Multiple Choice

1. A bomb hanging from a string explodes into pieces of different shapes and sizes.

   After the explosion:
   a) the vector momentum of each piece is identical
   b) the total momentum is unchanged
   c) the momentum of all the pieces, exhaust, and smoke adds up to zero
   d) not enough information to comment
   e) none of these

2. If an inelastic collision takes place between two objects and there are no external forces, then:
   a) momentum and kinetic energy are conserved
   b) momentum is conserved, but kinetic energy is not
   c) neither momentum nor kinetic energy is conserved
   d) it is not possible to determine if either momentum or kinetic energy are conserved without knowing more of the details of the collision

3. For the potential energy function \( E(x, y) = 3x^2 + 5y^2 + 6xy \), the corresponding force is:
   a) \( F_x = -6y \), \( F_y = -3x - 10y \)
   b) \( F_x = -3y + 3x \), \( F_y = -3x + 10y \)
   c) \( F_x = -3y + 3x \), \( F_y = -3x + 10y \)
   d) \( F_x = -3y + 3x \), \( F_y = -3x + 10y \)

4. An object moves in a circle at constant speed. The work done by the centripetal force is zero because:
   a) the displacement for each revolution is zero
   b) the average force for each revolution is zero
   c) there is no friction
   d) the magnitude of the acceleration is zero
   e) the centripetal force is perpendicular to the velocity

5. A man pulls a 100-N crate up a frictionless 30° slope 5 m high as shown. Assuming that the crate moves at constant speed, the work done by the man is:
   a) 500 J
   b) 250 J
   c) 0 J
   d) 0 J
   e) 0 J

6. When a certain rubber band is stretched a distance \( x \), it exerts a restoring force \( F = -ax - bx^2 \), where \( a \) and \( b \) are constants. The work done in stretching this rubber band from \( x = 0 \) to \( x = a/2 \) is:
   a) \( \frac{1}{2}aL^2 + \frac{1}{2}bL^3 \)
   b) \( \int_0^a (ax + bx^2) \, dx \)
   c) \( aL \)
   d) \( \frac{1}{2}aL^2 + \frac{1}{2}bL^3 \)
   e) \( \frac{1}{2}aL + \frac{1}{2}bL^2 \)

7. An escalator is used to move 20 people (90 kg each) per minute from the first floor of a department store to the second floor, 5 m above. The power required is approximately:
   a) 100 W
   b) 200 W
   c) 200 W
   d) 2000 W
   e) 60,000 W

8. The first graph shows the potential energy \( U(x) \) for a particle moving on the \( x \)-axis. Which of the following five graphs correctly gives the force \( F \) exerted on the particle?

9. The diagram shows a plot of the potential energy as a function of \( x \) for a particle moving along the \( x \)-axis. The points of stable equilibrium are:
   a) only \( a \)
   b) only \( b \)
   c) only \( a \)
   d) \( a \) and \( d \)
   e) both \( b \) and \( d \)
10. Which one of the following statements is true?
   A) The center of mass of an object must be within the object.
   B) All the mass of an object need not be concentrated at its center of mass.
   C) The center of mass of an object cannot move if there is zero net force on the object.
   D) The center of mass of a cylinder must lie on its axis.
   E) None of the above.

11. The center of mass of a system of particles has a constant velocity if
   A) the forces exerted by the particles on each other sum to zero.
   B) the velocity of the center of mass is initially zero.
   C) the particles are distributed symmetrically around the center of mass.
   D) the center of mass is at the geometric center of the system.
   E) None of the above.

12. A man sits in the back of a canoe in still water. He then moves to the front of the canoe and sits there. Afterwards, the canoe
   A) moves forward with an equal velocity in the opposite direction.
   B) moves backward with an equal velocity in the opposite direction.
   C) moves with an equal velocity in the same direction.
   D) moves with an equal velocity in the opposite direction.
   E) None of the above.

13. A 1000 kg space probe is motionless in space. To start moving, its main engine is fired for 5 s during which time it ejects exhaust gases at 3000 m/s. At the end of this process it is moving at 20 m/s. The approximate mass of the ejected gas is
   A) 0.8 kg
   B) 4 kg
   C) 5 kg
   D) 20 kg
   E) 25 kg

14. One revolution is the same as
   A) 2 rad
   B) 57 rad
   C) m/2 rad
   D) 2 m rad
   E) 28 rad

15. The figure below shows a disk spinning about an axis through its center. For each of the three situations described, indicate the direction of the angular velocity $\omega$ and the angular acceleration $\alpha$.

   Situation 1: Disk spinning clockwise with an increasing angular speed.
   Situation 2: Disk spinning counterclockwise with a decreasing angular speed.
   Situation 3: Disk spinning clockwise with a constant angular speed.

