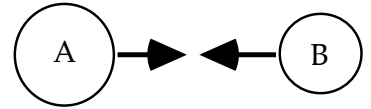


iii) Two balls of masses 2 kg and 3 kg slide along a frictionless horizontal surface with speeds of 4 m/s and 2 m/s, respectively. After an inelastic collision, the balls stick together and move at a speed of 2 m/s. What direction did the two balls move before the collision?

- a) In the same direction b) In opposite directions
 c) At an angle not equal to 0° or 180° d) The situation described is impossible
 e) Not enough information given to select an answer

Problem 6

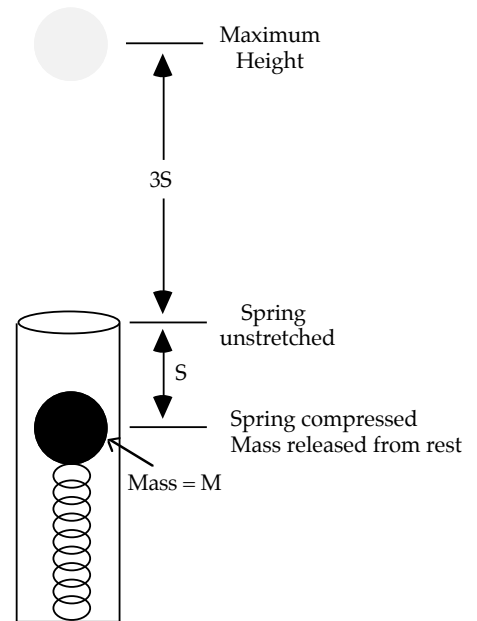
Two steel spheres are shot at each other and then collide head-on as shown. Sphere A has a mass of 10 kg and a velocity just before the collision of 3 m/s to the right. Sphere B has mass of 4 kg and velocity just before the collision of 4 m/s to the left. Immediately after the collision the velocity of sphere B is observed to be 6 m/s to the right.



- a) What is the magnitude and direction of the velocity of sphere A immediately after the collision? Clearly indicate your coordinate system and what direction is positive.
 b) Is this collision elastic or inelastic? Explain your answer.
 c) Assume that the collision lasts 10^{-3} seconds. Calculate the magnitude and direction of the average force that sphere A exerts on sphere B during the collision. Clearly indicate your coordinate system and what direction is positive.

Problem 7

A spring-loaded toy gun is used to shoot a ball of mass M straight up in the air. The ball is not attached to the spring. The ball is pushed down onto the spring so that the spring is compressed a distance S below its unstretched point. After release, the ball reaches a maximum height $3S$, measured from the unstretched position of the spring (see diagram).



- a) Find the spring constant of the spring.
 b) Find the equilibrium point of the ball when it is sitting on the spring with no forces other than gravity and the spring acting on it. Clearly indicate the point you are using as the origin of your coordinate system and what direction is positive.
 c) Now, the ball is glued onto the spring so that it oscillates up and down rather than flying off the spring. The spring is again compressed the same distance S below its **unstretched** point. Write an equation for the position of the ball as a function of time after it is released. Clearly indicate the point you are using as the origin of your coordinate system and what direction is positive.

Problem 8

A projectile is launched straight up. It explodes into two pieces at the top point of its trajectory. One piece has twice the mass of the other one. The more massive piece has kinetic energy equal to K right after the explosion. Show that the total energy released in the explosion (i.e. the total kinetic energy of the two pieces right after the explosion) is exactly equal to $3.0K$. Justify your answer with a calculation.

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 = +.

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

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

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

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

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

Problem 8

~~$$Mv_1 = 2Mv_2, \quad v_1 = 2v_2, \quad \frac{1}{2}(2M)v_2^2 = K, \quad v_2 = \sqrt{\frac{K}{M}}$$~~
~~$$KE_{TOT} = \frac{1}{2}Mv_1^2 + \frac{1}{2}(2M)v_2^2 = \frac{1}{2}M(4v_2^2) + \frac{1}{2}(2M)v_2^2 = 3Mv_2^2 = 3M\left(\frac{K}{M}\right)$$~~
~~$$KE_{TOT} = 3K$$~~

Problem 9

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

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

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

~~$$KE_F = \frac{MV^2}{8}\left(\frac{5}{9}\right) \neq KE_I, \quad \boxed{\text{Not elastic}}$$~~

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

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

Problem 10

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

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

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

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