Conceptual Questions (1 point each)

1. The free-body diagram at the right is supposed to represent a box sliding at a constant speed toward the right along a tabletop as it is pulled by a string. How should we label the leftward force?

A. $\vec{F}_D$
B. $\vec{F}_{KF}$
C. $\vec{F}_{SF}$
D. The diagram is wrong: the left force should not be there at all.

2. A box sits at rest on an inclined plank. How do the magnitudes of the normal force and the gravitational force exerted on the box compare? (Hint: Draw a picture!)

A. $F_N < F_g$
B. $F_N = F_g$
C. $F_N > F_g$
D. $F_N = 0!$
E. We do not have enough information to answer.

3. An object’s x-position $x(t)$ is shown in the boxed graph of the following set of graphs. Which of the other graphs in the set most correctly describes its x-velocity?

A. $v_x(t)$  
B. $v_x(t)$  
C. $v_x(t)$  
D. $v_x(t)$  
E. $v_x(t)$
4. Which graph best describes the x-acceleration of the object described in the previous problem?

![Graphs A, B, C, D, E]

5. A weight hangs from a string but is pulled to one side by a horizontal string, as shown. The tension force exerted by the angled string is

![Diagram of a weight hanging from a string]

A. Less than the hanging object’s weight.
B. Equal to the hanging object’s weight.
C. Greater than the hanging object’s weight.

6. Two boxes of the same mass sit on a rough floor. These boxes are made of the same kind of cardboard and are identical except that one is twice as large as the other. If it takes 200 N to start moving the smaller box, how much force does it take to start moving the larger one?

A. Still 200 N
B. 400 N
C. 800 N
D. It depends (specify)

7. A child grips tightly the outer edge of a playground merry-go-round as other kids push on it to give it a dizzying rotational velocity. When the other kids let go, the horizontal component of the net force on the child points most nearly

A. Inward toward the center of the merry-go-round.
B. Outward away from the center of the merry-go-round.
C. In the direction of rotation.
8. As a projectile moves along its parabolic trajectory, which of the following remain constant (ignoring air resistance, and defining the z-axis to point upward)?

A. Its speed.
B. Its velocity.
C. Its x-velocity and y-velocity.
D. Its z-velocity.
E. Its acceleration.
F. Its x-velocity, y-velocity, and acceleration.
G. Some other combination of the given quantities.

9. Arrows representing four forces having equal magnitudes are shown below. What combinations of these forces, acting together on the same object, will allow that object to move with a constant velocity?

A. $\vec{F}_2$ and $\vec{F}_3$
B. $\vec{F}_3$ and $\vec{F}_4$
C. $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_4$
D. $\vec{F}_1$, $\vec{F}_3$ and $\vec{F}_4$
E. A and D
F. None of the above

10. When a speeding roller-coaster car is at the bottom of a loop, the magnitude of the normal force exerted on the car’s wheels due to its interaction with the track is

A. Greater than the weight of the car and its passengers.
B. Equal to the weight of the car and its passengers.
C. Less than the weight of the car and its passengers.
1. (15 points) Imagine that a pole with a mass of 12 kg and a length of 2.2 m is connected to a wall so that the pole sticks out horizontally from the wall. One end of the pole is connected directly to the wall, while the other end is connected to a higher point on the wall by a chain that makes a 45° angle with respect to the pole and exerts a tension force of 550 N on the pole. If a 70-kg person hangs from the pole, how far from the end of the pole is the person located?

![Diagram of the pole and forces](image)

**Given:**
- \( m_1 = 12 \text{ kg} \)
- \( m_2 = 70 \text{ kg} \)
- \( L = 2.2 \text{ m} \)
- \( \theta = 45^\circ \)
- \( F_T = 550 \text{ N} \)

- \( \vec{C} = \vec{r} \times \vec{F} = \vec{r} F \sin \theta = 0 \)

- \[
\begin{bmatrix}
0 \\
0 \\
0 \\
0 \\
0 \\
\end{bmatrix} = \begin{bmatrix}
l_1 m_1 g \\
0 \\
r_2 m_2 g \\
0 \\
-L F_T \sin 45 \\
0 \\
\end{bmatrix}
\]

- \( 0 = \frac{L}{2} m_1 g + r_2 m_2 g - L F_T \sin 45 \)

- \( r_2 m_2 g = L F_T \sin 45 - \frac{L}{2} m_1 g \)

