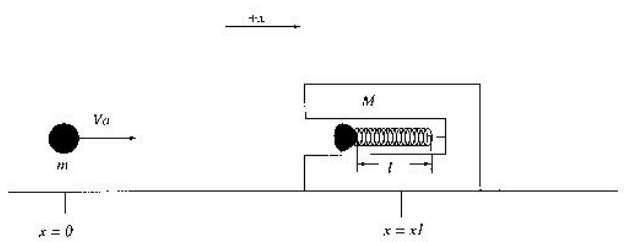
QP8



A spring gun of mass M sits at rest on a frictionless surface. A suction cup is attached to the end of the spring, and a rubber ball of mass m is incident on the spring with velocity V_0. At time $t = 0$, the gun is at $x = xl$ and the ball is at $x = 0$ as shown above. The spring and suction cup have negligible mass, the initial length of the spring is l, and the spring constant is k. When the ball hits the suction cup it sticks and remains attached to the end of the spring. Assume that the spring does not sag (i.e. ignore the effects of gravity). Express your answer in terms of m, M, V_0, xl, l and k.

a) (1 point) For times before the ball hits the suction cup, when the gun sits at $x = xl$, write the location of the center of mass of the gun/ball system as a function of time.

b) (1 point) Suppose a latch is located at the point of maximum compression of the spring, so that the latch stops the ball at this point. What is the final velocity of the ball/gun system after the ball hits the cup and the latch is tripped?

c) (2 points) What fraction of the inital kinetic energy of the ball is stored in the spring?

d) (1 point) When the spring has its maximum compression, by what amount Δl, is the length of the spring decreased?

e) (2 points) At time $t = t2$, when the center of the mass of the gun/ball system is at position $x = x2$, the latch pops loose (but the ball remains attached to the end of the spring). On a graph of x versus time, plot the position of the center of the mass of the system (you may make the origin of your plot ($t2$, $x2$)). Also, on a similar plot, sketch qualitatively the position of the gun (mass M) relative to the center of mass, assuming that $M > m$.

f) **Extra Credit Point** After the latch pops loose, what is the frequency of the osciallation for the system?