MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) A plastic ball in a liquid is acted upon by its weight and by a buoyant force. The weight of the ball is 3.6 N. The buoyant force has a magnitude of 4.3 N and acts vertically upward. At a given instant, the ball is released from rest. The acceleration of the ball at that instant, including direction, is closest to:
   A) 0.95 m/s², downward
   B) 1.9 m/s², downward
   C) 1.9 m/s², upward
   D) zero
   E) 0.95 m/s², upward
   1) C

2) Consider what happens when you jump up in the air. Which of the following is the most accurate statement?
   ✓ A) 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.
   ✗ B) 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.
   ✗ C) 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.
   ✗ D) It is the upward force exerted by the ground that pushes you up, but this force can never exceed your weight.
   2) A

3) If you were to move into outer space far from any stars or planets,
   A) your weight would change, but your mass would not change.
   ✓ B) your mass would change, but your weight would not change.
   C) both your weight and mass would change.
   D) neither your weight nor your mass would change.
   E) None of these is true.
   3) A

4) A man pushes against a rigid, immovable wall. Which of the following is the most accurate statement concerning this situation?
   A) The man can never exert a force on the wall which exceeds his weight.
   B) Since the wall cannot move, it cannot exert any force on the man.
   ✓ C) If the man pushes on the wall with a force of 200 N, we can be sure that the wall is pushing back with a force of exactly 200 N on him.
   D) The friction force on the man's feet is directed to the left.
   E) The man cannot be in equilibrium since he is exerting a net force on the wall.
   4) C
since \( v = \text{constant} \),
\[ a = 0 \Rightarrow \sum F = 0 \]
Therefore \( \sum F_A = 0 \)
\[ F_A - W = 0 \]
\[ F_A = W \]
\[ (4.68 \times 9.8 \text{ N/s}^2) \]
\[ FA = 45 \text{ N} \]

A 5.0 kg block and a 4.0 kg block are connected by a 0.6 kg rod. The links between the blocks and the rod are denoted by A and B. A force \( F \) is applied to the upper block.

5) In Figure 4.2, the blocks and rod assembly move upward at constant velocity. The force in link A is closest to:
- A) 45 N
- B) 47 N
- C) 41 N
- D) 39 N
- E) 43 N

6) As shown in Figure 4.3, 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.

How are the magnitudes of these forces related, while the person is trying unsuccessfully to lift the crate? Explain your reasoning.

- A) \( P + C < W \)
- C) \( P + C > W \)
- B) \( P = C \)
- D) \( P + C = W \)

7) A person who normally weighs 200 pounds is standing on a scale inside an elevator. The elevator is moving upwards with a speed of 7 m/s, and then begins to slow down at a rate of 5 \text{ m/s}^2. Before the elevator begins to slow down, the reading of the scale is 200, and while the elevator is slowing down, the reading of the scale is 100.

- A) greater than 200 pounds, 100 pounds
- B) 200 pounds, 100 pounds
- C) greater than 200 pounds, 0 pounds
- D) less than 200 pounds, 100 pounds
- E) none of the above
Three forces A, B, and C act on a body as shown. A fourth force F is required to keep the body in equilibrium.

8) In Figure 5.5, the x-component of force F is closest to:
   A) -32 N  B) +19 N  C) -28 N  D) +32 N  E) +28 N

