

4. ~~Cart A moves to the right with a speed slightly less than the original speed of cart B and cart B moves to the right with a very small speed.~~

a) ~~Suppose you drop paperclips into an open cart rolling along a straight horizontal track with negligible friction. As a result of the accumulating water, explain whether the momentum and kinetic energy increase, decrease, or stay the same.~~

### ~~Problem 2: Center of Mass~~

~~The mean distance from the earth to the sun is  $r_{e,s} = 1.49 \times 10^{11} \text{ m}$ . The mass of the earth is  $m_e = 5.98 \times 10^{24} \text{ kg}$  and the mass of the sun is  $m_s = 1.99 \times 10^{30} \text{ kg}$ . The mean radius of the earth is  $r_e = 6.37 \times 10^6 \text{ m}$ . The mean radius of the sun is  $r_s = 6.96 \times 10^8 \text{ m}$ . Where is the location of the center of mass of the earth sun system?~~

### ~~Problem 3: Impulse and Momentum~~

~~A ball of mass  $m_1 = 8.0 \times 10^{-2} \text{ kg}$ , starting from rest, falls a height of  $3.0 \text{ m}$  and then collides with the ground. The ball bounces up to a height of  $2.0 \text{ m}$ . The collision with the ground takes place over a time,  $\Delta t_{col} = 5.0 \times 10^{-3} \text{ s}$ .~~

a) ~~What is the momentum of the ball immediately before the collision?~~

b) ~~What is the momentum of the ball immediately after the collision?~~

c) ~~What is the average force of the ground on the ball?~~

d) ~~What impulse is imparted to the ball?~~

e) ~~What is the change in the kinetic energy during the collision?~~

### ~~Problem 4:~~

~~A block of mass  $m_b$  on a horizontal table is connected to one end of a spring with spring constant  $k$ . The other end of the spring is attached to a wall. The block is set in motion so that it oscillates about its equilibrium point with amplitude  $A_0$ .~~

a) ~~What is the period of the motion?~~

~~A lump of sticky putty of mass  $m_p$  is dropped onto the block. The putty sticks without bouncing. The putty hits the block at the instant when the velocity of the block is zero.~~

b) ~~Find the new period, the new amplitude, and the change in mechanical energy of the system.~~

The putty is removed and the block is set in motion with the same amplitude  $A_0$ . This time the putty is dropped and hits the block at the instant the block has its maximum velocity.

- c) Find the new period, the new amplitude, and the change in mechanical energy of the system.

**Problem 4:**

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b) Find the new period, the new amplitude, and the change in mechanical energy of the system.

b) When the putty hits the block, the velocity of the block is zero. Therefore the string is stretched or compressed to maximum. The putty does not transfer any momentum to the block, thus the amplitude and the mechanical energy stay the same. The new period is

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m_b + m_p}{k}}$$

The putty is removed and the block is set in motion with the same amplitude  $A_0$ . This time the putty is dropped and hits the block at the instant the block has its maximum velocity.

c) Find the new period, the new amplitude, and the change in mechanical energy of the system.

c) The period is again given by

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m_b + m_p}{k}}.$$

We can use the result of Problem 1 c) to find the change of the mechanical energy after the collision

$$\Delta E = \Delta K = K_f - K_i = \frac{m_b}{m_b + m_p} K_i - K_i = -\frac{m_p}{m_p + m_b} K_i = -\frac{m_p}{m_p + m_b} \frac{kA_0^2}{2}.$$

The new amplitude is found using

$$\frac{kA^2}{2} = K_f = \frac{m_b}{m_b + m_p} \frac{kA_0^2}{2}.$$

Thus

$$A = \sqrt{\frac{m_b}{m_b + m_p}} A_0$$