Academic Year 2021-22

Tutorial #04

PH100: Mechanics and Thermodynamics

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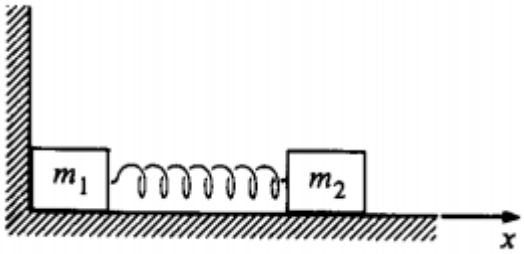
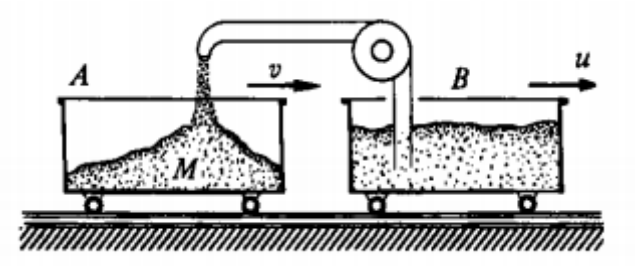
1. Find the center of mass of a thin uniform plate in the shape of an equilateral triangle with sides *a*.

2. An instrument-carrying projectile accidentally explodes at the top of its trajectory. The horizontal distance between the launch point and the point of explosion is *L*. The projectile breaks into two pieces which fly apart horizontally. The larger piece has three times the mass of the smaller piece. To the surprise of the scientist in charge, the smaller piece returns to earth at the launching station. How far away does the larger piece land? Neglect air resistance and effects due to the earth's curvature.

3. A system is composed of two blocks of mass m_1 and m_2 connected by a massless spring with spring constant *k*. The blocks slide on a frictionless plane. The un-stretched length of the spring is *l*. Initially m_2 is held so that the spring is compressed to *l/2* and m_1 is forced against a stop, as shown. m_2 is released at *t = 0*. Find the motion of the center of mass of the system as a function of time.



4. Material is blown into cart *A* from cart *B* at a rate *b* kilograms per second. The material leaves the chute vertically downward, so that it has the same horizontal velocity as cart *B*, *u*. At the moment of interest, cart *A* has mass *M* and velocity *v*, as shown. Find *dv/dt*, the instantaneous acceleration of *A*.



5. *N* men, each with mass *m*, stand on a railway flatcar of mass *M*. They jump off one end of the flatcar with velocity *u* relative to the car. The car rolls in the opposite direction without friction.
   (a). What is the final velocity of the flatcar if all the men jump at the same time?
   (b). What is the final velocity of the flatcar if they jump off one at a time? (The answer can be left in the form of a sum of terms.)
   (c). Does case a or case b yield the largest final velocity of the flat car? Can you give a simple physical explanation for your answer?

6. A raindrop of initial mass *Mo* starts falling from rest under the influence of gravity. Assume that the drop gains mass from the cloud at a rate proportional to the product of its instantaneous mass and its instantaneous velocity: dM/dt= kMV, where k is a constant. Show that the speed of the drop eventually becomes effectively constant, and give an expression for the terminal speed. Neglect air resistance.