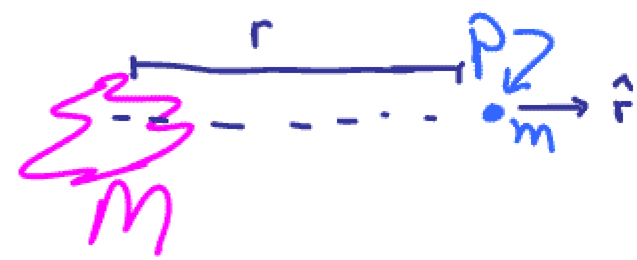
# Physics 113 – October 24, 2006

## momentum conservation, collisions

- Exam 2 – Thursday 0800 Hubbell Aud.
- Q+A session Today 5 pm
  B+L 109
- Lecture as usual Thursday
- P.S. 7 posted
  - due 1 week from Thursday
    (longish)

Last Time —




$$\vec{F}_{\text{of } M \text{ on } m} = -\frac{GMm}{r^2}\,\hat{r}$$

gravitational field

$$\vec{g}(p) = \vec{F}/m = -\frac{GM}{r^2}\,\hat{r}$$

For mass brought in from $\infty$ to point P

$$PE_{grav} = -\frac{GMm}{r}$$

Scalar

Science + Conceptual views/models of gravitation

$$\vec{F} = m\vec{a} = m\frac{d\vec{v}}{dt}$$

$$\vec{F} = \frac{d(m\vec{v})}{dt} = m\frac{d\vec{v}}{dt} + \cancel{\frac{dm}{dt}\vec{v}}$$

ignore

$$\vec{F} = \frac{d(m\vec{v})}{dt} = \frac{d\vec{p}}{dt}$$

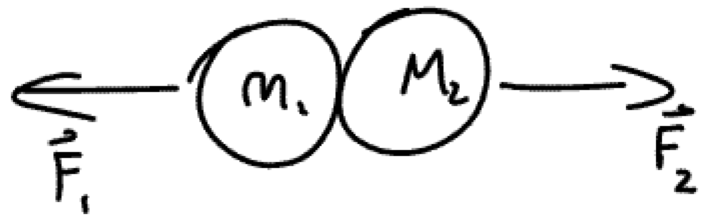
$$\vec{p} \equiv m\vec{v} \rightarrow \begin{array}{l} p_x = mv_x \\ p_y = mv_y \\ p_z = mv_z \end{array}$$

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$d\vec{p} = \vec{F}\,dt$$

$$\Delta\vec{p} = \vec{p}_2 - \vec{p}_1 = \int_{t_1}^{t_2} \vec{F}\,dt$$

$\vec{J}$ = impulse


$$\Delta\vec{p}_1 = \int_{t_i}^{t_f} \vec{F}_1 \, dt \qquad \Delta\vec{p}_2 = \int_{t_i}^{t_f} \vec{F}_2 \, dt$$

$$\vec{F}_1 = -F_2$$

$$\Downarrow$$

$$\Delta\vec{p}_1 = -\int_{t_i}^{t_2} \vec{F}_2 \, dt = -\Delta\vec{p}_2$$

$$\Delta\vec{p}_1 + \Delta\vec{p}_2 = 0$$

**Important** $\sum \Delta$'s in $\vec{p} = 0$

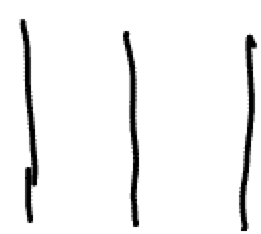
Momentum Conservation

If there are no external forces acting the system, the total momentum of the system is conserved.

$$\sum \Delta\vec{p} = 0 \quad \text{-or-} \quad \sum \vec{P}_i = \sum \vec{P}_f$$

