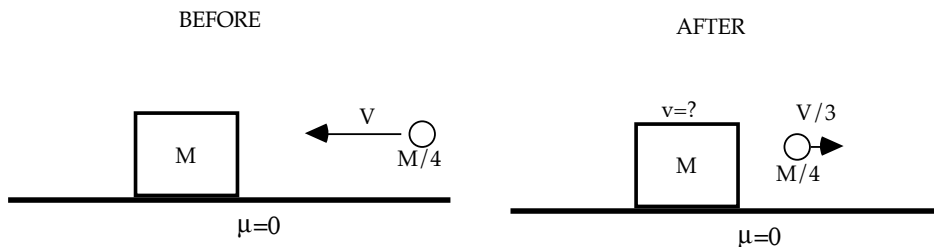


### Problem 9

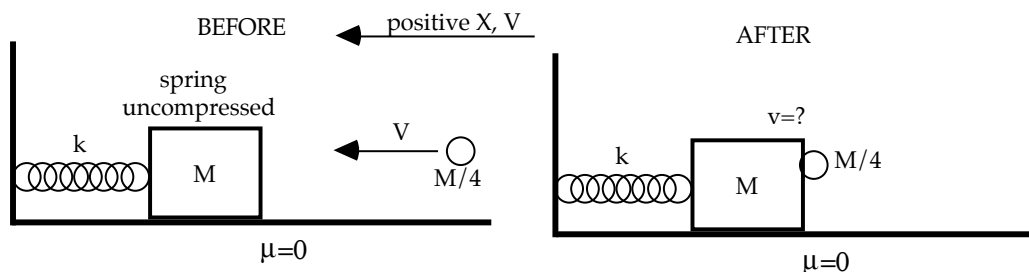
~~A metal block of mass  $M$  is free to slide on a frictionless, horizontal surface. A metal ball of mass  $M/4$  is fired at the block with velocity  $V$ , and bounces straight backward off the block with one-third its original speed. The block is initially at rest.~~



- ~~What is the speed of the block after the impact?~~
- ~~Is this collision elastic?~~
- ~~If the impact lasts  $\Delta t$  sec, what average force (magnitude and direction) acts on the block?~~
- ~~How does the average force (magnitude and direction) that acts on the ball compare to what you found in part (c) for the force on the block. Explain your answer.~~

### Problem 10

A metal block of mass  $M$  is attached to a spring of negligible mass and spring constant  $k$  as shown, and is free to slide on a frictionless, horizontal surface. A clay ball of mass  $M/4$  is fired at the block with velocity  $V$ , and sticks to it as shown. The block is initially at rest and the spring is initially uncompressed.

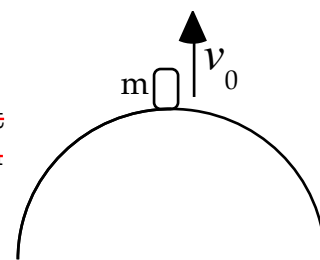


- What is the speed of the block+ball immediately after the impact?
- Write an equation for the position of the block as a function of time after the collision, assuming that at  $t = 0$ , the instant of the impact, it is at  $x = 0$  which is the unstretched point of the spring. Determine values for the amplitude, angular frequency, and phase in terms of the given quantities. Assume that  $X$  and  $V$  are positive to the left as shown.

### Problem 11

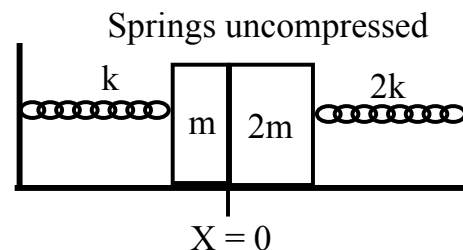
~~A small object of mass  $m$  is launched from the surface of the Earth with a speed of  $v_0$  in a direction perpendicular to the Earth's surface.~~