16. A ball is dropped from a height $h$ and hits the ground with speed $v$. To have the ball hit the ground at a speed of 2v, it should be dropped from a height $h'$.
   A) $h/2$
   B) $h$
   C) 2h
   D) 3h
   E) 4h

17. A pitcher throws a 44 m/s fastball. The bat receives the ball's velocity and it leaves the bat at 26 m/s. What was the average force on the 0.145 kg baseball during the contact time of 3 ms?
   A) 0.43 kN
   B) 0.34 kN
   C) 0.07 kN
   D) 1.45 kN
   E) None of the above

18. A block of mass 5 kg slides down an inclined plane of length 3 m that makes an angle of 30° with the horizontal. The coefficient of friction between the block and the plane is 0.2. The block is released from rest at the top of the incline, and at the bottom has a speed of
   A) 2.5 m/s
   B) 3.3 m/s
   C) 5.4 m/s
   D) 7.1 m/s
   E) None of the above

19. A block is released from rest at the top of the incline, and at the bottom has a speed of
   A) 2.5 m/s
   B) 3.3 m/s
   C) 5.4 m/s
   D) 7.1 m/s
   E) None of the above

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   A) 2.5 m/s
   B) 3.3 m/s
   C) 5.4 m/s
   D) 7.1 m/s
   E) None of the above

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   A) 2.5 m/s
   B) 3.3 m/s
   C) 5.4 m/s
   D) 7.1 m/s
   E) None of the above

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   A) 2.5 m/s
   B) 3.3 m/s
   C) 5.4 m/s
   D) 7.1 m/s
   E) None of the above

23. A block of mass 5 kg slides down an inclined plane of length 3 m that makes an angle of 30° with the horizontal. The coefficient of friction between the block and the plane is 0.2. The block is released from rest at the top of the incline, and at the bottom has a speed of
   A) 2.5 m/s
   B) 3.3 m/s
   C) 5.4 m/s
   D) 7.1 m/s
   E) None of the above

24. A block of mass 5 kg slides down an inclined plane of length 3 m that makes an angle of 30° with the horizontal. The coefficient of friction between the block and the plane is 0.2. The block is released from rest at the top of the incline, and at the bottom has a speed of
   A) 2.5 m/s
   B) 3.3 m/s
   C) 5.4 m/s
   D) 7.1 m/s
   E) None of the above
Problem 2
A proton hits a stationary alpha particle causing the alpha particle to recoil at 240° w.r.t. with respect to the initial proton velocity. Assuming the mass of the alpha to be 4 times the proton mass, the deflected proton moves 560 m/s at what angle with respect to its initial velocity?”

\[
x_{\text{comp of momentum}} = m_{v_0} = m_v \cos \theta + M \frac{v}{c} \cos \theta,
\]

\[
y_{\text{comp of momentum}} = 0 = M \sin \theta - m_v \sin \theta
\]

\[
\theta = 240^\circ
\]

Problem 3
Tarzan, who weighs 688 N, swings from a cliff at the end of a convenient vine that is 18 m long. From the top of the cliff to the bottom of the swing, he descends by 3.2 m. The vine will break if the force on it exceeds 500 N.
Find the tension in the vine... does it break?

\[
mgh = \frac{1}{2} mv^2
\]

\[
9.8(3.2) = \frac{1}{2} v^2
\]

\[
v = 7.92 \text{ m/s}
\]

\[
\tau = \frac{mg}{\sin \theta}
\]

\[
\frac{9.8}{\frac{18}{9.8}} = \frac{10}{v^2} = T - mg
\]

\[
688 \left( \frac{7.92}{18} \right)^2 = T - 688
\]

\[
T = 932 \text{ Newtons}
\]

Problem 4
A large block of ice, 13 kg, slides down a ramp towards a spring at the bottom as shown below. The ramp is frictionless and the spring has a spring constant of \( k = 490 \text{ N/m} \). At the instant that the block is 3 m up the ramp from the top of the spring, the block of ice has a speed of 12 m/s.
Find the distance that the spring is compressed before the ice first comes to rest.

\[
mgh + \frac{1}{2}mv^2 = \frac{1}{2} kx^2
\]

\[
13(9.8) \cdot 3 \sin 10^\circ + \frac{1}{2} \cdot 12^2 = \frac{1}{2} \cdot 490 \cdot x^2
\]

\[
x = 0.56 \text{ m}
\]

Actually we should have set \( h = (L + x) \sin \theta \)
which would have resulted in
\[
x = 0.60 \text{ m}
\]

1530 = 15.5

\[
\frac{1530}{3} = 46.5 \text{ min}
\]