New York: Cambridge University Press, 1998.

Problem 4 (adapted from Ginsberg, Problem 6.42)

The bar, whose mass is m, is pinned to a collar that permits precessional rotation ψ about the vertical guide, as well as nutational rotation θ. The collar is fastened to a spring whose extensional stiffness is k_e and whose torsional stiffness for precessional rotation is k_t.

(a) Derive the Lagrangian equations of motion for this system.

(b) Determine the constraint forces using Lagrange multipliers.

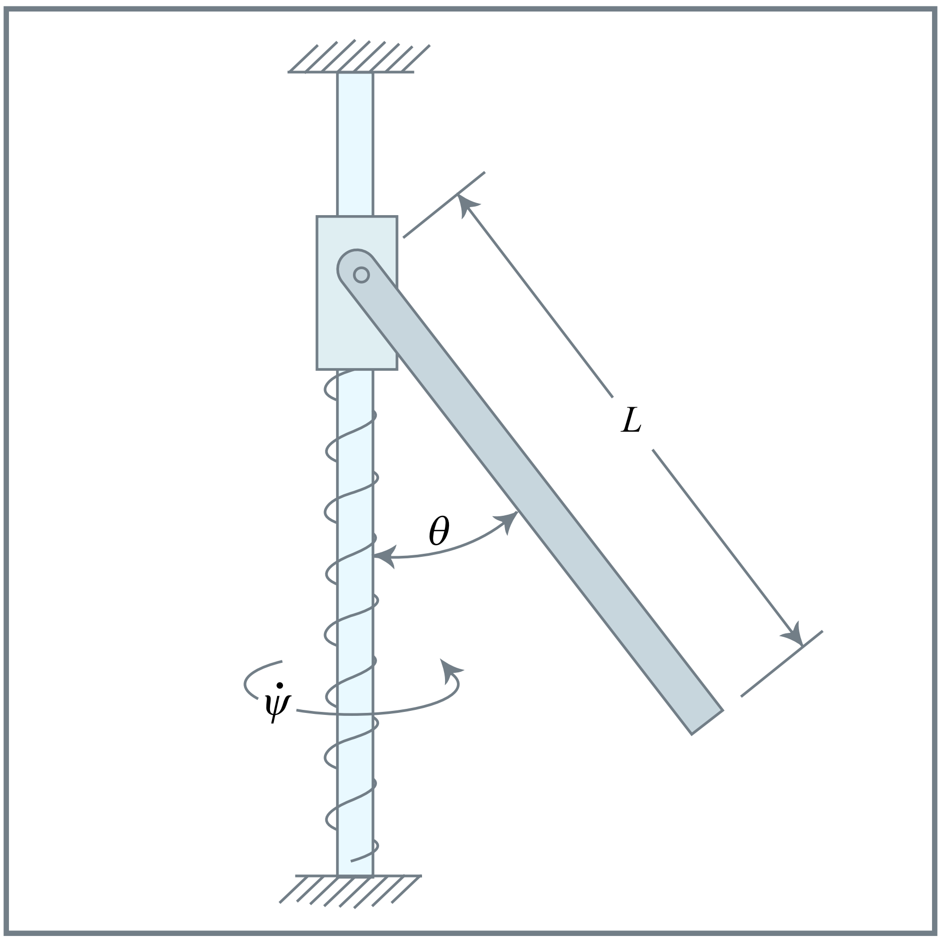


Figure by OCW. After problem 6.42 in Ginsberg, J. H. *Advanced Engineering Dynamics.* 2nd ed. New York: Cambridge University Press, 1998.