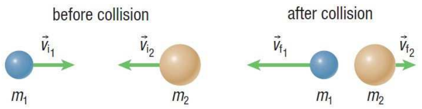
SPH4U UNIVERSITY PHYSICS

ENERGY & MOMENTUM

- Perfectly Elastic Collisions (P.240-248)

Perfectly Elastic Collisions

*As suspected, when hard objects such as billiard balls collide, bounce off each other, and return to their original shape, they have undergone elastic collisions. Very few collisions are **perfectly elastic**, but in many cases, the loss of kinetic energy is so small that it can be neglected.*



Perfectly Elastic Collisions

NOTE!

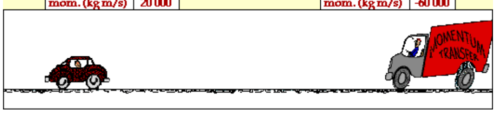
Since both kinetic energy and momentum are conserved in perfectly elastic collisions, an analysis of this type of collision yields two very useful equations.

Car

mass (kg)	1000
vel. (m/s)	20.0
mom. (kg m/s)	20 000

Truck

mass (kg)	3000
vel. (m/s)	-20.0
mom. (kg m/s)	-60 000



Perfectly Elastic Collisions

PERFECTLY ELASTIC COLLISIONS

$$v_{Af} = \left(\frac{m_A - m_B}{m_A + m_B}\right)v_{Ai} \quad \& \quad v_{Bf} = \left(\frac{2m_A}{m_A + m_B}\right)v_{Ai}$$

where v_f is the velocity of the object after the collision (m/s)
v_{Ai} is the velocity of the moving object before the collision (m/s)
m is the mass of the object (kg)

NOTE!
These equations assume that object A is moving and object B is stationary.

Perfectly Elastic Collisions

PRACTICE

1. Suppose you have two objects. Object A, with a mass of 0.26 kg travelling at 1.3 m/s[E], collides head-on with a stationary object B, with a mass of 0.15 kg. If the collision is perfectly elastic, determine the final velocities of both objects after the collision. Express your answers to 2 decimal places. (Hint: assume [E] is positive.)

v_{Af} = 0.35 m/s
v_{Bf} = 1.65 m/s

Perfectly Elastic Collisions

PRACTICE

2. Suppose object B in the previous problem was not stationary but was initially travelling at 1.0 m/s[W]. What would the final velocities of both objects be after the perfectly elastic collision? Express your answers to 2 decimal places. (Hint: assume [E] is positive.)

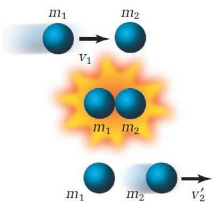
FYI ☞ You can still use the "perfectly elastic collision" equations but there are a couple of extra steps.

v_{Bi}' = -1.0 {+1.0} = 0 ☜ make v_{Bi} = 0 by +/- the opposite #
v_{Ai}' = 1.3 {+1.0} = 2.3 m/s ☜ what you did to v_{Bi} you do to v_{Ai}
v_{Af} = 0.62 {-1.0} = -0.38 m/s ☜ find v_{Af} & then do the opposite
v_{Bf} = 2.92 {-1.0} = 1.92 m/s ☜ find v_{Bf} & then do the opposite

Perfectly Elastic Collisions

PRACTICE

3. Without doing any calculations, draw some general conclusions about perfectly elastic collisions if:
   (a) $m_1 = m_2$



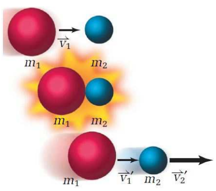
(a) when the masses are equal

$v_1' = 0$ & $v_2' = v_1$

Perfectly Elastic Collisions

PRACTICE

3. Without doing any calculations, draw some general conclusions about perfectly elastic collisions if:
   (b) $m_1 >>> m_2$



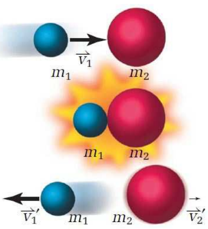
(b) when mass 1 is much larger than mass 2, you can almost ignore mass 2

$v_1' \cong v_1$ & $v_2' \cong 2v_1$

Perfectly Elastic Collisions

PRACTICE (3 continued …)

