1. (4 pts) A force of \((3i + 4j)\text{lb}\) acts through a displacement of \((6i - 2j)\text{ft}\). What is the amount of work that was done?

\[ W = \mathbf{F} \cdot \mathbf{d} = (3)(6) + (4)(-2) = 10 \text{ ft-lb} \]

2. (4 pts) It takes 5.8 J of energy for a pitching machine to throw a baseball. Determine the work that had to be input into the machine if the machine were 85% efficient.

\[ W = \frac{\text{measured}}{\text{efficiency}} = \frac{5.8 \text{ J}}{0.85} = 6.8 \text{ J} \]

3. (4 pts) A 12 kg cart is moving with a velocity of -3.0 m/s. A +144 N-s impulse is applied to the cart. What is the final velocity of the cart?

Impulse = \(\Delta\) momentum
\[ +144 \text{ N-s} = 12 \text{ kg} \cdot v_f - 12 \text{ kg} \cdot (-3) \text{ m/s} \]

\[ v_f = 9.0 \text{ m/s} \]

4. (4 pts) A 10 gram rubber bullet is fired horizontally at a 5.0 kg stationary block of wood resting on a frictionless table. The speed of the bullet before entry is 500 m/s. What is the velocity of the block if the bullet bounces back with a speed of 200 m/s?

\[ m_0 v_{0B} + m_0 v_{0W} = m_0 v_1 + m_0 v_W \]

\[ (10 \text{ g})(500 \text{ m/s}) = (10 \text{ g})(-200 \text{ m/s}) + (500 \text{ g})(v_f) \]

\[ v_f = +1.4 \text{ m/s} \]

5. (4 pts) A 4000 pound truck moving at 40 mph crashes into a 1500 pound stationary crate. What is the speed of the truck after the collision if the collision is perfectly inelastic?

\[ m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f \]

\[ (4000 \text{ lb})(40 \text{ mph}) = (4000 + 1500) \text{ lb} \cdot v_f \]

\[ v_f = 29.1 \text{ mph} \]

6. (16 pts) A 4000 pound truck moving at 12 ft/sec along a horizontal track has a braking force applied as shown in the graph. How far does the truck go before it stops?

\[ d = 11.3 \text{ ft} \]

\[ \frac{1}{2}mv^2 - \frac{1}{2}mv_0^2 = \frac{1}{2}(400 \text{ lb})(12 \text{ ft/s})^2 - \frac{1}{2}(400 \text{ lb})(4 \text{ ft/s})^2 \]

\[ \frac{1}{2} \left( \frac{400 \text{ lb}}{32.2 \text{ ft}^2/\text{lb}} \right) \left( 12 \text{ ft/s} \right)^2 = \frac{1}{2}(400 \text{ lb})(4 \text{ ft/s})^2 + \frac{1}{2}(400 \text{ lb})(d - 4 \text{ ft})^2 \]

\[ d = 11.3 \text{ ft} \]

\[ \frac{1}{2} \cdot 400 \text{ lb} \cdot \left( 12 \text{ ft/s} \right)^2 = \frac{1}{2} \cdot 400 \text{ lb} \cdot (4 \text{ ft/s})^2 + \frac{1}{2} \cdot 400 \text{ lb} \cdot (d - 4 \text{ ft})^2 \]

\[ 2880 = 2400 + 900d - 3600 \]

\[ d = 11.3 \text{ ft} \]

7. (16 pts) A 1200 kg car starts at the top of a hill, elevation 54 m, with a speed of 12 m/s. As it goes down the hill a 500 N force (in the direction the car is moving) is applied for a distance of 75 m. At the bottom of the hill, elevation 16 m, the car is brought to rest by compressing a spring 9 m (k=7800 N/m). What was the energy loss on the way down the hill?

\[ KE = \frac{1}{2}mv^2 \]

\[ KE = \frac{1}{2}(1200 \text{ kg})(12 \text{ m/s})^2 = \frac{1}{2}(1200 \text{ kg})(4.17 \text{ m/s})(9 \text{ m})^2 + (500 \text{ kg})(75 \text{ m})^2 \]

\[ \frac{1}{2}(1200 \text{ kg})(12 \text{ m/s})^2 + (1200 \text{ kg})(4.17 \text{ m/s})(9 \text{ m})^2 + (500 \text{ kg})(75 \text{ m})^2 \]

\[ \frac{1}{2}(7800 \text{ N/m})(9 \text{ m})^2 + E_{loss} \]

\[ 86400 \text{ J} + 635688 \text{ J} + 45000 \text{ J} = 188352 \text{ J} + 249600 \text{ J} + E_{loss} \]

\[ E_{loss} = 329136 \text{ J} \]
8. (16 pts) A 200 lb cannon is mounted on wheels so that it can roll freely. A 12 lb bowling ball is shot with a speed of 300 ft/sec at an angle of 30° above the horizontal. Determine the amount of energy from the explosion that was converted to kinetic energy.

\[ V = 300 \text{ ft/sec} \]

\[ \theta = 30° \]

Com:\[ \begin{align*}
O &= 200 \text{ lb} \quad V^1 + 12 \text{ lb} \quad (180 \cos 30°) \quad \text{ft/sec} + 1 \text{ y motion} \\
V^1 &= 9.353 \text{ ft/sec} \\
KE_f &= \frac{1}{2} M_v v_c^2 + \frac{1}{2} M_b v_b^2 \\
&= \frac{1}{2} (200)(9.353)^2 + \frac{1}{2} (12)(180)^2 \\
&= 6308 \text{ ft-lb}
\end{align*} \]

9. (16 pts) Two identical bumper cars with initial velocities as shown have a direct impact collision. After the collision, Car A bounces back with a speed of 3 ft/sec. Determine the coefficient of restitution between the two cars.

\[ V_A^1 = 3 \text{ ft/sec} \]

\[ +5 \text{ ft/sec} \quad -7 \text{ ft/sec} \]

Com:\[ \begin{align*}
M_A v_A + M_B v_B &= M_A v_A^1 + M_B v_B^1 \\
5 - 7 &= -3 + v_B \\
v_B &= +1 \text{ ft/sec}
\end{align*} \]

\[ e = \frac{(v_B^1 - v_A^1)}{v_B - v_A} = \frac{(-1 - 3)}{-7 - 5} = 0.33 \]

10. (16 pts) A pool ball strikes the side rail of a pool table as shown. The coefficient of restitution between the pool ball and the side rail is 0.7. Determine the angle \( \theta \).

\[ 39.8° \]

\[ V_x = -6 \sin 50° = -4.596 \text{ m/s} \]
\[ V_y = -6 \cos 50° = -3.857 \text{ m/s} \]

\[ y \quad \text{POC} \quad V_y^1 = V_y = -3.857 \text{ m/s} \]

\[ x \quad \text{LOI} \quad e = \frac{V_x^1}{V_x} \]
\[ 0.7 = -\frac{V_x^1}{-4.596} \]
\[ V_x^1 = 3.217 \text{ m/s} \]

\[ \tan \theta = \left| \frac{V_x^1}{V_y} \right| = \frac{3.217}{3.857} \]
\[ \theta = 39.8° \]