Momentum and Impulse:

Consider the two objects shown below:



 20.0m

0m

-20.0m

2.0 m/s

2.0kg

4.0kg

0.50m/s

1. Assume the initial position of the 2.0kg mass is +18.0m and the initial position of the 4.0kg mass is -12.0m. Assume that the masses can pass each other without colliding, and that the number line is measured in metres.

A. Determine the location of the centre of mass of the system at the time shown (t=0s)

B. Determine the location of the centre of mass at t=1.0s.

C. Determine the location of the centre of mass at t=2.0s.

D. Determine the location of the centre of mass at t=3.0s.

E. Determine the location of the centre of mass at t=4.0s.

F. Determine the location of the centre of mass at t=5.0s.

G. Plot a graph of *position*  vs *time* for the centre of mass of the object.

H. Describe the function.

I. Find the velocity of the centre of mass of the system.

2. Consider the system shown below:

12m/s



A 9800kg train cart has a 1200kg car (A 1971 Datsun 240Z, to be precise) resting on it. Together the train cart and the car are moving right at 12m/s. At t=0s the car begins to accelerate toward the left end of the cart at 4.0m/s2.

A. What will happen to the location of the centre of mass of system, *relative to the train cart* as the car accelerates?

 i. moves to the left

 ii. moves to the right

 iii. remains at the same position.

B. What force provides the acceleration of the car?

C. What happens to the velocity of the centre of mass of the system as the car accelerates?

D. As a result of the car’s acceleration, the train cart will:

 i. speed up

 ii. slow down

 iii. remain moving at constant speed

E. Assuming the train cart is long enough, find the speed of the train cart after 4.0s.

A t=6.0s, the car then slams on its brakes, to avoid driving off the end of the cart. The car comes to rest at t=7.2s.

F. Find the speed of the train cart after the car comes back to rest.

3. A rubber ball is dropped onto the concrete floor. The 220g ball hits the floor travelling downward at 4.0m/s. The ball rebounds from the floor at 3.2m/s. The ball is in contact with the floor for 0.060s.

 A. What is the change in the velocity of the ball?

 B. What is the change in the momentum of the ball?

 C. What impulse does the ball experience?

 D. What is the average net force that is applied to the ball while in contact with the ground?

 E. Make a sketch of net force vs. time for the ball from the time it is dropped until it rebounds back to maximum height.

 F. What is the average force exerted by the ground on the ball?

 G. Was the momentum of the ball conserved? Explain.

 H. Was momentum conserved? Explain.

4. Cars are designed with crumple zones at the front and rear so that the car will crumple relatively easily in a collision, up until the passenger compartment. Use the concepts of impulse and momentum to explain why this increases passenger safety versus making the car more rigid.