- ~~What is the total mechanical energy of the object at its starting point in terms of  $m, v_0$ , the radius of the Earth  $R_e$ , the mass of the Earth  $M_e$ , and the gravitational constant  $G$ ?~~
- ~~Find an expression for the speed  $v$  of the object at a height  $h = R_e$  (i.e., a distance  $2R_e$  from Earth's center).~~
- ~~What is the minimum value of  $v_0$  that will allow the object to reach the height  $h$ ?~~
- ~~Now consider a different situation where the object is placed in a circular orbit at a height  $h = R_e$  (i.e., a distance  $2R_e$  from Earth's center). Find the velocity the object needs to be in a circular orbit at that height.~~



### Problem 12 Short Answer Questions

~~A) Two blocks move on a horizontal, frictionless surface and are attached to springs as shown. The left block has mass  $m$  and spring constant  $k$ . The right block has mass  $2m$  and spring constant  $2k$ . The masses just touch each other at  $X=0$  at which point both springs are at equilibrium (i.e. uncompressed). The left mass is pulled to the left a distance~~



### Problem 7

a)  ~~$KE_I = 0, PE_I = \frac{1}{2}kS^2, Work = 0$~~   
 ~~$KE_F = 0, PE_F = Mg(4S), \frac{1}{2}kS^2 = Mg(4S)$~~

$$k = \frac{2Mg(4S)}{S^2}, \quad \boxed{k = \frac{8Mg}{S}}$$

b) Use unstretched point as origin, and up = +.

~~$-ky_{eq} - Mg = 0, y_{eq} = \frac{-Mg}{k} = \frac{-Mg}{\frac{8Mg}{S}}$~~

$$\boxed{y_{eq} = \frac{-S}{8}}$$

c)  ~~$y = A\cos(\omega t + \phi), v_y = 0$  at  $t = 0$ , so  $\phi = 0$ .~~

~~$v_y = -A\sin(\omega t + \phi), \omega = \sqrt{\frac{k}{M}} = \sqrt{\frac{8g}{S}}$~~

~~$A = S - \frac{S}{8} = \frac{7S}{8}$~~

### Problem 8

~~$Mv_1 = 2Mv_2, v_1 = 2v_2, \frac{1}{2}(2M)v_2^2 = K, v_2 = \sqrt{\frac{K}{M}}$~~

~~$KE_{TOT} = \frac{1}{2}Mv_1^2 + \frac{1}{2}(2M)v_2^2 = \frac{1}{2}M(4v_2^2) + \frac{1}{2}(2M)v_2^2 = 3Mv_2^2 = 3M(\frac{K}{M})$~~

~~$KE_{TOT} = 3K$~~

### Problem 9

a)  ~~$V(\frac{M}{4}) = Mv - (\frac{M}{4})(\frac{V}{3})$~~

~~$Mv = (\frac{M}{4})\frac{4}{3}V, \quad \boxed{v = \frac{V}{3}}$~~

b)  ~~$KE_I = \frac{1}{2}(\frac{M}{4})(V^2) = \frac{1}{8}MV^2, KE_F = \frac{1}{2}(\frac{M}{4})(\frac{V}{3})^2 + \frac{1}{2}M(\frac{V}{3})^2 = \frac{MV^2}{9}(\frac{1}{8} + \frac{1}{2}) = \frac{MV^2}{9}(\frac{5}{8})$~~

~~$KE_F = \frac{MV^2}{8}(\frac{5}{8}) \neq KE_I, \quad \boxed{\text{Not elastic}}$~~

c)  ~~$F = \frac{\Delta p}{\Delta t} = \frac{M\frac{V}{3} - 0}{\frac{3\Delta t}{3}} = \frac{MV}{3\Delta t}, \text{ to the left.}$~~

d) ~~Same magnitude, opposite direction. Newton's 3rd law. Action/Reaction.~~

### Problem 10

a)  ~~$(\frac{M}{4}V) = (\frac{5}{4}M)v, \quad \boxed{v = \frac{V}{5}}$~~

b) Amplitude:  ~~$\frac{1}{2}kA^2 = \frac{1}{2}(\frac{5}{4}M)(\frac{V}{5})^2, \quad \boxed{A = \frac{V}{5}\sqrt{\frac{5M}{4k}}}$~~

Angular frequency:  ~~$\omega = \sqrt{\frac{k}{\frac{5M}{4}}} = \sqrt{\frac{4k}{5M}}$~~

~~$\boxed{X = A\sin(\omega t)}$~~