Part 1: 15 Multiple Choice Questions (2 points each)

1) The figure shows two forces acting on an object, with magnitudes $F_1 = 78$ N and $F_2 = 26$ N. What third force will cause the object to be in equilibrium?

![Diagram showing two forces $F_1$ and $F_2$]

A) 52 N pointing up  
B) 52 N pointing down  
C) 82 N pointing up  
D) 82 N pointing down

2) Consider what happens when you jump up in the air. Which of the following is the most accurate statement?

A) It is the upward force exerted by the ground that pushes you up, but this force can never exceed your weight.  
B) You are able to spring up because the earth exerts a force upward on you which is stronger than the downward force you exert on the earth.  
C) When you push down on the earth with a force greater than your weight, the earth will push back with the same magnitude force and thus propel you into the air.  
D) Since the ground is stationary, it cannot exert the upward force necessary to propel you into the air. Instead, it is the internal forces of your muscles acting on your body itself which propels the body into the air.

3) A person gives a shopping cart an initial push along a horizontal floor to get it moving, and then lets go. The cart travels forward along the floor, gradually slowing as it moves. Consider the horizontal force(s) on the cart while it is moving forward and slowing. Which of the following statements is correct?

A) Only a forward force is acting, which diminishes with time.  
B) Only a backward force is acting, no forward force.  
C) Both a forward and a backward force are acting on the cart, but the forward force is larger.  
D) Both a forward and a backward force are acting on the cart, but the backward force is larger.
4) Two bodies P and Q on a perfectly smooth horizontal surface are connected by a light cord. The mass of P is greater than that of Q. A horizontal force \( \mathbf{F} \) is applied to Q as shown in the figure, accelerating the bodies to the right.

![Diagram of two blocks connected by a cord, with force \( \mathbf{F} \) applied to Q](image)

The magnitude of the force exerted by the connecting cord on body P will be
A) greater than \( \mathbf{F} \).
B) equal to \( \mathbf{F} \).
C) less than \( \mathbf{F} \) but not zero.
D) zero.

5) An object is moving to the right, and experiencing a net force that is directed to the right. The magnitude of the force is decreasing with time. The speed of the object is
A) constant in time.
B) increasing.
C) decreasing.

6) If you jumped out of a plane, you would begin speeding up as you fall downward. Eventually, due to wind resistance, your velocity would become constant with time. After this occurs, the magnitude of the force of wind resistance is
A) equal to the force of gravity acting on you.
B) is much smaller than the force of gravity acting on you.
C) is slightly smaller than the force of gravity acting on you.
D) is greater than the force of gravity acting on you.

7) A woman is straining to lift a large crate, without success. It is too heavy. We denote the forces on the crate as follows: \( P \) is the upward force being exerted on the crate by the person, \( C \) is the contact force on the crate by the floor, and \( W \) is the weight of the crate.

![Image of a woman lifting a crate](image)

How are the magnitudes of these forces related, while the person is trying unsuccessfully to lift the crate?
A) \( P + C < W \)
B) \( P + C > W \)
C) \( P = C \)
D) \( P + C = W \)
8) A piano mover raises a 100 kg piano at a constant rate using a frictionless pulley system, as shown in the figure. With roughly what force is the mover pulling down on the rope?

A) 250 N  
B) 500 N  
C) 1000 N  
D) 2500 N  
E) Depends on the velocity!

9) A cyclist is riding up a hill having a constant slope of 30° with respect to the horizon at a constant speed (in a straight line). Which statement is true?
A) The net force on the bike (due to gravity, the normal force, and friction) is in the direction of motion.
B) The net force on the bike (due to gravity, the normal force, and friction) is in the opposite direction of motion.
C) The net force on the bike (due to gravity, the normal force, and friction) is zero.
D) None of the above statements are true.

10) A brick initially has its largest-area face in contact with a rough surface, as shown on the left in the figure. A force F is required to pull the brick along the surface at constant speed.

The brick is now flipped so that a face of smaller area is in contact, as on the right in the figure. The material of the brick is uniform on all faces. What force is now required to pull the brick along at constant speed as before?
A) the same force  
B) a smaller force  
C) a greater force  
D) One cannot say without knowing the coefficient of friction.
11) A block is at rest on a rough incline as shown.

The frictional force acting on the block, along the incline, is
A) zero.
B) less than the weight of the block.
C) equal to the weight of the block.
D) greater than the weight of the block.

12) Two unequal masses M and m are connected by a light cord passing over a pulley of negligible mass. When released, the system accelerates. Friction is negligible.

Which figure below gives the correct free-body force diagrams for the two masses in the moving system?
13) A person ties a rock to a string and whirls it around in a vertical circle such that sometimes the rock is going straight upward and sometimes the rock is going straight down. She whirls the rock at the minimum speed (constant in time) such that the string is always taut (no sag). When is the tension the highest?
A) It is highest when the rock is at the lowest elevation.
B) It is highest when the rock is at the highest elevation.
C) The tension is constant as the rock moves around in a circle.

14) A merry-go-round is spinning at a fixed rate. As a person is walking toward the edge,
A) the force of static friction such that the person does not slide off remains the same.
B) the force of static friction must increase in order for the person not to slide off.
C) the force of static friction must decrease in order for the person not to slide off.