- \( r_2 = \frac{L F_T \sin 45 - \frac{L}{2} m_1 g}{m_2 g} = \frac{2.2 \cdot 550 \cdot \sin 45 - 2.2 \cdot 12 \cdot 9.8}{70 \cdot 9.8 \cdot \frac{5}{2}} \) m

- \( r_2 = 1 \text{ m} \) away from \( O \)
2. (15 points) A 75-kg crate slides on a rough plane inclined upward at an angle of 33°. The crate is hauled up the plane by lightweight rope that goes parallel to the incline and then over a pulley at the top of the incline. The kinetic friction force acting on the crate is 180 N. A worker standing below the pulley pulls vertically downward on the rope. The 70-kg worker hangs from the rope with his entire weight and gets the crate moving.

(a) Determine the acceleration of the crate.

(b) What is the coefficient of kinetic friction between the box and the incline?
3. (5 points) A plane is traveling in a circular path with a speed of 600 mph. It is banking at an angle of 9°, which indicates that its sideward acceleration is 1.5 m/s². What is its diameter?

Solution 1:

\[ a = \frac{v^2}{R} \]

\[ R = \frac{v^2}{a} = \frac{600 \text{ mph} \times 0.45 \text{ m/s}}{1.5 \text{ m/s}^2} = 48600 \text{ m} \]

\[ R = 49 \text{ km} \Rightarrow D = 2 \cdot R = 97.2 \text{ km} = D \]

Solution 2:

\[ \begin{bmatrix} m \frac{\dot{v}}{R} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} F_L \sin \theta \\ 0 \\ F_L \cos \theta \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ -mg \end{bmatrix} \]

\[ a = \frac{v^2}{R} \]

\[ \frac{mv^2}{R} = F_L \sin \theta \quad 0 = F_L \cos \theta - mg \Rightarrow F_L = \frac{mg}{\cos \theta} \]

\[ \frac{mv^2}{R} = \frac{mg}{\cos \theta} \cdot \sin \theta = g \tan \theta \]

\[ \frac{v^2}{R} = g \tan \theta \]

\[ v^2 = R g \tan \theta \]

\[ R = \frac{v^2}{g \tan \theta} = \frac{[600 \text{ mph} \times (0.45 \text{ m/s})]^2}{(9.8 \text{ m/s}^2) \tan (8.7^\circ)} = 48613 \text{ m} \Rightarrow D = 97.2 \text{ km} \]
4. (15 points) A police officer is chasing a burglar across a rooftop. Both are running at a speed of 4.5 m/s. Before the burglar approaches the edge of the roof, the burglar needs to make a decision about whether to jump the gap to the next building, whose roof is 3.4 m away but 3.0 m lower. Will the burglar be able to land on the next building on his or her feet (assuming that the burglar’s initial velocity is 4.5 m/s horizontally when the jump begins)?

\[
\begin{bmatrix}
X \\
Y \\
Z
\end{bmatrix} = \begin{bmatrix}
V_{0x}t + X_0 \\
V_{0y}t + Y_0 \\
\frac{1}{2}gt^2 + V_{0x}t + Z_0
\end{bmatrix}
\]

There are two ways to solve this.

Sol’n 1: \(x(t_f) = V_{0x}t_f\)

\[t_f = \frac{x}{V_{0x}} = \frac{3.4}{4.5} = 0.76 \text{ s}\]

It will take the burglar 0.76 s to make it 3.4 m in the x-direction.

\[z = -\frac{1}{2}gt^2 + V_{0x}t + Z_0\]
\[z = -\frac{1}{2}(9.8 \text{ m/s}^2)(0.76^2) + 3.0 \text{ m}\]
\[z = 0.17 \text{ m}\]

Because \(z\) is greater than zero, the burglar makes it.
Solve 2: \[ z(t) = -\frac{1}{2} gt^2 + v_0^2 t + z_0 \]

\[ z(t_f) = 0 \]

\[ 0 = -\frac{1}{2} gt^2 + z_0 \]

\[ t = \sqrt{\frac{2z_0}{g}} \]

\[ t = \sqrt{\frac{2 \cdot 3 \text{ m}}{9.8 \text{ m/s}^2}} \]

\[ t = 0.78 \text{ s} \]

It will take the burglar 0.78 s to in the z-direction.

\[ x = v_0 x t \]

\[ x = (4.5 \text{ m/s})(0.78 \text{ s}) \]

\[ x = 3.52 \text{ m} \]

Because \( x \) is greater than 3.4 m, the burglar will make it.