Answers – Week 8

8-1. $K = \frac{p^2}{2M}$

$\frac{P_{3M}}{P_M} = 1.732$

8-3. Because $\underrightarrow{F_{ext}} \neq 0$, every particle of the rigid body has acceleration and the total momentum must change.

8-5. A head on collision is essentially one dimensional. Take masses M_1, M_2 give them velocities $\underrightarrow{V_1}$, $\underrightarrow{V_2}$ before the collision and $\underrightarrow{V_1}'$ and $\underrightarrow{V_2}'$ after the collision.

Conservation of Momentum

$$M_1V_1' + M_2V_2' = M_1V_1 + M_2V_2 \quad \rightarrow (1)$$

Total Elastics – K.E. also conserved

$$M_1V_1'^2 + M_2V_2'^2 = M_1V_1^2 + M_2V_2^2 \quad \rightarrow (2)$$

Rewrite Eq.(1)

$$M_1(V_1' - V_1) = M_2(V_2 - V_2') \quad \rightarrow (3)$$

and Eq. (2)

$$M_1(V_1'^2 - V_1^2) = M_2(V_2^2 - V_2'^2) \quad \rightarrow (4)$$

Divide (4) by (3)

$$V_1' - V_1 = V_2 - V_2'$$

OR

$$V_1' - V_2' = V_2 - -V_1 = -(V_2 - V_1)$$

8-7. (i) $\underrightarrow{V_1}' = 0$, $\underrightarrow{V_2} = 5\ \text{m/s}\ \hat{x}$

(ii) Since wall mass is large, it can pick up momentum but not kinetic energy

$$\underrightarrow{V_1}' = -10\ \text{m/s}\ \hat{x},\ V_2 = 0$$

(iii) $\underrightarrow{V_1}' = 10\ \text{m/s}\ \hat{x}$ $\quad \underrightarrow{V_2}' = 20\ \text{m/s}\ \hat{x}$

(iv) $\underrightarrow{V_1}' = -2\ \text{m/s}\ \hat{x}$ $\quad \underrightarrow{V_2}' = 4\ \text{m/s}\ \hat{x}$

8-9. Totally inelastic collision

$(M_1 + M_2)\ \underrightarrow{V}' = M_1\underrightarrow{V_1} + M_2\underrightarrow{V_2}$

$\underrightarrow{V_x}' = 2.2\ \text{m/s}\ \hat{x}$

$\underrightarrow{V_y}' = -2.2\ \text{m/s}\ \hat{y}$

8-11. Put Earth at r = 0

$$r_{moon} = 4 \text{ x } 10^5 \text{ km}$$

$$r_{cm} = \frac{M_E r_E + M_M r_M}{M_E + M_M} = 4940\text{km}$$

(Inside the Earth since R_E = 6400 km)

8-13. Totally inelastic collision.

$$\underset{\rightarrow}{V}' = 0.5\text{m/s}\,\hat{x}$$

at 0.32 m

8-15. $M g \ell (1 - \text{Cos}\,\theta) = \frac{1}{2} M V^2$

$$\ell (1 - \text{Cos}\,\theta) = \frac{v^2}{2g} = \frac{1}{8g} = \underline{0.013\text{m}}$$