3. Without doing any calculations, draw some general conclusions about perfectly elastic collisions if:
   (c) m1 <<< m2



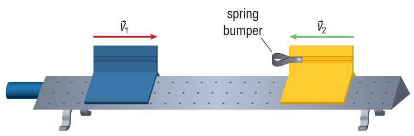
(c) when mass 1 is much smaller than mass 2, you can almost ignore mass 1

$v_1' \cong -v_1$ & $v_2' \cong 0$

Elastic Collisions & Mechanical Energy

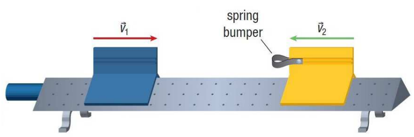
PRACTICE

4. Consider the two carts shown below. What do you suppose happens to the total mechanical energy during an elastic collision?



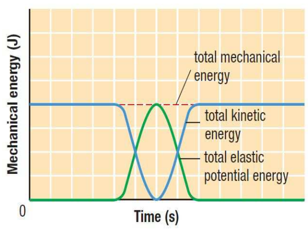
Elastic Collisions & Mechanical Energy

When the two gliders collide, the spring bumper compresses initially and then springs back to its original shape. This occurs because some of the kinetic energy of the moving gliders is converted into elastic potential energy in the spring bumper during the compression which is then converted back into kinetic energy during the rebound.



Elastic Collisions & Mechanical Energy

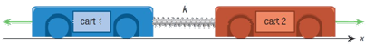
The graph shows that as the spring compresses, the elastic energy increases and the total kinetic energy of the two carts decreases. The total mechanical energy, however, stays constant. As the compression decreases, the elastic energy decreases and the total kinetic energy increases. The total mechanical energy still remains constant.



Elastic Collisions & Mechanical Energy

PRACTICE

5. Dynamics cart A has a mass of 1.8 kg and is moving with a velocity of 4.0 m/s[right] along a frictionless track. Dynamics cart 2 has a mass of 2.2 kg and is moving at 6.0 m/s[left]. The carts collide in a head-on elastic collision cushioned by a spring ($k = 8.0 \times 10^4$ N/m).

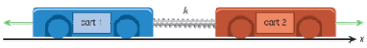


(a) Determine the compression of the spring, in centimetres, during the collision when cart 2 is moving at 4.0 m/s[left]. (Hint: find the velocity of the cart 1 first and then use conservation of energy to find the amount of compression.)

Elastic Collisions & Mechanical Energy

PRACTICE

5. (a)



Assume motion to the right as positive

$m_1 = 1.8$ kg	$m_2 = 2.2$ kg
$v_{1i} = 4.0$ m/s	$v_{2i} = -6.0$ m/s
$v_{1f} = ??$	$v_{2f} = -4.0$ m/s

$v_{1f} = 1.56$ m/s

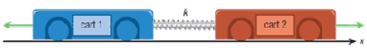
$\Delta x = 0.029$ m

☜ $E_{k1i} + E_{k2i} = E_{k1f} + E_{k2f} + E_e$

Elastic Collisions & Mechanical Energy

PRACTICE

5. Dynamics cart A has a mass of 1.8 kg and is moving with a velocity of 4.0 m/s[right] along a frictionless track. Dynamics cart 2 has a mass of 2.2 kg and is moving at 6.0 m/s[left]. The carts collide in a head-on elastic collision cushioned by a spring ($k = 8.0 \times 10^4$ N/m).

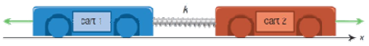


(b) Calculate the maximum compression of the spring, in centimetres. (Hint: at maximum compression both gliders will have the same velocity – if they did not they would be catching up to or pulling away from each other.)

Elastic Collisions & Mechanical Energy

PRACTICE

5. (b)



Assume motion to the right as positive

m_1 = 1.8 kg　　m_2 = 2.2 kg

v_{1i} = 4.0 m/s　　v_{2i} = -6.0 m/s

v_{1f} = ??　　v_{2f} = v_{1f}

$v_{2f} = v_{1f} = -1.5$ m/s

$\Delta x = 0.035$ m　　☜ $E_{k1i} + E_{k2i} = E_{k1f} + E_{k2f} + E_e$

✔ Check Your Learning

TEXTBOOK

P.248　Q.3,5

WIKI (ENERGY & MOMENTUM)

✎....　4U2 - QUIZ#3 (E&M - Part 2)