Ch. 7 "Momentum" (Impulse & momentum)

The Formulas we have so far...

① $I = F \times t$ (Impulse)

② $p = m \times v$ (momentum)

③ $\Delta \overrightarrow{Ft} = \Delta mv$

④ Explosion

$$m_{1B}v_{1B} + m_{2B}v_{2B} = \emptyset$$

⑤ Elastic Collision (aka... "Non-Sticky Collision")

$$m_{1B}v_{1B} + m_{2B}v_{2B} = m_{1A}v_{1A} + m_{2A}v_{2A}$$

⑥ Inelastic Collision (aka... "Sticky Collision")

$$m_{1B}v_{1B} + m_{2B}v_{2B} = (m_{1A} + m_{2A})\,v_{1A+2A}$$

7.5 Collisions (and explosions)

- show figure 7.9 pg. 94

Elastic Collisions
See fig. 7.9 (3 examples)

Inelastic Collisions
pg. 95 fig. 7.10 (1 example)

- Now example Problems...

Explosion Problem #1:

$$m_{1B}v_{1B} + m_{2B}v_{2B} = \emptyset$$

Solve for v_{2A}:

Knowns:

$m_1 = 1.0\,kg$

$m_2 = 1.0\,kg$

$v_{1A} = +20.0\,m/s$

$v_{2A} = ?$

$m_{1B}v_{1B} + m_{2B}v_{2B} = \emptyset$

$+\leftarrow$ $\qquad\qquad$ $\rightarrow -$

$$+m_{1A}v_{1A} = -m_{2A}v_{2A}$$

$$\frac{+m_{1A}v_{1A}}{-m_{2A}} = \frac{-m_{2A}v_{2A}}{-m_{2A}}$$

$$\frac{+m_{1A}v_{1A}}{-m_{2A}} = v_{2A}$$

$$\frac{(1.0\,kg)(+20.0\,m/s)}{(-1.0\,kg)} = v_{2A}$$

$$\frac{20\,kg\cdot m/s}{-1.0\,kg} = v_{2A}$$

$$\boxed{-20.0\,m/s = v_{2A}}$$

"Explosion" Example Problem #2:

- A person on a skateboard with a bowling ball...

(See illustration) pg. 94

Equation:

Before she Throws The bowling ball:

$$M_{1B}V_{1B} + M_{2B}V_{2B} = \emptyset$$

Now she Throws The bowling ball ("explosion"):

$$+M_{1A}V_{1A} = -M_{2A}V_{2A}$$

Knowns:

M_1 (skaterdudette + skateboard) $= 100\,kg$

M_2 = (Bowling Ball) $= 5\,kg$

$V_{2A} = -5\,m/s$

$V_{1A} = ?\ m/s$

Solve for V_{1A}:

$$\frac{+M_{1A}V_{1A}}{+M_{1A}} = \frac{-M_{2A}V_{2A}}{+M_{1A}}$$

$$V_{1A} = \frac{-M_{2A}V_{2A}}{+M_{1A}}$$

$$V_{1A} = \frac{(-5\,kg)(-5\,m/s)}{(100\,kg)} = \frac{+25\,kg \cdot m/s}{100\,kg}$$

$$\boxed{V_{1A} = +0.25\,m/s}$$

Explosion Problem #3:

$$m_{1B}v_{1B} + m_{2B}v_{2B} = \emptyset$$

Solve for v_{1A}:

Knowns:

$m_1 = 90.0\,kg$

$m_2 = 20.0\,kg$

$v_{2A} = -3.0\,m/s$

$v_{1A} = \underline{?}\ m/s$

$$m_{1B}v_{1B} + m_{2B}v_{2B} = \emptyset$$

$+\leftarrow \qquad \rightarrow -$

$$+m_{1A}v_{1A} = -m_{2A}v_{2A}$$

$$\frac{m_{1A}v_{1A}}{m_{1A}} = \frac{-m_{2A}v_{2A}}{m_{1A}}$$

$$v_{1A} = \frac{-m_{2A}v_{2A}}{m_{1A}}$$

$$v_{1A} = \frac{-(20.0\,kg)(-3.0\,m/s)}{(90.0\,kg)}$$

$$v_{1A} = \frac{+60\,kg\cdot m/s}{90.0\,kg}$$

$$\boxed{v_{1A} = +0.\overline{6}\,m/s}$$

$$\boxed{v_{1A} = +0.7\,m/s}$$

Elastic Collision Example Problem #1:

$$m_{1B}v_{1B} + m_{2B}v_{2B} = m_{1A}v_{1A} + m_{2A}v_{2A}$$

Solve the Equation for V_{2A} (1st!)

