2.032 DYNAMICS Fall 2009

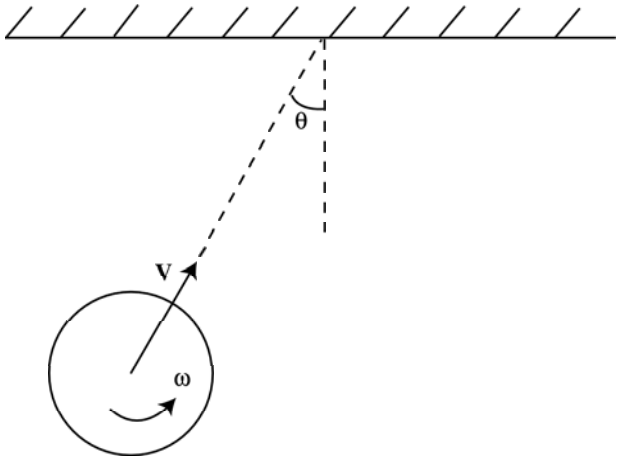
Problem Set No. 5

Out: Monday, October 5, 2009

The homework problems are for practice only. Solutions are posted in a separate file. Please work on the problems and be prepared to ask questions related to this homework in the recitation of Friday, October 9, 2009 (4:00–6:00pm in Room TBA).

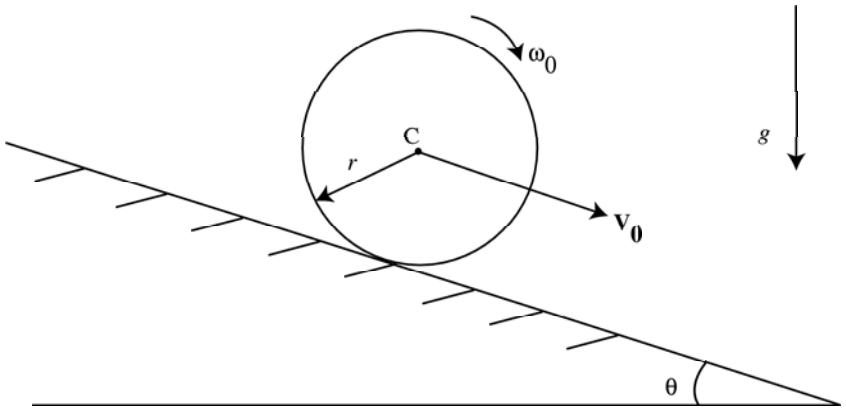
Problem 1 (adapted from Doctoral Qualifying Exam 2000)

A rigid, uniform flat disk of mass m and radius R is moving in the plane towards a wall with central velocity $\boldsymbol{V}$ while rotating with angular velocity ω, as shown below. Assuming that the collision in the normal direction is elastic and no slip occurs at the wall, find the velocity of the (center of the) disk after it collides with the wall.



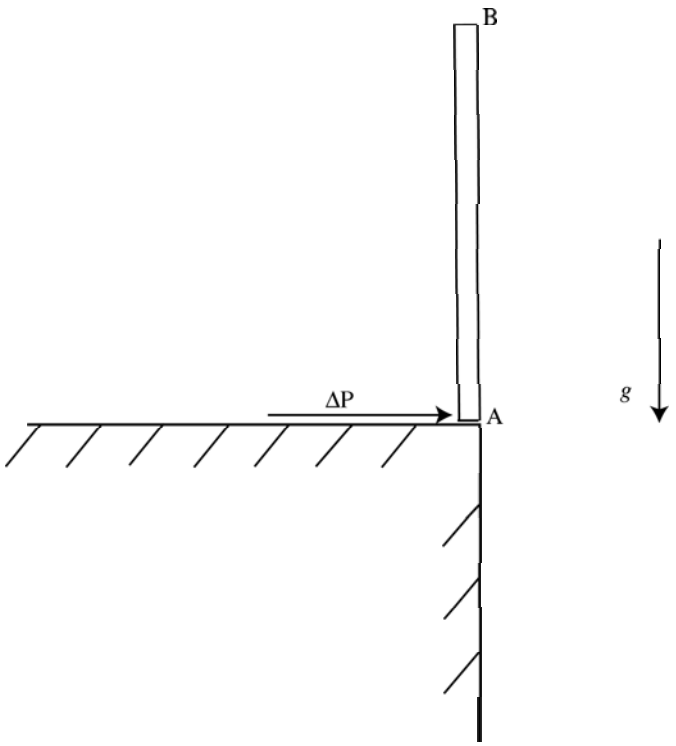
Problem 2 (adapted from Doctoral Qualifying Exam 2003)

The homogeneous sphere of mass m and radius r is projected along the incline of angle θ with an initial central velocity $\boldsymbol{V_0}$ and no angular velocity ($\omega_0 = 0$). If the coefficient of kinetic friction is μ, determine the time duration T of the period of slipping. In addition, state the velocity $\boldsymbol{V_f}$ of the mass center C at the end of the period of slipping.



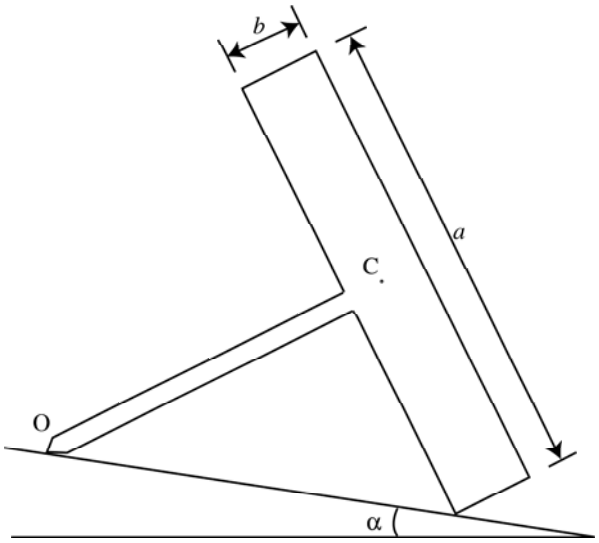
Problem 3

A pencil, modeled as a uniform bar AB of length $2a$ and mass m, is initially at rest standing upright at the edge of a table as shown below. A horizontal impulse ΔP is delivered to the base A of the pencil, causing it to lose contact with the table. Determine the value of ΔP for which the motion of the pencil is such that point B clips the edge of the table. Sketch the position of the pencil at this instant.



Problem 4

The heavy disk of mass M and centroidal principal moments of inertia $I_1 = I_2, I_3$ rolls without slipping in contact with the inclined plane, as shown below. A ball joint at O holds the end of the massless shaft in place. Derive an expression for the kinetic energy of the disk.



Problem 5 (adapted from Crandall et al., 4-17)

A table with axial moment of inertia I can turn in fixed bearings without friction. The table carries a massless rigid frame from which is suspended a massless pendulum arm carrying a spinning disk. The disk has mass M and principal moments of inertia I_1, I_1 and I_3 at the centroid.

(a) Select generalized coordinates to describe the motion of the table and the disk.

(b) Derive expressions for the kinetic energy and the potential energy of this system.