Ballistic

Pendulum



Block of wood

$V_{Bullet}$ $V_{wood + bullet}$

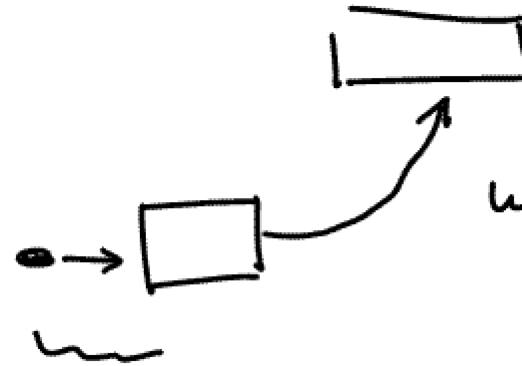
$$\frac{1}{2} M_{bullet} V_{bullet}^2 = E \longrightarrow \frac{1}{2} (M_{wood + bullet}) V_{w+b}^2$$

$\vec{P}$ always conserved

Kinetic Energy is NOT always conserved

if KE conserved → elastic collision

" KE Not conserved → inelastic collision



use E cons

P cons

$$\cancelto{0}{M_w \vec{V}_{w_i}} + m_{bull}\vec{V}_{bull} = m_{bull}\vec{V}_{w+b} + M_{wood}\vec{V}_{w+b}$$

$$m_{bull}\vec{V}_{bull} = \left(M_{bull} + M_{wood}\right)\vec{V}_{w+b}$$

$$\underset{w+b}{m} g h = \frac{1}{2}\underset{w+b}{m} v_{w+b}^2$$

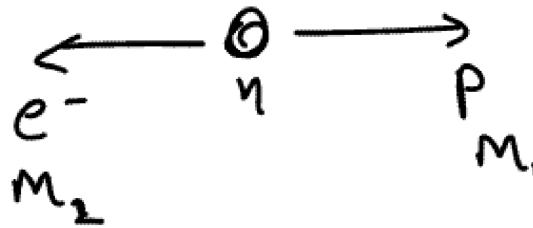
The discovery of the neutrino ($\nu$)

– from momentum conservation

~1930

Pauli:

$^{40}_{19}K \rightarrow {}^{40}_{20}Ca$ $\qquad n \longrightarrow p + e^-$ $\qquad \beta$ decay




$P_{cons}$ $\qquad M_1V_1 = -M_2V_2$ $\qquad V_1 = -\frac{M_2}{M_1} V_2$

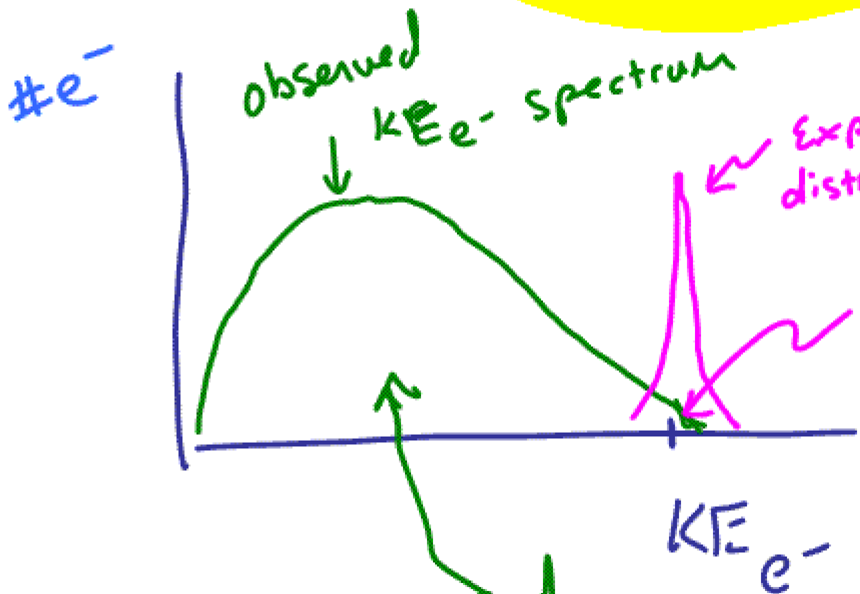
$$Q = KE_1 + KE_2 = \frac{1}{2}M_1V_1^2 + \frac{1}{2}M_2V_2^2$$

