Chapter 11 Discussion
Impulse and Momentum

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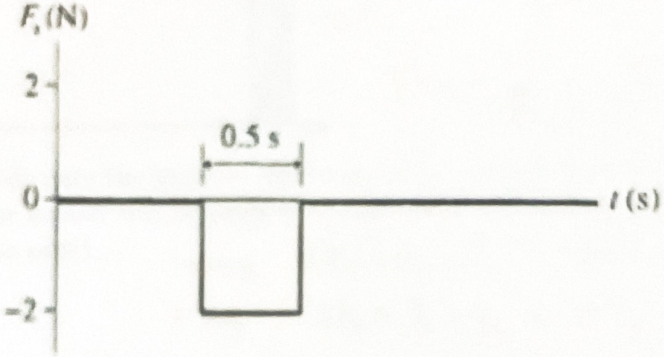
1. A 2 kg object is moving to the right with a speed of 1 m/s when it experiences an impulse due to a time-dependent force.

   (a) Suppose $F_x(t)$ is as shown in the graph. What is the object's speed and direction after the impulse?



$\boxed{\frac{1}{2}\ m/s}$, right

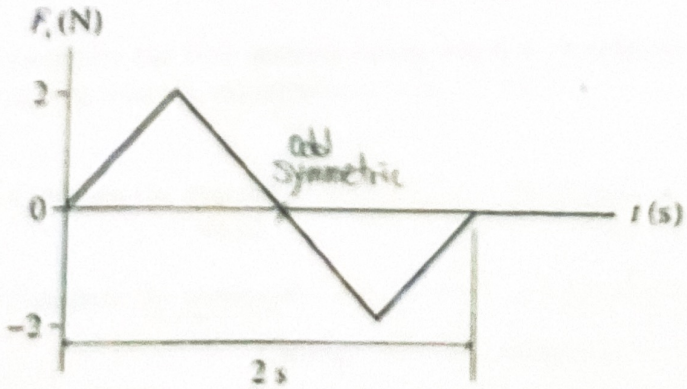
Impulse - momentum theorm

$\Delta P_x = \int F_x\,dt = (-2N)(0.5s) = -1N\cdot s$

$= P_x' - P_x$ = final - initial

$= mv_x' - mv_x = -1$, $v_x' = +0.5\,m/s$, right

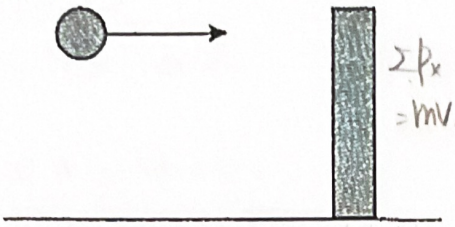
   (b) What if the force graph was the one shown below instead?



$\boxed{1\,m/s\ ,\ \text{right}}$

$\Delta P_x = \int F_x\,dt = P_x' - P_x = mv_x' - mv = 0$

2. A carnival game requires you to knock over a wooden post by throwing a ball at it. You're offered a very bouncy rubber ball and a very sticky clay ball of equal mass m. Assume that you can throw them with equal speed v_0 and equal accuracy. You only get one throw.



Before

$\Sigma P_x = mV_0$

Bouncy: m, V_0, $V=0$

clay: m, V_0, $V=0$

After

V_0, m, V_p'

$\Sigma P_x' = -mV_0 + MV_p'$

V_p'

$\Sigma P_x' = (m+M)V_p'$

(a) Calculate the impulse delivered to the wooden post for both types of ball (assume the rubber ball bounces with essentially no loss of speed, and the clay ball sticks to the post).

bouncy : $\Delta P_x = P_x' - P_x = -MV_0 - MV_0 = -2mV_0$

clay : $\Delta P_x = P_x' - P_x = mV_p' - mV_0 = (V_p' - V_0)m$

(b) Which ball will you choose? Why?

Bouncy

3. A small, light ball S and a large, heavy ball L move toward each other, collide, and bounce apart.

(a) Compare the force that S exerts on L during the collision to the force that L exerts on S (i.e., is F_{LS} larger, smaller, or equal to F_{SL}?) equal, Newton 3rd Law

(b) Compare the time interval during which S experiences a force to the time interval during which L experiences a force. equal

$\Delta P = \int F_x dt$

(c) Compare the impulse delivered to S to the impulse delivered to L.

equal $\Delta P_S = \int F_x dt$, $\Delta P_L = \int F_x dt$

(d) Compare the momentum change of S to the momentum change of L.

Change of the momentum = impulse, equal

$\Delta P_S = \Delta P_L$

$M_S \Delta V_S = M_L \Delta V_L$

$\Delta V_S \neq \Delta V_L$

(e) Compare the velocity change of S to the velocity change of L.