15) A satellite of mass \( M \) takes time \( T \) to orbit a planet. If the satellite had twice as much mass, the time for it to orbit the planet would be:
A) 4\( T \)
B) 2\( T \)
C) \( T/2 \)
D) \( T/4 \)
E) \( T \)

Part II – 5 PROBLEMS, 4 points each – show your work

16) A 80 N force is needed to slide a 50.0 kg box across a flat surface at a constant velocity. What is the coefficient of kinetic friction between the box and the floor? (Use \( g = 9.8 \text{ m/s}^2 \).)

\[ F = 80 \text{N} \]

\[ \begin{align*}
\text{constant velocity} & \Rightarrow \\
\alpha &= 0 \Rightarrow \\
\Sigma F_x &= 0 \Rightarrow \\
n &= F_k = \mu_k \cdot mg \\
\text{so} \quad \mu_k &= \frac{F}{mg} = \frac{(80 \text{N})}{(50 \text{kg}) \cdot (9.8 \text{ m/s}^2)}
\end{align*} \]

\[ \mu_k = 0.163 \]
17) In a shuffleboard game, the puck slides a total of 12 m before coming to rest. If the coefficient of kinetic friction between the puck and board is 0.10, what was the initial speed of the puck?

\[ \vec{v_c} \rightarrow ? \]

Since \( a = \text{constant} \), we can use the kinematic equation:

\[ v_f^2 - v_i^2 = 2a \Delta x \]

\[ v_i = \sqrt{-\frac{2a \Delta x}{\text{ friction}}} = \sqrt{-\left(2 \times 0.1 \times 9.8 \frac{m}{s^2}\right) \Delta x} \]

\[ v_i = \sqrt{2 \times 9.8 \times 12 m} = 4.85 \frac{m}{s} \]

18) A child is sitting on the outer edge of a merry-go-round that is 18 m in diameter. If the merry-go-round makes 8.3 rev/min, what is the velocity of the child in m/s?

\[ r = \frac{\text{diameter}}{2} = \frac{18 m}{2} = 9 \text{ meters} \]

\[ f = 8.3 \frac{\text{rev}}{\text{min}} \]

\[ f = (8.3 \frac{\text{rev}}{\text{min}}) \left( \frac{1}{60} \frac{\text{min}}{\text{sec}} \right) = 0.1383 \frac{\text{rev}}{\text{sec}} \]

\[ T = \frac{1}{f} = \frac{1}{0.1383} \frac{\text{sec}}{\text{rev}} = 7.29 \frac{\text{sec}}{\text{rev}} \]

\[ v = \frac{\text{dist}}{\text{time}} = \frac{2 \pi r}{T} = \pi \frac{d}{f} = \pi \left( 18 m \right) \left( 0.1383 \frac{\text{rev}}{\text{sec}} \right) \]

\[ v = 7.82 \frac{m}{s} \]
19) Through what angle in degrees does a 33 rpm record turn in 0.25 s?

\[ f = \left(33 \ \text{rev/min}\right) = \left(33 \ \text{rev/min}\right) \left(\frac{1}{60} \ \text{min/sec}\right) = \frac{33}{60} \ \text{rev/sec} \]

\[ \omega = 2\pi f = \left(2\pi \ \frac{\text{rad}}{\text{rev}}\right) \left(\frac{33}{60} \ \text{rev/sec}\right) = \frac{33\pi}{30} \ \text{rad/sec} \]

\[ \theta = \omega t + \theta_0 = \left(\frac{33\pi}{30} \ \frac{\text{rad}}{\text{sec}}\right) \left(\frac{1}{4} \ \text{sec}\right) = \frac{33\pi}{120} \ \text{rad} \]

\[ \theta = \left(\frac{33\pi}{120} \ \text{rad}\right) \left(\frac{360}{2\pi} \ \frac{\text{degrees}}{\text{rad}}\right) = 33 \cdot \frac{3}{2} \ \text{degrees} = 49.5^\circ \]

20) Starting from rest, a 75 kg skier slides down a 17.0° slope. If the coefficient of kinetic friction between the skis and snow is 0.120 and it takes 16.9 s to get to the bottom, how long is the ski trail? (Use g = 9.8 m/s².)

\[ \Sigma F_y = 0 \quad N - mg\cos\theta = 0 \quad N = mg\cos\theta \]

\[ \Sigma F_x \geq ma \]

\[ mg\sin\theta - f_k = ma \]

\[ mg\sin\theta - \mu_kN = ma \]

\[ mg\sin\theta - \mu_kmg\cos\theta = ma \]

\[ a_x = g \left(\sin \theta - \mu_k \cos \theta\right) \]

\[ \theta = 17^\circ \]

\[ M_k = 0.12 \]

\[ t = 16.9 \ \text{sec} \]

\[ \Delta x = \frac{1}{2}at^2 = \frac{1}{2} \left[9.8 \ \text{m/s}^2\right] \left[\sin 17^\circ - M_k \cos 17^\circ\right] \left(16.9 \ \text{sec}\right)^2 \]

\[ = \frac{1}{2}(9.8)\left[(1.292) - (0.12)(0.956)\right] \left(16.9\right)^2 \]

\[ \Delta x = 248 \ \text{meters} \]