$$Q = \frac{1}{2}M_1\left(\frac{M_2}{M_1}\right)^2 V_2^2 + \frac{1}{2}M_2V_2^2$$

$$Q = KE_2\left[\frac{M_2}{M_1} + 1\right] = KE_2\left[\frac{M_2 + M_1}{M_1}\right)$$

$$KE_2 = \frac{Q\,M_1}{M_1 + M_2}$$

A fixed #




Observe KE of e⁻ From β decay

3 body decay

1931

Hypothesized 3-body decay

$$n \longrightarrow p + e^- + \bar{\nu}$$

neutrino

does Not interact readily w/ matter

(Pauli predicts existance of neutrino

→ discovered experimentally
Reines 1959

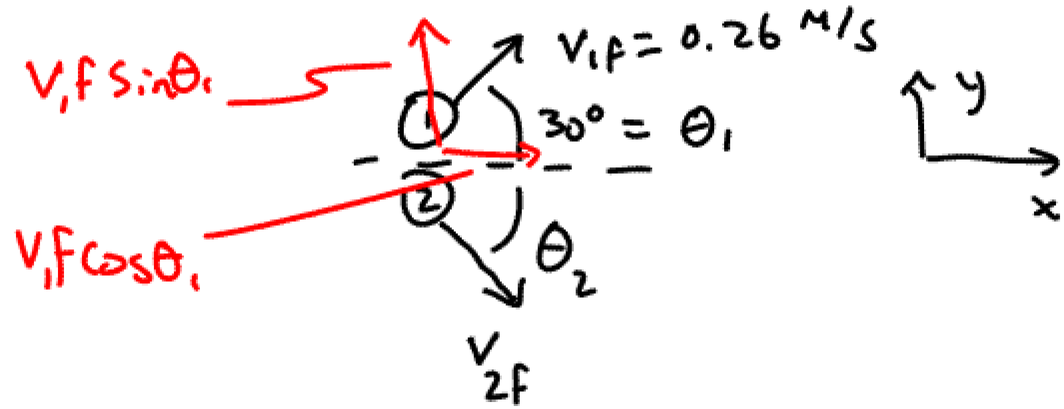
Example Hockey Pucks each w/ Mass 0.1 kg

Initial

$|v_1| = 0.3\ m/s$

$|\vec{v}_2| = 0$

Final




$$\sum \vec{P}_i = \sum \vec{P}_f \longrightarrow \sum P_{x_i} = \sum P_{x_f}$$

$$\longrightarrow \sum P_{y_i} = \sum P_{y_f}$$

x eqn

$$\underbrace{m_1 V_{1ix}}_{0.3\,m/s} + \underbrace{\cancel{m_2 V_{2ix}}}_{0} = \underbrace{m_1 V_{1fx}}_{V_{1f}\cos\theta_1} + \underbrace{m_2 V_{2fx}}_{V_{2f}\cos\theta_2}$$

$$m_1 V_{1x_i} = m_1 v_{1f}\cos 30 + m_2 V_{2f}\cos\theta_2$$

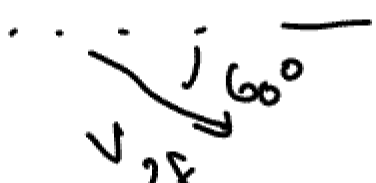
Y eqn

$$0 = m_1 v_{1f}\sin 30 - m_2 V_{2f}\sin\theta_2$$

2 eqns, 2 unknowns $\rightarrow$ soluble

Answer $\rightarrow$

$$|\vec{V}_{2f}| = 0.15\ m/s$$




$\theta_2 = 60°$ down from horiz