

Conservation of Momentum

- 1) A 60kg man is coasting to the right at 4m/s on a 5.0 kg skateboard. He jumps off the skateboard causing it to move to the left at 13m/s. (a) What is the velocity of the man after he jumps off the skateboard and is in the air? (b) If he lands on a 8.0kg long board, how fast will he be moving? Assume the long board is initially not moving.

$$\begin{aligned}m_1 &= 60\text{kg} \\ v_{01} &= +4\text{m/s} \\ m_2 &= 5\text{kg} \\ v_{02} &= +4\text{m/s} \\ v_{f2} &= -13\text{m/s} \\ v_{f1} &= ?\end{aligned}$$

$$(a) \quad v_0(m_1 + m_2) = p_{1f} + p_{2f}$$

$$4(60 + 5) = 60v_{1f} + 5(-13)$$

$$260 = 60v_{1f} - 65$$

~~195~~

$$325 = 60v_{1f}$$

$$\boxed{v_{1f} = 5.42\text{m/s}}$$

$$\begin{aligned}m_3 &= 8.0\text{kg} \\ v_{03} &= 0\text{m/s}\end{aligned}$$

$$(b) \quad p_{10} + p_{30} = v_f(m_1 + m_3)$$

$$60(5.42) + 0 = v_f(60 + 8)$$

$$325 = 68v_f$$

$$\boxed{v_f = 4.78\text{m/s}}$$

2) A 800kg car moving west at 30m/s hits and bounces off of a large 1800kg truck that is moving at 25m/s to the east. (a) What is the velocity of the car after the collision if the truck continues to move east at 3m/s? (b) Mathematically prove if this was a perfectly elastic collision. (c) If the impact lasts for 0.5s, what force was applied to the car?

$$\begin{aligned} m_1 &= 800\text{kg} & (a) \quad p_{1i} + p_{2i} &= p_{1f} + p_{2f} \\ u_{1i} &= -30\text{m/s} \\ m_2 &= 1800\text{kg} & 800(-30) + 1800(25) &= 800v_{1f} + 1800(3) \\ u_{2i} &= +25\text{m/s} \\ v_{1f} &= ? & -24,000 + 45,000 &= 800v_{1f} + 5400 \\ v_{2f} &= +3\text{m/s} & 21,000 &= 800v_{1f} + 5400 \\ & & 15,600 &= 800v_{1f} \\ & & \boxed{v_{1f} = 19.5\text{m/s}} & \end{aligned}$$

$$\begin{aligned} (b) \quad K_{1i} + K_{2i} &= K_{1f} + K_{2f} \\ \frac{1}{2}(800)(30)^2 + \frac{1}{2}(1800)(25)^2 &= \frac{1}{2}(800)(19.5)^2 + \frac{1}{2}(1800)(3)^2 \\ 360,000 + 202,500 &= 152,100 + 8,100 \\ 562,500 &\neq 160,200 \\ &\text{elastic, not perfectly elastic} \end{aligned}$$

$$\begin{aligned} t &= .5\text{s} & (c) \quad F t &= m \Delta v \\ F &= ? & F(.5) &= 800(19.5 - (-30)) \\ & & .5F &= +39,600 \end{aligned}$$

$$\boxed{F = +79,200\text{N}}$$