Short Answer
(5 Points Each)

1. A 45 kg cargo package is dropped from an airplane and begins falling downwards. What is the magnitude of the drag force on the package once it reaches terminal velocity?

\[
\begin{align*}
\text{AT TERMINAL VELOCITY } F_{\text{NET}} &= 0 \\
\Rightarrow F_{\text{drag}} &= mg \\
\therefore F_{\text{drag}} &= 4.4 \times 10^1 N
\end{align*}
\]

2. Draw a picture of a hill curved in such a way that a ball would roll down it with increasing speed but decreasing acceleration.

![Diagram of a hill](image)

3. A tennis ball is thrown directly up into the air with an initial speed of 15 m/s. How long does it take the ball to reach its highest point?

\[
V(t) = V_0 - gt
\]

\[
0 = 15_{\text{m/s}} - (9.8 \text{m/s}^2)t
\]

\[
\Rightarrow t = 1.5_s
\]
Multiple Choice
(5 Points Each)

1. In a vacuum, a hammer and a feather fall side by side. This exemplifies how the gravitational force pulls all objects on the surface of the Earth with the same force. Is this statement true or false? Why or why not?

(a) True, because of Newton’s 3rd Law
(b) False, the forces on the two objects are different
(c) False, the hammer would fall faster than the feather
(d) Both (b) and (c) are correct

2. Alice throws a ball up into the air with a speed of 10 meters per second. George throws a ball with the same speed as Alice but instead of throwing it upwards, he throws it directly down at the ground. Ignoring air resistance, whose ball will hit the ground with a greater speed?

(a) Alice’s ball
(b) George’s ball
(c) They both hit the ground with the same speed
(d) Not enough information provided

3. A small car and an eighteen wheel Mack truck collide in a head-on collision. Which vehicle experiences a larger impact force? Why?

(a) The car, because the truck is much more massive
(b) The truck, because it hits the car harder
(c) They both experience the same impact force
(d) It depends on which one is going faster

SAME ACCELERATION BUT DIFFERENT FORCES!
4. According to Newton’s 3rd Law, for every action there is an equal and opposite reaction. Why don’t the action and reaction forces simply cancel each other out?

(a) Because the action force is stronger
(b) Because the reaction force is stronger
(c) They do cancel out
(d) Because they act on different objects

5. When you walk down the sidewalk, what is the force that is actually pushing you forward?

(a) The normal force
(b) Static friction
(c) Tension
(d) Kinetic friction
Problems
(30 Points Each)

1. A cannonball is fired at an angle 45° above the horizontal over a 30 meter wide pit. The other side of the pit is raised 20 meters above the cannon. What is the minimum speed with which the cannonball must be fired in order to clear the pit?

INITIAL VELOCITY:

\[ V_o^{(x)} = V_o \cos(45°) \]
\[ V_o^{(y)} = V_o \sin(45°) \]

\[ V_o \]

\[ \theta \rightarrow \]

\[ \{ V_o^{(x)} \} \]

\[ \{ V_o^{(y)} \} \]

\[ X \]

\[ X(t) = X_o + V_o^{(x)} t + \frac{1}{2} A_x t^2 \]

\[ 30_m = 0 + V_o \cos(45°) t + 0 \]
\[ \Rightarrow V_o t = \frac{60_m}{\sqrt{2}} \]

\[ \Rightarrow \quad \text{Plug this into the y-direction equation} \]

\[ Y \]

\[ Y(t) = Y_o + V_o^{(y)} t + \frac{1}{2} A_y t^2 \]

\[ 20_m = 0 + V_o \sin(45°) t - \frac{1}{2} \left( \frac{10m}{s^2} \right) t^2 \]
\[ 20_m = \frac{\sqrt{2}}{2} V_o t - \frac{5m}{s^2} t^2 \]

\[ \Rightarrow \quad 20_m = \frac{\sqrt{2}}{2} \left( \frac{60_m}{\sqrt{2}} \right) - \frac{5m}{s^2} t^2 \]
\[ \Rightarrow \quad t = \sqrt{2}s \]

\[ \text{But} \quad V_o t = \frac{60_m}{\sqrt{2}} \quad \text{So...} \]
\[ V_o = 30_m/s \]
2. A spherical weight of mass $m$ hangs from the ceiling of an empty train car. The train car accelerates down a straight track with constant acceleration causing the weight to hang at an angle $\theta$ from the vertical. What is the train car’s acceleration?

$F_{NET_x} = T \sin(\theta)$

$MA = T \sin(\theta)$

$\Rightarrow T = \frac{mg}{\cos(\theta)}$

$F_{NET_y} = T \cos(\theta) - mg$

$0 = T \cos(\theta) - mg$

$\Rightarrow A = g \tan(\theta)$

HENCE

$A = g \tan(\theta)$
3. A block of mass $M$ is at rest on a flat ramp that is inclined by an angle \( \theta \) above the horizontal. The coefficient of kinetic friction between the block and ramp is \( \mu_k \). The block is given a nudge and begins to slide down the ramp.

(a) Determine the acceleration of the block down the ramp.

(b) If the length of the ramp is \( \Delta x \), how fast will the block be moving when it reaches the bottom?

\[ F_{\text{NET}_x} = M g \sin(\theta) - f_k \]
\[ F_{\text{NET}_y} = F_N - M g \cos(\theta) \]
\[ \sum a_x = M g \sin(\theta) - \mu_k M g \cos(\theta) \]
\[ \Rightarrow F_N = M g \cos(\theta) \]
\[ \Rightarrow A = g \left[ \sin(\theta) - \mu_k \cos(\theta) \right] \]

\[ v^2 = v_0^2 + 2a \Delta x \]
\[ \Rightarrow v = \sqrt{2g \Delta x \left[ \sin(\theta) - \mu_k \cos(\theta) \right]} \]