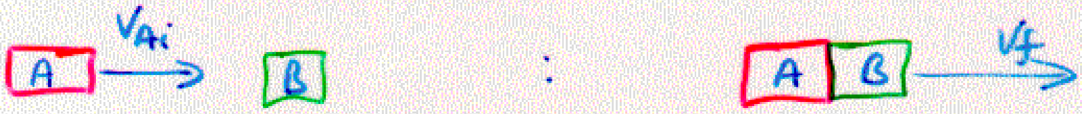
Inelastic Collisions

Momentum conserved as before (if no external forces)

BUT K.E. not conserved - lost to deformation (damage) heat, sound energy

Special Case: Totally Inelastic Collisions

$|\Delta KE| = |(KE)_f - (KE)_i|$ is max. when objects "stick" together after collision:



Then $P_i = m_A V_{Ai} + m_B V_{Bi} = P_f = (m_A + m_B) v_f$

1 unknown, 1 equation!

$(KE)_i = \frac{1}{2} m_A V_{Ai}^2 + \ldots\ldots$ $\qquad (KE)_f = \frac{1}{2}(m_A+m_B) v_f^2 = \dfrac{P_f^2}{2(m_A+m_B)}$

Examples: throw clay lump at door
"sack" quarterback (Ex. 7.9)
catch a ball (if no friction)
car crash

Can show $\Delta KE = (KE)_f - (KE)_i = -\dfrac{m_B}{m_A+m_B} \cdot (KE)_i$

$\therefore$ more "damage" when $m_B >> m_A$ $\therefore$ car hits truck vs. truck hits car

Inelastic Collisions in time-reverse!

i.e. when objects fly apart

e.g. rocket ejects fuel, astronaut throws ball (no friction)

bomb explodes

recoil of gun

skaters push apart (look at v_A, v_B just after separation, before Friction force has time to change $\vec{P}$)

If initial $\vec{P}_i = 0$, $\quad \vec{P}_f = m_A\vec{v}_A + m_B\vec{v}_B + \dots = 0$

But $(KE)_i = 0$

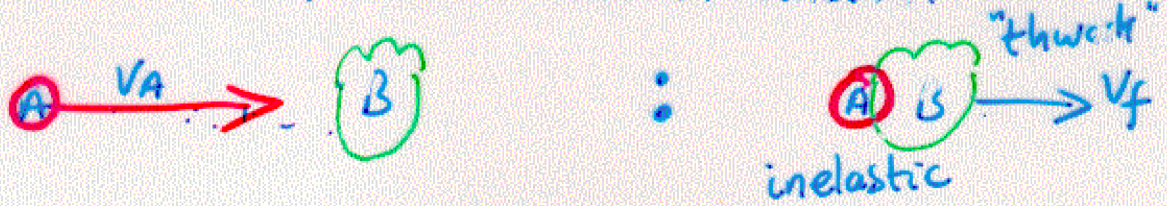
$$(KE)_f = \left.\begin{aligned} &\tfrac{1}{2}m_A v_A^2 + \dots\dots \\ &= \frac{p_A^2}{2m_A} + \dots\dots \end{aligned}\right\} > 0$$

So K.E. must come from another source of energy (e.g. chemical, muscles)

Example [illegible] $m_A = 0.4$ kg, $V_A = 50$ m/s

hits catch[illegible] $m_B = 0.8$ kg. Find speed [illegible]

(ball + mitt), [illegible] K.[illegible] lost in coll[illegible]



Just after collision (before catcher can apply braking force)

$P_f = (m_A + m_B) V_f = P_i = m_A V_A = 0.4 \times 50 = 20$ Ns

→ [illegible] (kg m/s)

$\Rightarrow V_f = \frac{m_A V_A}{(m_A + m_B)} = \frac{20}{(0.4 + 0.8)} = 16.67$ m/s

[illegible]

Initial $(KE)_i = \frac{1}{2} m_A V_A^2 = \frac{P_i^2}{2 m_A} = \frac{20^2}{(2 \times 0.4)} = 500$ J

Final $(KE)_f = \frac{1}{2}(m_A + m_B) V_f^2$

$= \frac{P_f^2}{2(m_A + m_B)} = \frac{20^2}{2(0.4 + 0.8)} = 166.7$ J

$\therefore$ K.E. lost $= 333.3$ J (heat, sound)

so catcher only needs to apply work

$F \Delta x = 166.7$ J to bring ball to rest, not 500 J.

