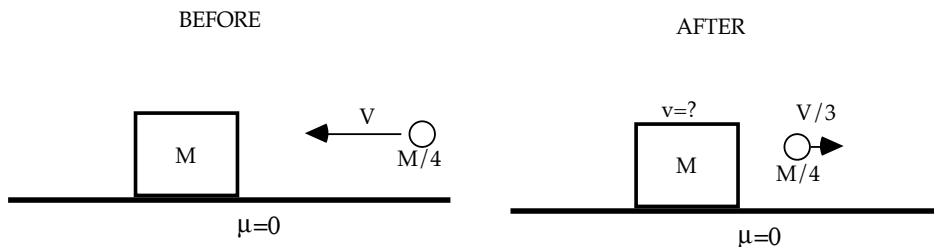


Problem 9

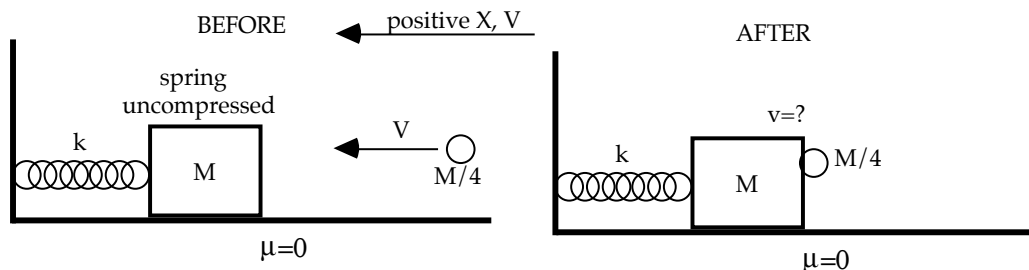
~~A metal block of mass M is free to slide on a frictionless, horizontal surface. A metal ball of mass $M/4$ is fired at the block with velocity V , and bounces straight backward off the block with one-third its original speed. The block is initially at rest.~~



- ~~What is the speed of the block after the impact?~~
- ~~Is this collision elastic?~~
- ~~If the impact lasts Δt 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.~~

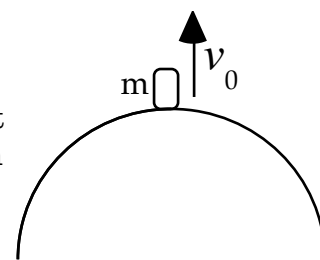


- ~~What is the speed of the block+ball immediately after the impact?~~
- ~~Write an equation for the position of the block as a function of time after the collision, assuming that at $t=0$, the instant of the impact, it is at $x=0$ which is the unstretched point of the spring. Determine values for the 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

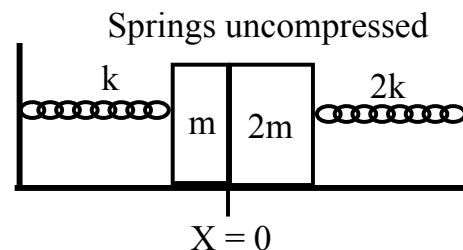
A small object of mass m is launched from the surface of the Earth with a speed of v_0 in a direction perpendicular to the Earth's surface.

- 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 11

$$\text{a) } E = \frac{1}{2}mv_0^2 - \frac{GmM_E}{R_E}$$

$$\text{b) } \frac{1}{2}mv^2 - \frac{GmM_E}{2R_E} = \frac{1}{2}mv_0^2 - \frac{GmM_E}{R_E} \quad \cdot \quad v^2 = v_0^2 - \frac{GM_E}{R_E}$$

$$\text{c) } v = 0, \text{ if } v_{0,\min} = \sqrt{\frac{GM_E}{R_E}}$$

$$\text{d) } \frac{mv^2}{2R_E} = \frac{GmM_E}{(2R_E)^2}, \quad v = \sqrt{\frac{GM_E}{2R_E}}$$

Problem 12

~~$$\text{A) } \omega_{\text{left}} = \sqrt{\frac{k}{m}}, \quad \omega_{\text{right}} = \sqrt{\frac{2k}{2m}} = \sqrt{\frac{k}{m}}$$~~

~~Same $\omega \Rightarrow$ same period \Rightarrow same time to $x=0$.~~

~~$$\text{B) i) Let right be positive direction: } F_{TOT} = 0 = \frac{G(5M)m}{(D-d)^2} - \frac{G(M)m}{d^2}$$~~

~~Two forces can cancel. Could also write $(D-d)^2 = 5d^2$
(Not required: $d = 0.31D$)~~

~~$$\text{B) ii) } PE_{TOT} = \frac{-G(5M)m}{(D-d)} - \frac{GMm}{d}, \quad D > d \text{ so both terms are negative, so it can NEVER be zero.}$$~~

Problem 13

~~$$\text{Rocket A: } E_I = \frac{-GMm}{R_E}, \quad E_F = \frac{-GMm}{4R_E}, \quad W_A = \Delta E = \frac{-GMm}{4R_E} - \left(-\frac{GMm}{R_E}\right) = \frac{3GMm}{4R_E} = W_A$$~~

~~$$\text{Rocket B: } E_I = \frac{-GMm}{R_E}, \quad \frac{GMm}{(2R_E)^2} = \frac{mv^2}{2R_E}, \quad v^2 = \frac{GM}{2R_E}, \quad KE_F = \frac{1}{2}GMm - \frac{1}{4}GMm$$~~

~~$$PE_F = \frac{-GMm}{2R_E}, \quad E_F = \frac{1}{4}GMm - \frac{GMm}{2R_E} = -\frac{GMm}{4R_E}, \quad W_B = \Delta E = \frac{3GMm}{4R_E} \Rightarrow \text{Same as A.}$$~~

Problem 14

~~$$\text{a) } C = \omega = \sqrt{\frac{k}{m}}, \quad B = V_0, \quad \frac{1}{2}kA^2 = \frac{1}{2}mV_0^2 \Rightarrow A = \sqrt{\frac{m}{k}}V_0$$~~

~~$$\text{b) At } T/2, \text{ block returns to } x=0, \text{ so } V_{AVG} = 0 \text{ at } t=T/2$$~~

~~$$\text{c) } V_{AVG} = \frac{\sqrt{\frac{m}{k}}V_0 \sin(\sqrt{\frac{k}{m}}\frac{T}{3})}{T/3}, \quad \text{But } T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}, \text{ so: } V_{AVG} = \frac{3V_0}{2\pi} \sin\left(\frac{2\pi}{3}\right)$$~~

~~(Not required: $V_{AVG} = 0.4V_0$)~~