$$+ \longleftarrow \quad \frac{m_{1B}v_{1B} + m_{2B}v_{2B} - m_{1A}v_{1A} = m_{2A}v_{2A}}{m_{2A}} \qquad \frac{}{m_{2A}}$$

$$\frac{m_{1B}v_{1B} + m_{2B}v_{2B} - m_{1A}v_{1A}}{m_{2A}} = V_{2A}$$

Knowns:

$m_1 = 1.0\,kg$

$m_2 = 1.0\,kg$

$V_{1B} = +2.0\,m/s$

$V_{2B} = 0\,m/s$

$V_{1A} = 0\,m/s$

$\boxed{V_{2A} = ?\,m/s}$

$$\frac{(1.0kg)(2.0m/s) + 0 - 0}{(1.0kg)} = V_{2A}$$

$$\frac{(2.0kg \cdot m/s)}{(1.0kg)} = V_{2A}$$

$$\boxed{+2.0\,m/s = V_{2A}}$$

ELASTIC Collision Example Problem #2:

$$m_{1B}V_{1B} + m_{2B}V_{2B} = m_{1A}V_{1A} + m_{2A}V_{2A}$$

Solve for V_{2A}:

$$\frac{m_{1B}V_{1B} + m_{2B}V_{2B} - m_{1A}V_{1A}}{m_{2A}} = V_{2A}$$

Knowns:

$m_1 = 2.0\ kg$

$m_2 = 1.5\ kg$

$V_{1B} = 5.0\ m/s$

$V_{2B} = 0.0\ m/s$

$V_{1A} = 0.5\ m/s$

$V_{2A} = ?\ m/s$

$$\frac{(2.0\ kg)(5.0\ m/s) + 0 - (2.0\ kg)(0.5\ m/s)}{(1.5\ kg)} = V_{2A}$$

$$\frac{10.0\ kg\cdot m/s - 1.0\ kg\cdot m/s}{1.5\ kg} = V_{2A}$$

$$\frac{9.0\ kg\cdot m/s}{1.5\ kg} = V_{2A}$$

$$6.0\ m/s = V_{2A}$$

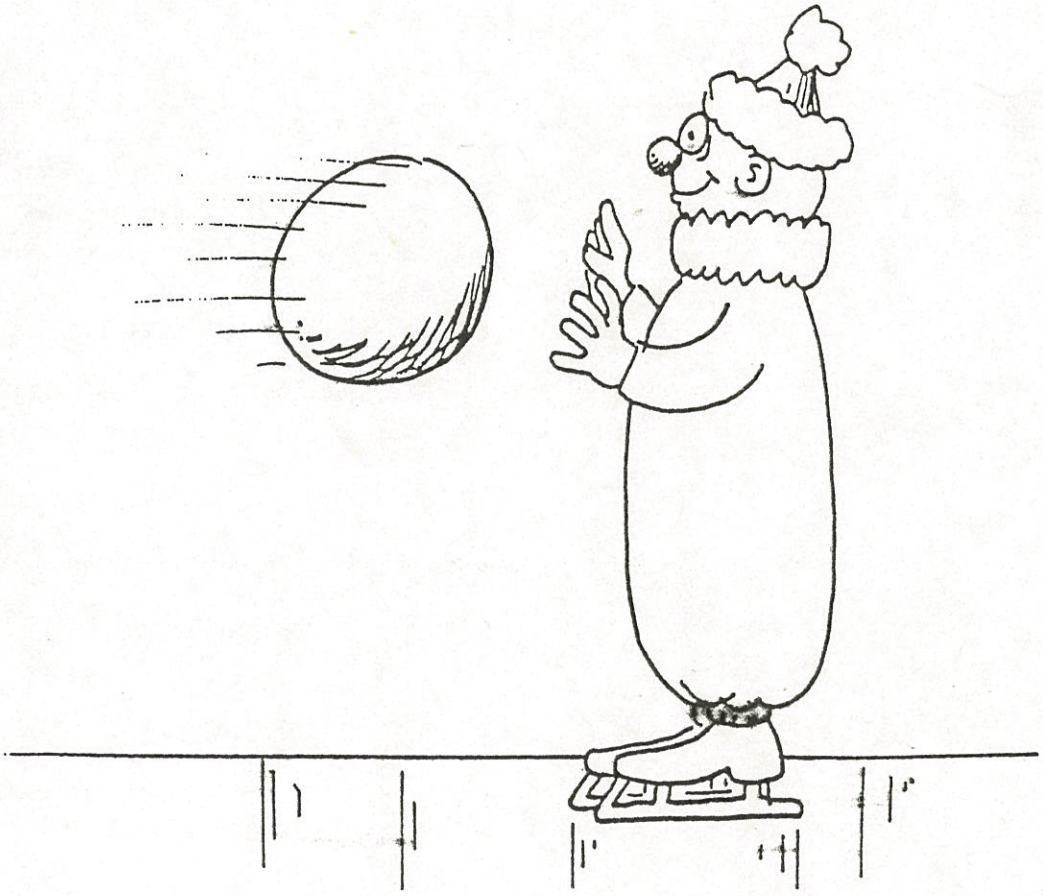
Do Jocko catching the Ball!