9) A box with weight 40 N is on a rough horizontal surface. An external force F is applied horizontally to the box. A normal force and a friction force are also present, denoted by n and f. A force diagram, showing the four forces that act on the box, is shown in Figure 5.7. When force F equals 8.8 N, the box is in motion at constant velocity. The box decelerates when force F is removed. The magnitude of the acceleration of the box is closest to:
   A) 0.55 m/s²
   B) 2.2 m/s²
   C) 1.7 m/s²
   D) 1.1 m/s²
   E) zero
10) 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?
A) 4.8 m/s  B) 3.8 m/s  C) 4.5 m/s  D) 4.3 m/s

\[
\begin{align*}
\Delta x &= 12 \text{ m} \\
\mu_k &= 0.1 \\
\Delta x &= \frac{1}{2} a \Delta x \\
\frac{1}{2} v_i^2 &= 2a \Delta x \\
v_i^2 &= 2a \Delta x \\
v_i &= \sqrt{2a \Delta x} \\
\mu_k mg &= m a \\
\alpha &= -\mu_k g \\
v_i &= \sqrt{2\mu_k g \Delta x} \\
\mu_k &= 0.1 \\
\Delta x &= 12 \text{ m} \\
v_i &= \sqrt{2(0.1)(9.8)(12)} = 11.85 \text{ m/s}
\end{align*}
\]

\[\begin{array}{c}
a = 7 \text{ kg} \\
\mu_k = 0.40 \\
\mu_k = 0.30 \\
T = m_k g
\end{array}\]

11) Block A of mass 7 kg and block X are attached to a rope which passes over a pulley. A 60 N force is applied horizontally to block A, keeping it in contact with a rough vertical face. The coefficients of static and kinetic friction are \(\mu_s = 0.40\) and \(\mu_k = 0.30\). The pulley is light and frictionless. In Figure 5.19, the mass of block X is set so that block A is on the verge of slipping upward. The mass of block X is closest to:
A) 8.5 kg  B) 9.9 kg  C) 8.0 kg  D) 9.0 kg  E) 9.4 kg

\[\begin{align*}
2F &= 0 \\
T - mg - m_s \rho &= 0 \\
T &= m_k g + m_s \rho \\
2F &= 0 \\
T &= m_k g + m_s \rho \\
M_s \rho &= F
\end{align*}\]

\[\begin{align*}
\mu_k &= 0.30 \\
m_k &= 7 + \frac{2 \cdot 1}{4.8} = 9.4 \text{ kg} \\
m_k &= m_A + m_s \rho \\
T &= m_k g + m_s \rho
\end{align*}\]

12) A 76 kg mass is connected to a nail on a frictionless table by a (massless) string of length 1.3 m. If the tension in the string is 51 N while the mass moves in a uniform circle on the table, how long does it take for the mass to make one complete revolution?
A) 8.1 s  B) 9.5 s  C) 8.7 s  D) 7.0 s

\[\begin{align*}
r &= 1.3 \text{ m} \\
T &= 51 \text{ N} \\
m &= 76 \text{ kg} \\
T &= \frac{mv^2}{r} \\
T &= \frac{m(\frac{2\pi r}{v})^2}{r} \\
T &= \frac{4\pi^2 m r}{L^2} \\
t &= 2\pi \left( \frac{m k}{T} \right)^{1/2} = 2\pi \left( \frac{76 (1.3)}{51} \right)^{1/2} \\
t &= 8.7 \text{ s}
\end{align*}\]
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) The tension is constant as the rock moves around in a circle.
B) It is highest when the rock is at the lowest elevation.
C) It is highest when the rock is at the highest elevation.

14) You need to make a sharp turn on a flat road, making a radius of curvature of 15 meters. How does the required force of static friction between your tires compare if you make the turn at 30 mph vs. 60 mph?
A) The force of friction needs to be four times as large.
B) the force of friction is the same for both speeds since the radius of curvature is the same.
C) The force of friction needs to be twice as large.
D) None of the above

15) Figure 6.5 shows two wires that are tied to a 150 g mass which revolves in a horizontal circle at a constant speed of 7.5 m/s. What is the tension in the upper wire?

