2. When a car goes around a circular curve on a level road without slipping,

A. no frictional force is needed because the car simply follows the road.
B. the frictional force of the road on the car increases when the car's speed decreases.
C. the frictional force of the road on the car increases when the car's speed increases.
D. the frictional force of the road on the car increases when the car moves to the outside of the curve.
E. there is no net frictional force because the road and the car exert equal and opposite forces on each other.

3. A race car traveling at 100 m/s enters an unbanked turn of 400 m radius. The coefficient of (static) friction between the tires and the track is 1.1. The track has both an inner and an outer wall. Which statement is correct?

A. The race car will crash into the outer wall.
B. The race car will crash into the inner wall.
C. The car will stay in the center of the track.
D. The car will stay in the center of the track if the driver speeds up.
E. The car would stay in the center of the track if the radius were reduced to 200 m.

\[
R_c = \frac{v^2}{R}, \quad F_f = \mu mg = 11 \text{ m}
\]

\[
= 25 \text{ m/s}^2
\]

\[
F_f \ll F_c
\]

4. A 0.3-kg mass attached to the end of a string swings in a vertical circle \( R = 1.6 \text{ m} \), as shown. At an instant when \( \theta = 50^\circ \), the mass is moving with a speed of 4.0 m/s. What is the magnitude of the total acceleration of the mass at this instant?

A. 10 m/s^2
B. 9.1 m/s^2
C. 156 m/s^2
D. 13 m/s^2
E. 22 m/s^2

\[
A = \sqrt{A_e^2 + A_c^2}
\]

\[
A_e = -g \sin 50^\circ
\]

\[
= 7.5 \text{ m/s}^2
\]

\[
A_c = \frac{v_e^2}{R} = 10 \text{ m/s}^2
\]

\[
A = 12.5 \text{ m/s}^2
\]

5. If a 20-kg object dropped in air has a terminal speed of 60 m/s, what was its acceleration at 30 m/s, if the drag force is proportional to the speed squared \( bv^2 \)?

A. 9.8 m/s^2
B. 7.4 m/s^2
C. 4.9 m/s^2
D. 2.5 m/s^2
E. More information is needed to answer this question.

\[
\text{At the terminal speed} \quad b v_T^2 = mg
\]

\[
b = \frac{mg}{v_T^2}
\]

\[
a = g \left( 1 - \frac{v_f^2}{v_T^2} \right) = \frac{3}{4} g = 7.4 \text{ m/s}^2
\]
6. In the figure shown, the coefficient of kinetic friction between the block and the incline is 0.29. What is the magnitude of the acceleration of the suspended block M as it falls? Disregard the friction of the pulley.

A 5.4 m/s²  
B 5.9 m/s²  
C 4.9 m/s²  
D 5.6 m/s²  
E 7.9 m/s²

\[ M g - T = M a \]

\[ T + 2 M g \sin \theta - 2 M g \cos \theta = 2 M a \]

\[ 3 M a = g + 2 M g \sin \theta - 2 M g \cos \theta \]

\[ a = \frac{1}{3} g \left( 1 + 2 \sin \theta - 2 \cos \theta \right) = 4.9 \]

7. A 5.0-kg object is pulled along a horizontal surface at a constant speed by a 15-N force acting 20° above the horizontal. How much work is done by this force as the object moves 6.0 m?

A 31 J  
B 80 J  
C 43 J  
D 74 J  
E 85 J

\[ W = F \Delta x = 6 \times 15 \cos 20° = 85 \text{ N} \]

8. A variable force is represented on an F-versus-x graph. Which of the following is the work done by this force?

A the slope of the curve  
B the area bounded by the curve and the x axis  
C the area bounded by the curve and the F axis  
D the F value multiplied by the x value  
E the F value divided by the x value

9. The horizontal surface on which the block of a mass 2.0 kg slides is frictionless. The speed of the block before it touches the spring is 6.0 m/s. How fast is the block moving at the instant the spring has been compressed 15 cm? \( k = 2.0 \text{ kN/m} \)

A 5.4 m/s  
B 4.4 m/s  
C 4.9 m/s  
D 3.7 m/s  
E 14 m/s

\[ \frac{1}{2} M v^2 = \frac{1}{2} k \Delta x^2 + \frac{1}{2} M v_0^2 \]

\[ v^2 = \sqrt{2} \cdot \frac{1}{2} k \Delta x^2 \]

\[ v = \sqrt{0^2 - \frac{k}{M} \Delta x^2} \]

\[ = \sqrt{6^2 - 0.15 \times 10 \times 3} = 13.5 \text{ m/s}^2 \]
10. A 8.0-kg block starts from rest and slides 5.0 m down a plane inclined at $60^\circ$ to the horizontal. The coefficient of kinetic friction between the surface and the block is 0.10. The work done by friction on the block is

A 98 J  
B 20 J  
C 3.9 J  
D 3.4 J  
E 64 J

\[ W = -\int f \cdot dl = \mu mg \cos \theta \cdot d \\
= 0.1 \times 8 \times 9.8 \times \sin \theta \times \frac{1}{2} \times 5 = \]

11. The only force acting on a 1.8-kg body as it moves along the x axis is given by $F_x = -(3.0x)$ N, where $x$ is in m. If the velocity of the body at $x = 0$ is $v_x = +8.0$ m/s, at what value of $x$ will the body have a velocity of $+4.0$ m/s?