(Inelastic Collision)

- Inelastic Collision example problems ...

7-1 *Conceptual* **PHYSICS**
Next-Time Question

JOCKO, WHO HAS A MASS OF 60 kg AND STANDS AT REST ON ICE, CATCHES A 20 kg BALL THAT IS THROWN TO HIM AT 10 km/h. HOW FAST DOES JOCKO AND THE BALL MOVE ACROSS THE ICE?



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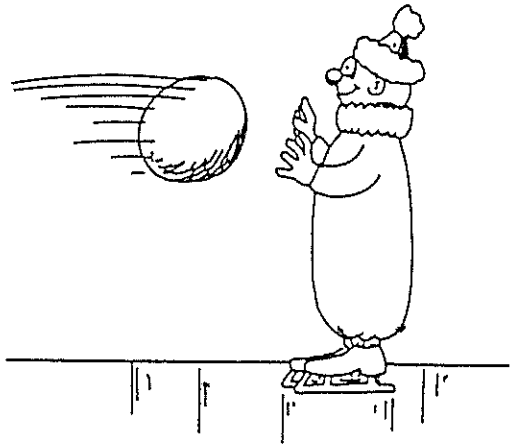


ANSWER:

THE MOMENTUM BEFORE THE CATCH IS ALL IN THE BALL, 20 kg × 10 km/h = 200 kg·km/h. THIS IS ALSO THE MOMENTUM AFTER THE CATCH, WHERE THE MOVING MASS IS 80 kg--- 60 kg FOR JOCKO AND 20 kg FOR THE CAUGHT BALL.

$$80\ \text{kg} \times v = 200\ \text{kg·km/h}$$

$$v = \frac{200\ \text{kg·km/h}}{80\ \text{kg}} = 2.5\ \text{km/h}$$

"Jocko & The Ball" Inelastic Collision Problem #1:

Inelastic Collision:

$$m_{1B}v_{1B} + m_{2B}v_{2B} = (m_1 + m_{2A})\,v_{1+2A}$$

Solve for v_{1+2A}:

$$\frac{m_{1B}v_{1B} + m_{2B}v_{2B}}{(m_1 + m_{2A})} = \frac{(m_1 + m_{2A})\,v_{1+2A}}{(m_1 + m_{2A})}$$

$$\boxed{\frac{m_{1B}v_{1B} + m_{2B}v_{2B}}{(m_1 + m_{2A})} = v_{1+2A}}$$

Knowns:

(Jocko) $m_1 = 60.0\,kg$

(Med. Ball) $m_2 = 20.0\,kg$

$v_{2B} = 10\ km/h$

$v_{1B} = 0.0\ km/h$

$v_{1+2A} = ?\ km/h$

$$\frac{0 + (20.0\,kg)(10.0\,km/h)}{(80.0\,kg)} = v_{1+2A}$$

$$\frac{200\,kg\cdot km/h}{80\,kg} = v_{1+2A}$$

$$\boxed{2.5\,km/h = v_{1+2A}}$$

Inelastic Collision "Granny & Ambrose"

Example Problem #2: (see CDPPT-1, Pg. 2)

$$m_{1B}v_{1B} + m_{2B}v_{2B} = (m_{1A} + m_{2A})\,v_{1A+2A}$$

Solve for $v_{1A+2A} = ?$

$$\frac{m_{1B}v_{1B} + m_{2B}v_{2B}}{(m_{1A} + m_{2A})} = v_{1A+2A}$$

Knowns:

Granny $m_1 = 80\,kg$

Ambrose $m_2 = 40\,kg$

(G) $v_{1B} = 3.0\,m/s$

(A) $v_{2B} = 0.0\,m/s$

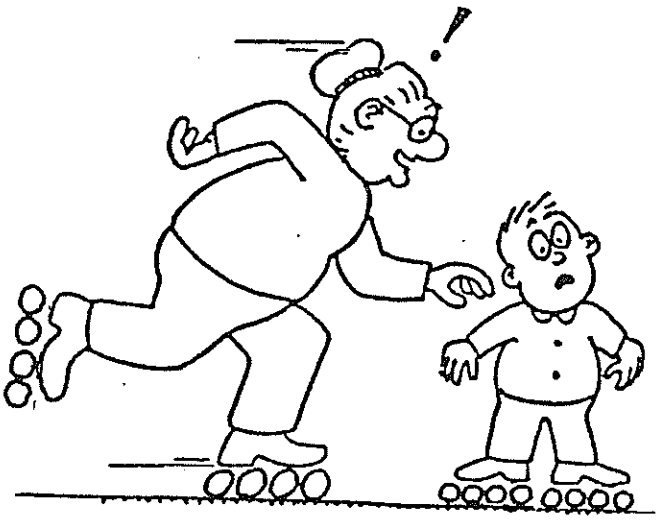
$v_{1A+2A} = ?$

$$\frac{(80\,kg)(3.0\,m/s) + 0}{(120\,kg)} = v_{1A+2A}$$

$$\frac{240\,kg \cdot m/s}{120\,kg} = v_{1A+2A}$$

$$\boxed{2.0\,m/s = v_{1A+2A}}$$

6. Granny whizzes around the rink and is suddenly confronted with Ambrose at rest directly in her path. Rather than knock him over, she picks him up and continues in motion without "braking."



Consider both Granny and Ambrose as two parts of one system. Since no outside forces act on the system, the momentum of the system before collision equals the momentum of the system after collision.

a. Complete the before-collision data in the table below.

BEFORE COLLISION	
Granny's mass	80 kg
Granny's speed	3 m/s
Granny's momentum	_____
Ambrose's mass	40 kg
Ambrose's speed	0 m/s
Ambrose's momentum	_____
Total momentum	_____

b. After collision, does Granny's speed increase or decrease?

_____

c. After collision, does Ambrose's speed increase or decrease?

_____

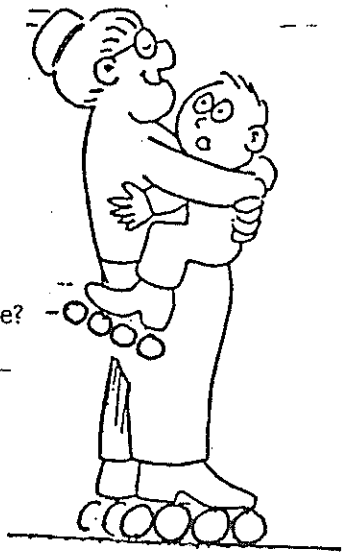
d. After collision, what is the total mass of Granny + Ambrose?

_____

e. After collision, what is the total momentum of Granny + Ambrose?

_____

f. Use the conservation of momentum law to find the speed of Granny and Ambrose together after collision. (Show your work in the space below.)



New speed = _____

Conceptual PHYSICS

Inelastic Collision Example

Problem #1:

$$m_{1B}v_{1B} + m_{2}v_{2B} = (m_{1A} + m_{2A})\, v_{1A+2A}$$

Solve for v_{1A+2A}:

$$\frac{m_{1B}v_{1B} + m_{2}v_{2B}}{(m_{1A} + m_{2A})} = v_{1A+2A}$$

Knowns:

$m_1 = 2000.0\ kg$

$m_2 = 2000.0\ kg$

$v_{1B} = 5.0\ m/s$

$v_{2B} = 0.0\ m/s$

$v_{1A+2A} = ?$

$$\frac{(2000.0\ kg)(5.0\ m/s) + 0}{(2000.0\ kg + 2000.0\ kg)} = v_{1A+2A}$$

$$\frac{10{,}000\ kg \cdot m/s}{(4{,}000.0\ kg)} = v_{1A+2A}$$

$$\boxed{2.5\ m/s = v_{1A+2A}}$$

Inelastic Collision Example

Problem #2:

$$m_{1B}v_{1B} + m_2v_{2B} = (m_{1A} + m_{2A})\,v_{1A+2A}$$

Solve for v_{1A+2A}:

$$\frac{m_{1B}v_{1B} + m_2v_{2B}}{(m_{1A} + m_{2A})} = v_{1A+2A}$$

$$\frac{(2000.0\,kg)(10.0\,m/s) + 0}{(6,500.0\,kg)} = v_{1A+2A}$$

$$\frac{20,000.0\,kg \cdot m/s}{6,500.0\,kg} = v_{1A+2A}$$

$$3.076923077\,m/s = v_{1A+2A}$$

$$\boxed{3.1\,m/s = v_{1A+2A}}$$

Knowns:

$m_1 = 2000.0\,kg$

$m_2 = 4500.0\,kg$

$v_{1B} = 10.0\,m/s$

$v_{2B} = 0.0\,m/s$

$v_{1A+2A} = ?$