PHYSICS 161, Spring 2003

Discussion Quiz , Tuesday, April 29

Q1). A bullet of mass m is fired into a large block of wood of mass M suspended from a light rod. (The mass of the rod is negligible.) The bullet gets embedded in the block, and the entire system swings through a height h. The bullet's initial velocity is v_0.

a). What is the total kinetic energy of the bullet + block system before the collision?

$\frac{1}{2} m V_0^2 = E_i$

b). Find the velocity of the bullet+ the block shortly after the collision.

$m(V_0) + M(0) = (m+M) V_f$

$V_f = \frac{m V_0}{m+M}$

c). What is the kinetic energy of the system shortly after the collision. Show that this kinetic energy is less than the initial kinetic energy of the system.

$\frac{1}{2} m V_0^2 : \frac{1}{2}(m+M) V_f^2$

$\frac{1}{2} m v_0^2 : \frac{1}{2}(m+M)\left(\frac{m V_0}{m+M}\right)^2$

$m V_0^2 : (m+M) \frac{m^2 V_0^2}{(m+M)^2}$

$1 : \frac{m}{m+M}$

$E_i < E_f$

d). Solve for the height h that the system swings through in terms of m, M, v_0, and g only.

$E_f = \frac{1}{2}(m+M)\left(\frac{m v_0}{m+M}\right)^2 = m g h$

$h = \frac{m V_0^2}{2g(m+M)}$

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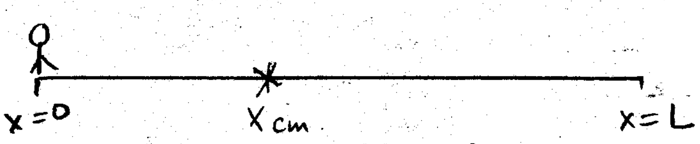
Discussion Quiz, Thursday, May 1

Q1). A girl of mass $m = 45.0\ kg$ is standing on the left edge of a plank that has a mass of $M = 150\ kg$. The plank is originally at rest on a frozen lake. (Assume negligible friction between the ice and the plank).

a). What is x_{cm} of the girl-plank system as measured by the owner person watching from the ground. Let the left edge of the plank be at $x = 0$.

$$x_{cm} = \frac{m(0) + M(\frac{L}{2})}{m + M} = \frac{150}{195}\left(\frac{L}{2}\right)$$

$$x_{cm} = 0.38L$$



b). The girl now begins to walk along the plank at a constant velocity of $v_{gx} = 1.5 m/s$ as measure by the person on the ground. What must be the velocity of the plank v_{px}?

$$P_{ix} = P_{fx}$$

$$0 = m v_{gx} + M v_{px}$$

$$\boxed{v_{px} = -\frac{m}{M} v_{gx}}$$

$$\Rightarrow v_{px} = -\left(\frac{45\ kg}{150\ kg}\right)(1.5 m/s)$$

$$\boxed{v_{px} = -0.45\ m/s}$$

c). For part (b) above, what is the velocity of the center of mass? And what is the location of the center of mass once the girl has reached the other end?

Since $F_{net,ext} = 0$, $\vec{a}_{cm} = 0$. [Since $F_{net,ext} = M_{total}\, \vec{a}_{cm}$]

$\Rightarrow$ if $v_{cm} = 0$ before, $v_{cm} = 0$ even when she's walking.

& the center of mass remains at $x = 0.38L$.

d). In part (b) above, using the word "constant" to describe the girl's velocity is not quite correct because every time she takes a step forward, a force must act on her feet.

(i) In separate diagrams, draw and label all the forces in the x-direction on the girl and the plank at the instant the girl is taking a step forward.

(ii) What is the net force on the system as the girl steps forward?

F_{net} on the system $= 0$.

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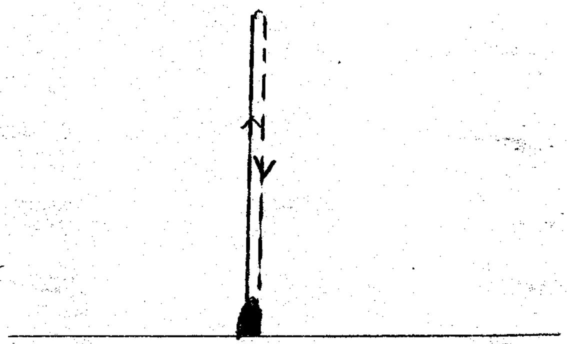
Discussion Quiz, Friday, May 2

Q1). A shell is fired **vertically upward** from a gun with a muzzle velocity $v_0 = 20m/s$. At the top of the trajectory, the shell explodes into two fragments of **unequal masses** such that $m_2 = 2m_1$.

a). Draw the **complete** trajectory of the center of mass of the shell before and after the collision.



Gravity is the only force acting on the system so the center of mass rises & falls vertically just as the shell would have, had it not exploded.

b). If the shell was fired from $x = 0$ and the fragment with mass m_1 falls at $x = +50m$, where does the other one land?

$$X_{cm} = \frac{m_1 X_1 + m_2 X_2}{m_1 + m_2}$$

$$0 = m_1 X_1 + m_2 X_2$$

$$\Rightarrow X_2 = -\frac{m_1}{m_2} X_1$$

$$\Rightarrow X_2 = -\frac{1}{2} X_1 \Rightarrow \boxed{X_2 = -25m}$$

c). What must be the ratio of their **velocities** immediately after the explosion?

$\vec{P}_i = 0$ since v at the top is zero.

$$\Rightarrow \vec{P}_i = \vec{P}_f$$

$$0 = m_1 \vec{v}_1 + m_2 \vec{v}_2$$

$$\Rightarrow m_1 \vec{v}_1 = -m_2 \vec{v}_2$$

$$\vec{v}_1 = -\frac{m_2}{m_1} \vec{v}_2 \Rightarrow \frac{|\vec{v}_1|}{|\vec{v}_2|} = 2$$

d) Is the kinetic energy immediately before the explosion less than, greater than or equal to the kinetic energy after the explosion?

Immediately before the collision, the shell is at the maximum height & so $v = 0$. So $K.E._i = 0$. But $K.E._f \neq 0$. This implies that kinetic energy is greater after the explosion.