Demo: Ballistic Pendulum for finding bullet speed v_A

Gun fires bullet m_A into mass m_B: inelastic collision

(Bullet + block) gain height, convert K.E. to P.E. $= mg\Delta h$

Before collision $p_i = m_A v_A$

After $p_f = p_i = (m_A + m_B) v_f$

K.E. after $= \frac{p_f^2}{2(m_A+m_B)} = \frac{p_i^2}{2(m_A+m_B)} = \frac{m_A^2 v_A^2}{2(m_A+m_B)}$

K.E. converted to P.E through height gain Δh

$\therefore (m_A + m_B) g \Delta h = \frac{m_A^2 v_A^2}{2(m_A+m_B)}$

$\therefore$ Measure Δh, m_A, m_B

$$\Rightarrow \quad v_A^2 = \frac{2(m_A+m_B)^2 g \Delta h}{m_A^2}$$

$$\text{OR} \quad v_A = \left(1 + \frac{m_B}{m_A}\right)\sqrt{2g\Delta h}$$

(Note: "stopping power" of bullet refers to momentum, not energy)

16/5

Figure 7.10

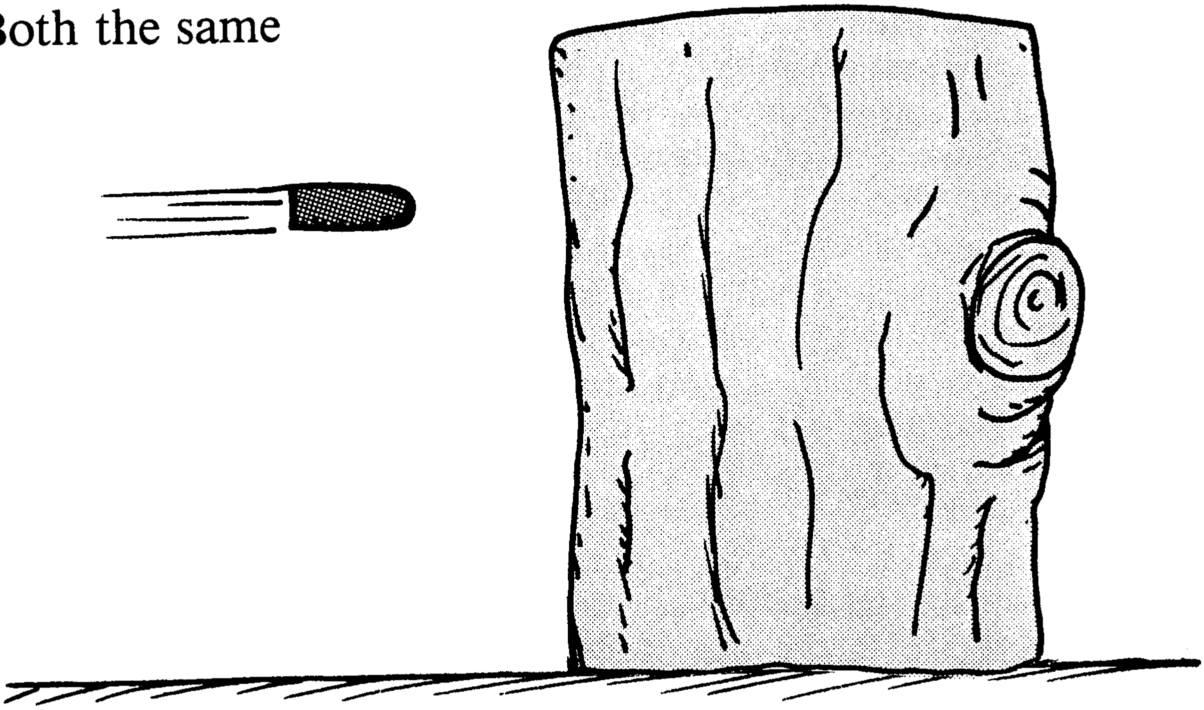
Inelastic collisions

16/6

RUBBER BULLET

A rubber bullet and an aluminum bullet both have the same size, speed, and mass. They are fired at a block of wood. Which is most likely to knock the block over?

a) The rubber bullet
b) The aluminum bullet
c) Both the same



Which is most likely to damage the block?

a) The rubber bullet
b) The aluminum bullet
c) Both the same