1. The blocks shown below are released from rest with the spring in its unstretched equilibrium position. The pulley and the horizontal surface are frictionless. If the spring constant is 400 N/m and $M = 4.5$ kg, what is the maximum amount that the spring will be stretched? Hint: the system is not in equilibrium when the spring is maximally stretched.

   - a) 11 cm
   - b) 66 cm
   - c) 22 cm
   - d) 33 cm
   - e) 55 cm

   $\frac{Kx^2}{2} = mgx$  \( x = \frac{2Mg}{K} = 0.22 \text{ m} \)

2. Two forces are applied to a 5.0-kg object, one is 6.0 N to the north and the other is 8.0 N to the west. The magnitude of the acceleration of the object is:

   - a) 0.50 m/s$^2$
   - b) 2.0 m/s$^2$
   - c) 2.8 m/s$^2$
   - d) 10 m/s$^2$
   - e) 50 m/s$^2$

   $\vec{F} = \vec{F_1} + \vec{F_2} = 6 \text{ N} - 8 \text{ N}$

   $|\vec{F}| = \sqrt{6^2 + 8^2} = 10 \text{ N}$

   $a = \frac{F}{m} = \frac{10}{5} = 2 \text{ m/s}^2$

3. A giant wheel, 20 m in radius, is fitted with a cage and platform on which a man can stand. The wheel rotates in a vertical plane at constant speed such that when the cage is at X (as shown) the magnitude of the force exerted by the man on the platform is equal to his weight. The speed of the man is:

   - a) 14 m/s
   - b) 20 m/s
   - c) 28 m/s
   - d) 80 m/s
   - e) 120 m/s

   $\sqrt{2gR} = 20 \text{ m/s}$

4. A student in the rear of a school bus tosses a ball to another student in the front of the bus while the bus is moving forward at constant velocity. The magnitude of the velocity of the ball as seen by a stationary observer in the street:

   - a) is less than that observed inside the bus.
   - b) is the same as that observed inside the bus.
   - c) may be either greater or smaller than that observed inside the bus.
   - d) is greater than that observed inside the bus.
   - e) none of the other answers is clearly correct without more information.

5. If $M = 1.1$ kg, what is the tension in String #1 in the figure?

   - a) 54 N
   - b) 47 N
   - c) 40 N
   - d) 62 N
   - e) 57 N

   $T_1 = \frac{Mg}{\cos 40^\circ - \sin 40^\circ}$

   $T_1 = 40 \text{ N}$
6. A Rutgers bird spots a member of the Syracuse football team in an amusement park. The football player is on a ride where he goes around a horizontal circle at a constant angular velocity $\omega$ at distance $R$ from the center. The bird flies in a horizontal circle (same radius, same angular velocity) above him. Will a dropping the bird releases while flying directly above the person’s head hit him?
   a) Yes, because it falls straight down.
   b) Yes, because it maintains the acceleration of the bird as it falls.
   c) No, because it falls straight down and will land behind the person.
   d) Yes, because it maintains the angular velocity of the bird as it falls.
   e) No, because it maintains the tangential velocity the bird had at the instant it started falling.

7. A 3.0-kg block is on a frictionless horizontal surface. The block is at rest when $t=0$. A force (magnitude = 2.0 N) acting at an angle of 22° above the horizontal is applied to the block. At what rate is the force doing work at $t = 2.0$ s?
   a) 2.0 W
   b) 2.3 W
   c) 1.4 W
   d) 1.7 W
   e) 1.2 W
   $P = F_x \cos \theta \cdot \dot{x} = F \cos \theta \cdot \dot{x}$

8. A woman on a sled with a combined weight of 0.70 kN goes over a frictionless circular hill as shown. If the sledder’s speed at point A is 9.2 m/s, what is her speed at the top of the hill (point B)?
   \[ \frac{m_1 v_0^2}{2} = \frac{m_1 v^2}{2} + m_1 g h \]
   a) 3.1 m/s
   b) 6.2 m/s
   c) 4.1 m/s
   d) 6.5 m/s
   e) 5.2 m/s

9. A 3.0-kg object moving in the positive $x$ direction has a one-dimensional elastic collision with a 5.0-kg object initially at rest. After the collision the 5.0-kg object has a velocity of 6.0 m/s in the positive $x$ direction. What was the initial speed of the 3.0-kg object?
   a) 6.0 m/s
   b) 7.0 m/s
   c) 4.5 m/s
   d) 8.0 m/s
   e) 5.5 m/s
   \[ \frac{m_1 v_0}{2} = \frac{m_1 v_1^2}{2} + m_2 v_2^2 \]

10. A stunt woman jumps off the roof of a tall building, but is not hurt because she lands on a large, air-filled bag. Which one of the following best describes why she is not injured?
   a) The bag provides the necessary force to stop her.
   b) The bag increases the amount of time during which the momentum is changing and reduces the average force on her.
   c) The bag reduces the impulse on her.
   d) The bag increases the amount of time the force acts on her and reduces the total change in momentum.
   e) The bag decreases the amount of time during which the momentum changes and reduces the average force on her.
11. A mass of 3 kg is placed on an 8 kg mass which lies on a horizontal, frictionless table, as shown. What is the maximum acceleration, that can be achieved due to force $F$ applied horizontally to the 3 kg mass so that the whole system accelerates without the 3 kg mass sliding on the 8 kg mass? The coefficient of static friction between them is 0.5.