A 5.8 m  
B 5.4 m  
C 4.6 m  
D 29 m  
E 6.6 m

\[ F_x = m \frac{dv}{dt} = m \frac{dv}{dx} \cdot v \\
= -3x \\
\frac{-3}{2} \int dx = mv \frac{dv}{dx} \\
-\frac{3}{2} x^2 = \frac{1}{2} mv^2 \\
\frac{1}{2} (64 - v^2) = \frac{m}{2} \left( \frac{64 - v^2}{2} \right). \]

12. A 0.04-kg ball is thrown from the top of a 30-m tall building (point A) at an unknown angle above the horizontal. As shown in the figure, the ball attains a maximum height of 10 m above the top of the building before striking the ground at point B. If air resistance is negligible, what is the value of the kinetic energy of the ball at B minus the kinetic energy of the ball at A? ($K_B - K_A$)

A 12 J  
B -12 J  
C 20 J  
D 16 J  
E 32 J

\[ K_A + PE_A = K_B + PE_B \\
K_B - K_A = PE_A = mg \cdot h \\
= 12 J \]

13. A 20-kg mass is fastened to a light spring ($k = 380$ N/m) that passes over a pulley as shown. The pulley is frictionless, and the mass is released from rest when the spring is unstretched. After the mass has dropped 0.40 m, what is its speed?

A 2.2 m/s  
B 2.5 m/s  
C 1.9 m/s  
D 4.8 m/s  
E 3.6 m/s

\[ m \frac{dx}{dt} = \frac{1}{2} k x^2 + \frac{1}{2} m v^2 \\
\frac{v^2}{g} = 2g x - \frac{k}{m} \frac{x}{x^2} \\
= (4.8 \text{ m/s})^2 \]
14. The work done by a conservative force between two points is
A. always positive.
B. always dependent upon the time.
C. always dependent upon the path.
D. always independent of the path.
E. always zero, so that the potential energy is conserved.

15. The speed of a 4.0-kg object is given by \( v = (2t) \) m/s, where \( t \) is in s. At what rate is the resultant force on this object doing work at \( t = 1.0 \) s?
A. 48 W
B. 40 W
C. 32 W
D. 56 W
E. 16 W

\[ F = ma = (m \cdot a) \cdot \dot{t} = \frac{(m \cdot 2t) \cdot 2t}{2} \]
\[ = 4 \cdot 2 \cdot 2 \cdot t = 16 \text{ W} \]

16. At the instant a 2.0-kg particle has a velocity of 4.0 m/s in the positive \( x \) direction, a 3.0-kg particle has a velocity of 5.0 m/s in the positive \( y \) direction. What is the speed of the center of mass of the two-particle system?
A. 3.8 m/s
B. 3.4 m/s
C. 5.0 m/s
D. 4.6 m/s
E. 4.8 m/s

\[ v_{\text{cm}} = \sqrt{\left( \frac{(m_1 v_1^2) + (m_2 v_2^2)}{m_1 + m_2} \right)} \]
\[ = \sqrt{\left( \frac{(2 \cdot 4)^2 + (3 \cdot 5)^2}{5} \right)} \]
\[ = \sqrt{\left( \frac{64 + 225}{5} \right)} \]

17. A 2.4-kg ball falling vertically hits the floor with a speed of 2.5 m/s and rebounds with a speed of 1.5 m/s. What is the magnitude of the impulse exerted on the ball by the floor?
A. 9.6 Ns
B. 2.4 Ns
C. 6.4 Ns
D. 1.6 Ns
E. 1.0 Ns

\[ \Delta P = m \Delta V = 2.4 \times 4 = 9.6 \text{ kg} \cdot \text{m/s} = \]
18. A 1.2-kg object moving with a speed of 8.0 m/s collides perpendicularly with a wall and emerges with a speed of 6.0 m/s in the opposite direction. If the object is in contact with the wall for 2.0 ms, what is the magnitude of the average force on the object by the wall?

A 9.8 kN
B 8.4 kN
C 7.7 kN
D 17 kN
E 14 kN

\[ \Delta P = 1.2 \times 14 \text{ kg} \cdot \text{m/s} = 16.8 \text{ kg} \cdot \text{m/s} \]

\[ F = \frac{\Delta P}{\Delta t} = 8.4 \text{ kN} \]

19. The condition necessary for the Conservation of Linear Momentum in a given system is that

A energy is conserved.
B kinetic energy is conserved.
C the net external force is zero.
D the net internal force is equal to the net external force
E All above

20. A 10-g bullet moving 1000 m/s strikes and passes through a 2.0-kg block initially at rest, as shown. The bullet emerges from the block with a speed of 400 m/s. To what maximum height will the block rise above its initial position? (Ignore the short penetrating time of the bullet.)

A 92 cm
B 66 cm
C 56 cm
D 46 cm
E 37 cm

\[ m V_b = m V_b' + M V \]

\[ V = \frac{m}{M} (V_b - V_b') = \frac{0.01}{2} \cdot 600 \]

\[ = 3 \text{ m/s} \]

\[ h = \frac{v^2}{2g} = \frac{9}{7 \times 9.8} = 0.46 \text{ m} \]

21. A 500-g firework explodes into two pieces of equal mass at an instant when it is traveling straight up at 10 m/s. If one half shoots off horizontally to the left at 20 m/s, what is the velocity, in m/s, of the other half immediately after the explosion? (The x axis is directed right; the y axis up.)

A \(-20i - 20j\)
B \(-20i + 20j\)
C \(+20i - 20j\)
D \(+20i + 20j\)
E None of the above

\[ U_x = -U_x = 20 \text{ m/s} \]

\[ U_y = \frac{M}{m} V_o = 2 U_o = 20 \text{ m/s} \]