$V_S > V_L$

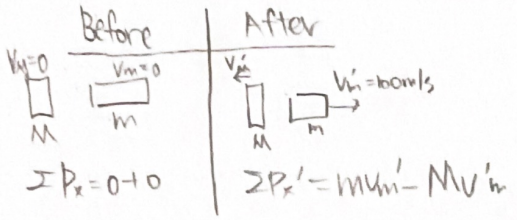
(f) Is the change in the *sum* of the momenta of the two balls positive, negative, or zero? Conservation of momentum if No external force

$\Delta \Sigma P_x = 0$

(g) acceleration $a_S > a_L$

4. For each question below, draw a Before/After diagram and apply momentum conservation to solve for the indicated quantity.

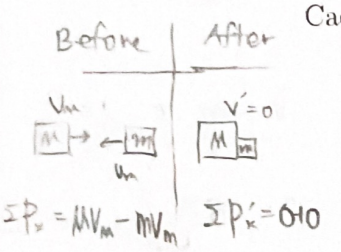
(a) A 50 kg archer, standing on frictionless ice, shoots a 100 g arrow at a speed of 100 m/s. What is the recoil speed of the archer?



$\Sigma P_x=\Sigma P'_x$ (No external force)

$0=mV'_m-MV'_m$, $\boxed{V'_M=0.2m/s}$

(b) The parking brake on a 2000 kg Cadillac has failed, and it is rolling slowly, at 0.3 m/s, toward a group of small innocent children. As you see the situation, you realize there is just time for you to drive your 1000 kg Volkswagen head-on into the Cadillac and thus save the children. With what speed should you impact the Cadillac to bring it to a halt? $\boxed{0.6m/s}$



$\Sigma P_x=\Sigma P'_x$ ← no net ext force

← no ext impulse

$MV_M-mV_m=0$

$MV_M=mV_m$

(c) Dan is gliding on his skateboard at 4 m/s. He suddenly jumps backward off the skateboard, kicking the skateboard forward at 8 m/s. How fast is Dan going as his feet hit the ground? Dan's mass is 50 kg and the skateboard's mass if 5 kg.

$(M+m)V=mV'_m-MV'_M$

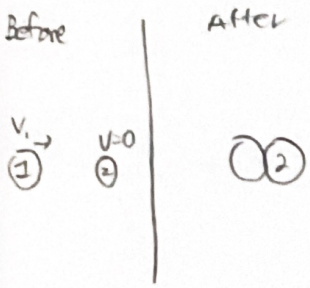
$(50+5)(4m/s)=(5kg)(8m/s)-(50kg)V'_M$

$V'_M=-3.6m/s$ (incorrect assumption)

Still moving to the right 3.6m/s

(d) Ball 1 with an initial speed of $v_1=14$ m/s has a perfectly elastic collision with ball 2 that is initially at rest. Afterward, the speed of ball 2 is $v'_2=21$ m/s. What will be the speed of ball 2 if v_1 is doubled? If m_1 is doubled?

Yes No



$\Sigma K=\Sigma K'$

$m_1V_1=m_1V'_1+m_2V'_2$

(1) 42m/s ?

$\frac{m_1(V_1-V'_1)}{m_2}=V'_2$

5. Indicate whether each of the following can be reasonably modeled as a perfectly elastic collision, a perfectly inelastic collision, both, or neither.

   (a) A bowling ball hits a bowling pin.

   neither

   (b) A bug hits your windshield while you're driving.

   Perfectly inelastic

   (c) A bat hits a Styrofoam ball.

   Neither

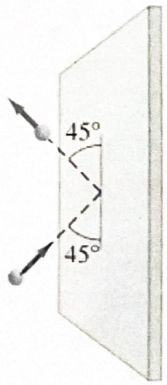
   (d) A flying bird meets and swallows a flying bug.

   Perfectly inelastic

   (e) A dropped ball bounces back to half its initial height.

   neither

6. A tennis ball of mass $m = 0.060$ kg and speed $v = 28$ m/s strikes a wall at a 45° angle and rebounds with the same speed at 45°. What is the impulse (magnitude and direction) given to the ball? What force produces this impulse?



$J = \Delta p = mv\cos 45° - mv\cos 45°$

$(0.06kg)(-28m/s)(\cos 45°) - (0.06)(28)(\cos 45°$

$= 2.376$ N/s

Normal force

7. Consider a rocket in empty space.

   (a) If a rocket motor's exhaust speed is increased by a factor of 2, does the rocket's maximum speed increase by a factor of 2, more than 2, or less than 2? Explain.

   more than two because of the existance of Net external force.

   (b) If a rocket's fuel-to-empty-rocket mass ratio is increased by a factor of 2, does the rocket's maximum speed increase by a factor of 2, more than 2, or less than 2? Explain.

$\frac{1}{2}mv^2$ when m, both be doubled as ratio more than 2?