\[ m = 0.15 \, \text{kg} \]
\[ v = 7.5 \, \text{m/s} \]
\[ \left(\frac{L}{2}\right)^2 + r^2 = L^2 \]
\[ r^2 = 1 - \frac{r}{L} = \frac{3}{4} \]
\[ r = \frac{\sqrt{3}}{2} = 0.866 \]
\[ \sin \theta = \frac{5 \, \text{m}}{\text{L}} = \frac{1}{2} \]
\[ \theta = 30^\circ \]

\[ T_u = \frac{m u^2}{r \sin \theta} \]
\[ T_u = \frac{0.15 \times (7.5 \, \text{m/s})^2}{0.866 \times 0.5} = 9.74 \, \text{N} \]

\[ T_u \cos 30 + T_u \cos 30 = \frac{m u^2}{r} \]
\[ T_u \sin 30 - T_L \sin 30 - mg = 0 \]

\[ T_u = T_L + \frac{mg}{\sin 30} \]
\[ T_u + T_L = \frac{m u^2}{r} \]
\[ T_L = 11.25 - T_u \]
\[ T_L = 11.25 - 9.74 = 1.51 \, \text{N} \]

D) 4.2 N
16) A roadway is designed for traffic moving at a speed of 22 m/s. A curved section of the roadway is a circular arc of 270 m radius. The curved section is temporarily replaced with an unbanked roadway of the same radius. The coefficient of friction of this roadway is 0.40. The maximum safe driving speed for this unbanked, curved section is closest to:

A) 31 m/s  
B) 29 m/s  
C) 33 m/s  
D) 27 m/s  
E) 25 m/s

17) A satellite having orbital speed \( V \) orbits a planet of mass \( M \). If the planet had half as much mass, the orbital speed of the satellite would be

A) \( V \)  
B) \( V\sqrt{2} \)  
C) \( V/2 \)  
D) \( V/\sqrt{2} \)  
E) \( 2V \)

18) Find the orbital speed of an ice cube in the rings of Saturn, if the mass of Saturn is \( 5.67 \times 10^{26} \) kg and the rings have an average radius of 100,000 km.

A) 19.5 km/s  
B) 1.95 km/s  
C) 13.8 km/s  
D) 27.5 km/s

19) An object is moving to the right in a straight line. The net force acting on the object is also directed to the right, but the magnitude of the force is decreasing with time. The object will

A) stop and then begin moving to the left.  
B) continue to move to the right, with its speed decreasing with time.  
C) continue to move to the right, with its speed increasing with time.  
D) continue to move to the right with a constant speed.

20) A force of 30 N stretches a spring 0.73 m from equilibrium. What is the value of the spring constant?

A) 22 N/m  
B) 34 N/m  
C) 41 N/m  
D) 46 N/m

\[ F = k \Delta x \]

\[ k = \frac{F}{\Delta x} = \frac{30 \text{ N}}{0.73 \text{ m}} = 41 \text{ N/m} \]
SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

21) A box of mass 72 kg is at rest on a horizontal frictionless surface. A constant horizontal force \( F \) then acts on the box, and accelerates it to the right. It is observed that it takes the box 3.4 seconds to travel 13 meters. What is the magnitude of the force?

\[
\begin{align*}
\Sigma F &= ma \\
M &= 72 \text{ kg} \\
\dot{t} &= 3.4 \text{ seconds} \\
\Delta x &= 13 \text{ meters}
\end{align*}
\]

Use kinematic equations:
Assume \( x_0 = 0 \) meters, \( v_0 = 0 \) m/s

\[
\Delta x = \frac{1}{2} \alpha \dot{t}^2
\]

so \( \Delta x = \frac{1}{2} \left( \frac{E}{m} \right) \dot{t}^2 \)

Solve for \( F \):

\[
F = \frac{2 \Delta x \cdot M}{\dot{t}^2} = \frac{2(13 \text{ m})(72 \text{ kg})}{(3.4 \text{ sec})^2}
\]

\[
F = 161.9 \text{ N}
\]

\[
F = 162 \text{ N}
\]
A Ferris wheel has radius 5.0 m and makes one revolution in 8.0 seconds. A person weighing 670 N is sitting on one of the benches attached at the rim of the wheel. What is the apparent weight (the normal force exerted on her by the bench) of the person as she passes through the highest point of her motion?

