2.003J/1.053J Dynamics and Control I
Fall 2007

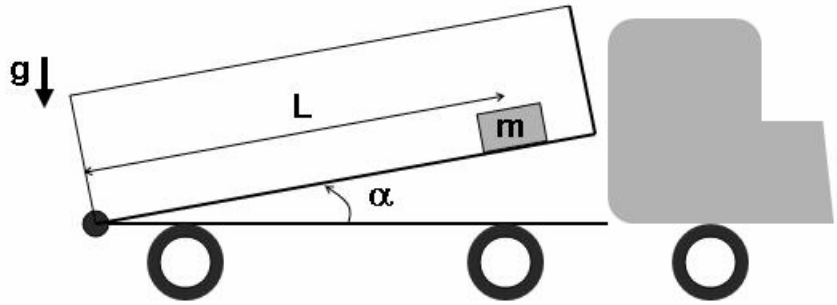
Problem Set 4

Out: Monday, 1 October, 2007
Due: Wednesday, 10 October, 2007

1. Dump truck

The bed of a dump truck is hinged at the rear, as shown in the figure below. Initially, the bed is at rest in the fully lowered position and a box of mass m lies at a distance L_0 from the back end of the truck.

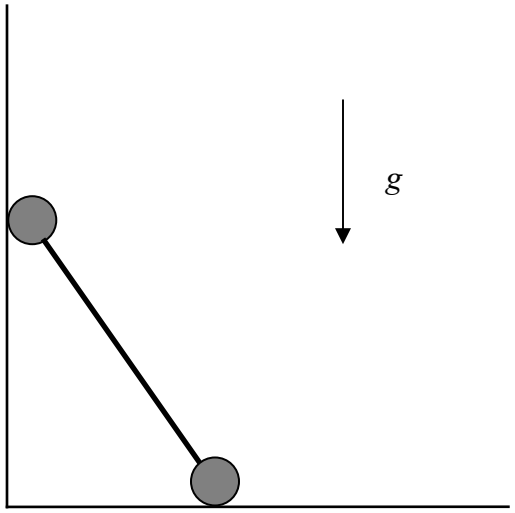
At time $t = 0$, the operator starts raising the bed at a constant angular acceleration α. Assume that the surface is frictionless and that the box can be treated as a point mass. Let L denote the instantaneous distance of the mass from the hinge. Note that gravity acts. Find the equation of motion of the mass and find the normal reaction force as a function of time, L or any of its derivatives and any other variables that are given.



2. Dumbbell problem

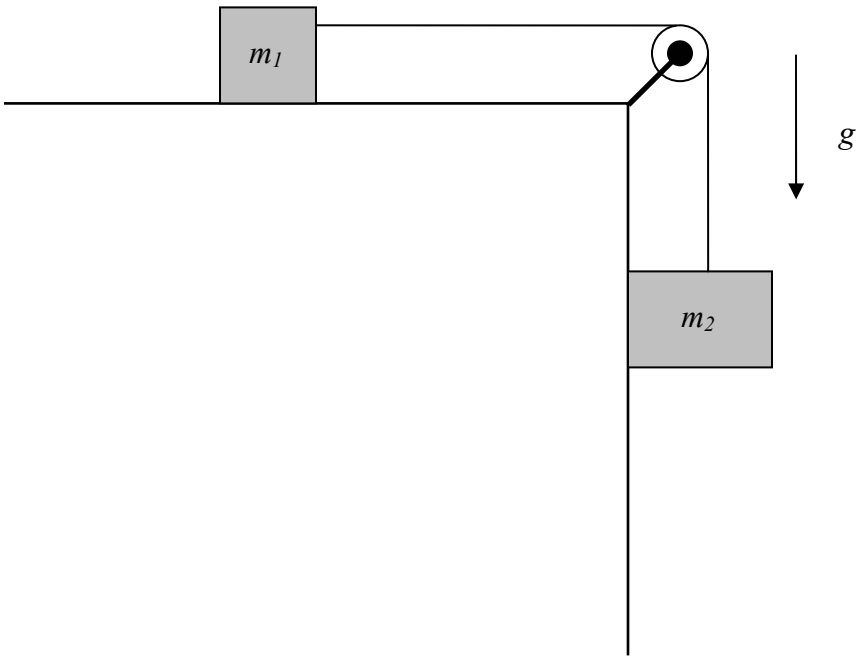
Two point masses each of mass m are connected by a massless rod of length L to form a dumbbell shape. Initially the dumbbell is held inclined between the ground and the wall perpendicular to the ground at a certain angle and suddenly released. The dumbbell starts sliding down. Note that gravity acts.

a. Find the equation(s) of motion of the dumbbell using Newton's laws.
b. Find the equation(s) of motion of the dumbbell using the work-energy principle.



3. Masses and a pulley

Two point masses, m_1 and m_2 are connected by a non-elastic string which goes over a pulley of negligible mass as shown in the figure below. Initially the masses are held at a certain position such that the string is tight. The masses are then suddenly released. Both the masses slide without friction. Assume that mass m_2 slides along the vertical wall and does not leave the wall. Note that gravity acts. Find the acceleration of each mass using the work-energy principle and find the tension in the string.



4. A bead on a fixed ring and a spring

A ring fixed to a support at the top is hanging vertically. A bead of mass m slides through the ring and is connected to the support through a spring of stiffness k as shown in the figure below. The length of the unstretched spring is almost negligible. Note that gravity acts.

a. Find the equation of motion of the bead using Newton's laws and find the normal reaction force on the bead.
b. Find the equation of motion of the bead using the work-energy principle.