2.032 DYNAMICS Fall 2009

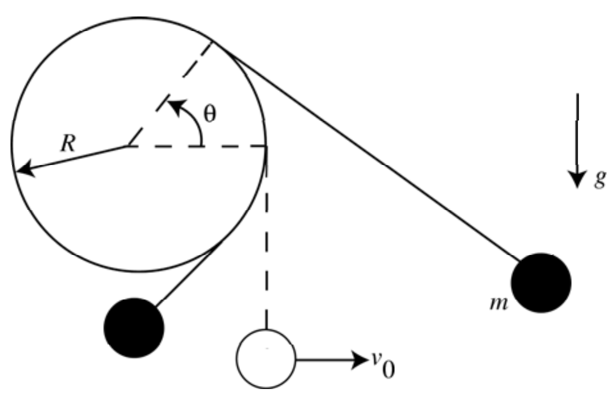
Problem Set No. 1

Out: Wednesday, September 9, 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 September 15, 2009 (4:00–5:30pm in Room TBA).

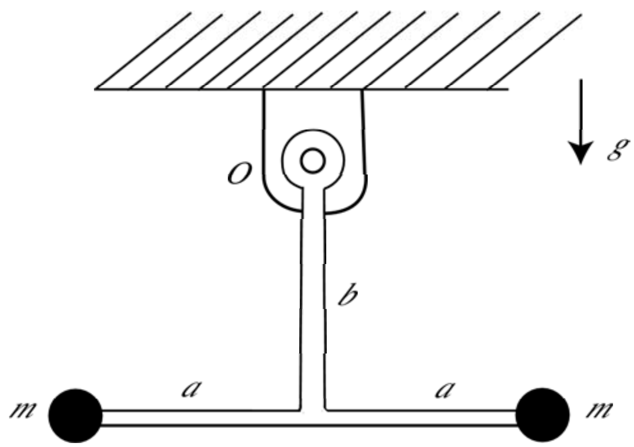
Problem 1 (Doctoral Exam, 1999)

A pendulum is contructed by attaching a mass m to an extensionless string of fixed length l. The upper end of the string is connected to the uppermost point of a vertical fixed disk of radius R ($R < l/\pi$), as shown below. At $t = 0$ the mass hangs at rest at the equilibrium position $\theta = 0$, when it is given an initial velocity v_0 along the horizontal. Determine the two extreme deflections (in terms of θ) of the pendulum resulting from this initial perturbation. Do *not* make a small-angle approximation.



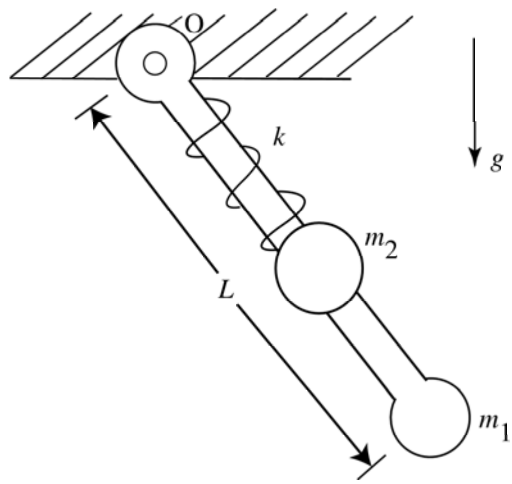
Problem 2 (Crandall et al., 2-34)

The pendulum shown below consists of two mass particles attached to a rigid massless frame which is constrained to pivot about O, in the plane of the sketch. Neglecting friction, obtain the equation of motion for the pendulum by applying momentum principles.



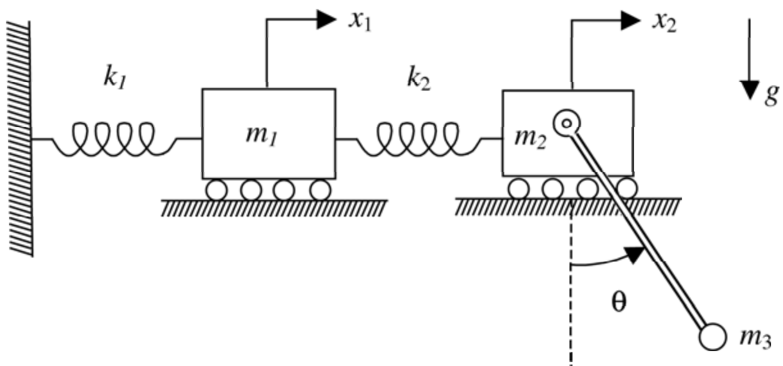
Problem 3

A particle of mass m_1 is attached to a massless rod of length L which is pivoted at O and is free to rotate in the vertical plane as shown below. A bead of mass m_2 is free to slide along the smooth rod under the action of a spring of stiffness k. (a) Choose a complete and independent set of generalized coordinates. (b) Derive the governing equations of motion by applying momentum principles.



Problem 4 (adapted from Crandall et al., 2-35)

Consider the system shown below under the assumption that the pendulum arm connecting m_2 and m_3 is massless. By applying momentum principles, obtain the differential equations of motion for the generalized coordinates x_1, x_2 and θ.



Problem 5 (Doctoral Exam, 1999)

Two identical rods of length l, that have equal masses m attached at their ends, are clamped at an angle θ to a shaft as shown. (The shaft and the rods are in the same plane.) What reaction forces must the bearings be able to withstand, if the angle θ can be set anywhere from zero to 90° and the maximum angular velocity of the shaft is ω? (For simplicity, you may neglect the mass of the rods and ignore the effects of gravity.)