\[ W = 670 \, \text{N} \]

\[ m = \frac{W}{g} = \frac{670}{9.8 \, \text{m/s}^2} = 68.4 \, \text{kg} \]

\[ T = 5.0 \, \text{meters} \]

\[ T = 8.0 \, \text{sec} \]

At the top, the free body diagram looks like

\[ \sum F = \frac{mv^2}{r} \]

\[ mg - n = \frac{mv^2}{r} \]

so

\[ n = mg - \frac{mv^2}{r} \]

Now

\[ v = \frac{2\pi r}{T} \]

so

\[ n = mg - \frac{mv^2}{r} = mg - \frac{m}{r} \left( \frac{2\pi r}{T} \right)^2 \]

\[ = mg - \frac{4\pi^2 m r}{T^2} \]

\[ = 670 \, \text{N} - \frac{4(11)^2 (68.4 \, \text{kg})(5.0 \, \text{m})}{(8 \, \text{sec})^2} \]

\[ = 670 - 210 \]

\[ = 460 \, \text{N} \]
23) A 200 g hockey puck is launched up a metal ramp that is inclined at a 30° angle. The coefficients of static and kinetic friction between the puck and the ramp are $\mu_s = 0.40$ and $\mu_k = 0.30$, and the puck's initial velocity at the base is 3.8 m/s parallel to the sloping surface of the ramp. What speed does the puck have when it slides back down to its starting point?

\[
\begin{align*}
\text{on way up incline} & \quad \varepsilon F_y = 0 \quad \Rightarrow \quad N = mg \cos \theta \\
\varepsilon F_x = m a_x \\
-m \sin \theta - \mu_k mg \cos \theta = -mg \sin \theta - \mu_k mg \cos \theta = ma_x \\
\therefore \quad a_x = -g (\sin \theta + \mu_k \cos \theta)
\end{align*}
\]

\[
\frac{v_f^2 - v_i^2}{2a_x} = -\frac{V_i^2}{2g(\sin \theta + \mu_k \cos \theta)}
\]

\[
\begin{align*}
\text{on way down} & \quad \varepsilon F_y = 0 \quad \Rightarrow \quad N = mg \cos \theta \\
\varepsilon F_x = m a_x \Rightarrow \quad m g \sin \theta - \mu_k mg \cos \theta = ma_x \\
\therefore \quad a_x = g (\sin \theta - \mu_k \cos \theta)
\end{align*}
\]

Again use kinematic equation

\[
\frac{v_f^2 - v_i^2}{2a_x} = \frac{V_i^2}{2g(\sin \theta - \mu_k \cos \theta)}
\]

\[
\begin{align*}
\sin 30^\circ &= \frac{1}{2} \\
\cos 30^\circ &= \frac{\sqrt{3}}{2} \\
\therefore \quad a_x &= \frac{V_i^2}{2g(\sin \theta - \mu_k \cos \theta)}
\end{align*}
\]

\[
\begin{align*}
V_f^2 &= 2a \Delta x \\
&= 2g \left[ \sin \theta - \mu_k \cos \theta \right] \frac{V_i^2}{2g(\sin \theta - \mu_k \cos \theta)}
\end{align*}
\]

\[
\therefore \quad V_f = V_i \sqrt{\frac{\sin \theta - \mu_k \cos \theta}{(\sin \theta + \mu_k \cos \theta)}} = \left(3.8 \text{ m/s}\right) \sqrt{\frac{\left(\frac{1}{2} - \frac{3}{10} \frac{\sqrt{3}}{2}\right)}{\left(\frac{1}{2} + \frac{3}{10} \frac{\sqrt{3}}{2}\right)}} = 2.01 \text{ m/s}
\]