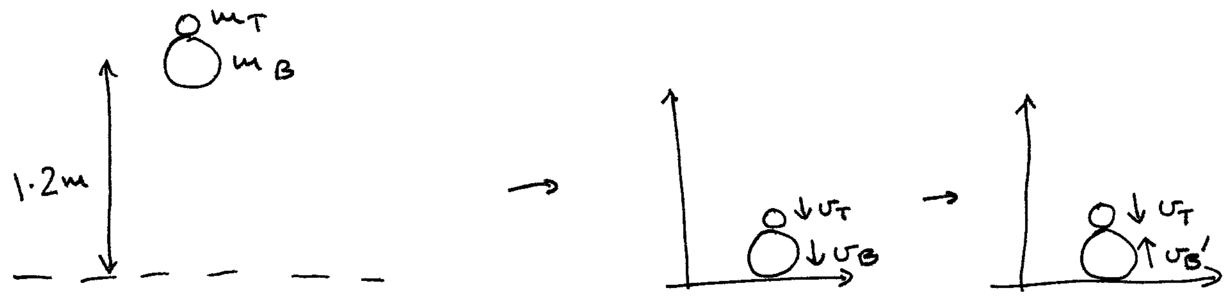
Lecture 17 10/20/09

73.



Conservation of energy.

$$(PE_g)_i = (KE)_f$$

$$\Rightarrow \quad m_B g h = \frac{1}{2} m_B v_B^2$$

$$\Rightarrow \quad v_B^2 = 2gh$$

$$\Rightarrow \quad v_B = -4.85 \text{ m/s}$$

Basketball bounce back with velocity v_B'

$$v_B' = -v_B = 4.85 \text{ m/s}$$

Basketball and tennis ball collide.

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f} \quad \text{(conservation of momentum)} \rightarrow \textcircled{1}$$

$m_1 = m_B$, $m_2 = m_T$

$v_{1i} = v_B'$, $v_{2i} = v_T$

Conservation of energy for tennis ball.

$$\frac{1}{2} m_T v_T^2 = m_T g h \Rightarrow v_T = -4.85 \text{ m/s}$$

$\Rightarrow m_B v_B' + m_T v_T = m_B v_1 + m_T v_2$ (from equation (1))

where $v_1 = v_{1f}$ (final velocity of basketball)

$v_2 = v_{2f}$ (final velocity of tennisball)

$\Rightarrow 0.59 \times 4.85 + 0.057 \times (-4.85) = 0.59 v_1 + 0.057 v_2$

$\Rightarrow 0.59 v_1 + 0.057 v_2 = 2.58 \rightarrow$ (2)

Elastic collision so $KE_f = KE_i$

$\Rightarrow \frac{1}{2} m_B v_B'^2 + \frac{1}{2} m_T v_T^2 = \frac{1}{2} m_B v_1^2 + \frac{1}{2} m_T v_2^2$

Difficult to solve $\rightarrow$ so need a slightly simpler equation.

⇓

Only for 1-D, elastic collisions

$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$ (conservation of momentum) $\rightarrow$ (3)

$\Rightarrow m_1 (v_{1i} - v_{1f}) = m_2 (v_{2f} - v_{2i}) \rightarrow$ (4)

Also $\frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2 = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2 \rightarrow$ (5)

$\Rightarrow m_1 (v_{1i}^2 - v_{1f}^2) = m_2 (v_{2f}^2 - v_{2i}^2)$

$\Rightarrow m_1 (v_{1i} - v_{1f})(v_{1i} + v_{1f}) = m_2 (v_{2f} - v_{2i})(v_{2f} + v_{2i}) \rightarrow$ (6)

Using (4) in (6) $\Rightarrow$ $\boxed{v_{1i} + v_{1f} = v_{2i} + v_{2f}} \rightarrow$ (7)

getting back to problem 73

from equation (7)

$$v_{1i} + v_{1f} = v_{2i} + v_{2f}$$

$$\Rightarrow v_B' + v_1 = v_T + v_2$$

$$\Rightarrow 4.85 + v_1 = -4.85 + v_2$$

$$\Rightarrow v_1 - v_2 = -9.7 \longrightarrow (8)$$

Using equations (2) & (8)

$$v_1 = 3.11 \text{ m/s}, \qquad v_2 = 12.81 \text{ m/s}$$

Conservation of energy for tennis ball after collision with basketball.

$$\frac{1}{2} m_T v_2^2 = m_T g h_1 \qquad \Rightarrow h_1 = \frac{v_2^2}{2g} = 8.37 \text{ m}$$

Inelastic collisions − KE is NOT conserved.

perfectly inelastic → masses stick together after collision.

DEMO → ballistic pendulum ($KE_f < KE_i$)

Also inelastic if $KE_f > KE_i$

DEMO → milk jug rocket

See lecture slides for glancing collisions.