- a) $1.3 \text{m/s}^2$
- b) $1.5 \text{m/s}^2$
- c) $1.8 \text{m/s}^2$
- d) $1.1 \text{m/s}^2$
- e) $0.9 \text{m/s}^2$

\[
\begin{align*}
F - \mu mg &= 3 \text{kg} \cdot a \\
a &= \frac{F}{11 \text{kg}}
\end{align*}
\]

12. Two runners, starting from rest, run the same course along a straight line. Runner B gets to the finish line in $(4/5)$ the time taken by runner A. Assuming constant acceleration for both runners over the whole course, what is the acceleration of runner A divided by that of runner B?

- a) $4/5$
- b) $1/5$
- c) $5/4$
- d) $16/25$
- e) $25/16$

\[
\begin{align*}
\frac{a_A}{a_B} &= \left(\frac{t_B}{t_A}\right)^2 = \left(\frac{4}{5}\right)^2 \quad \text{(d)}
\end{align*}
\]

13. A glider of mass 4.0 kg is placed on a horizontal airtrack and connected by a light, inextensible string over a frictionless pulley to a hanging 1.0 kg mass, both starting from rest. How long does it take the 1.0 kg mass to fall 1.0 m? (Take $g = 10 \text{ m/s}^2$).

- a) 2 s
- b) 1.5 s
- c) 1.25 s
- d) 1 s
- e) 0.75 s

\[
\begin{align*}
t &= \sqrt{2d/a} = \sqrt{2 \cdot 1.0 \text{ m} / (4 \text{ m/s}^2)} = 1 \text{ s}
\end{align*}
\]

14. The left 50 cm of a meter stick are made of a uniform plastic of density $d$. The other 50 cm are made of a uniform plastic of density $2d$. If the origin of the meter stick is at the left end, as shown how far is the center of mass of the meter stick from the origin?

\[
\begin{align*}
&\frac{m_1 \cdot x_1 + m_2 \cdot x_2}{m_1 + m_2} = \frac{25 \text{ cm} + 2 - 7.5 \text{ cm}}{1 + 2} = \frac{5.5 \text{ cm}}{3} \\
&= \frac{5.5 \text{ cm}}{3} = 1.83 \text{ cm}
\end{align*}
\]

15. Taking the acceleration due to gravity to be $9.8 \text{ m/s}^2$, which of the following four statements is false for a body in free fall from rest near the surface of the earth? If none of the four statements are false, choose "None". (Ignore air resistance.)

- a) after 1 second, the body has fallen $9.8 \text{ meters}$.
- b) after 3 seconds, its speed is $29.4 \text{ meters per second}$.
- c) during each time interval of 1 second, its speed changes by $9.8 \text{ meters per second}$.
- d) after 2 seconds, the body has fallen $19.6 \text{ meters}$.
- e) None.

16. A rifle is aimed horizontally at the center of a large target 60 m away. The initial speed of the bullet is $240 \text{ m/s}$. What is the distance from the center of the target to the point where the bullet strikes the target.

\[
\begin{align*}
t &= \frac{D}{v} = \frac{1}{2} \cdot 9.8 \cdot \left(\frac{60}{2 \cdot 240}\right)^2 = \frac{1}{2} \cdot 9.8 \cdot 0.31 \text{ m}
\end{align*}
\]
17. A juggler throws two balls to the same height so that one is at the halfway point going up when the other is at the halfway point coming down. Ignore air resistance. At that point:
   a) Their velocities and accelerations are equal in magnitude and direction.
   b) Their velocities are equal but their accelerations are equal in magnitude and opposite in direction.
   c) Their accelerations are equal but their velocities are equal in magnitude and opposite in direction.
   d) Their velocities and accelerations are both equal in magnitude and opposite in direction.
   e) Their velocities are equal to their accelerations.

18. The horizontal surface on which the block slides is frictionless. The speed of the 2.0-kg 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? The spring constant is \( k = 2.0 \text{ kN/m} \).
   
   \( v = \sqrt{u^2 - \frac{ck^2}{m}} = \sqrt{36 - \frac{2 \cdot 0.15}{2}} \)

19. Assuming that the earth is a uniform solid sphere, what is the earth’s kinetic energy of rotation? The earth’s radius is 6400 km, and its mass is \( 6 \times 10^{24} \text{ kg} \). The moment of inertia of a solid sphere is \( \frac{2}{5}MR^2 \). Remember that the earth makes one full turn approximately every 24 hours.
   
   a) \( 1.3 \times 10^{29} \text{ J} \)
   b) \( 1.4 \times 10^{29} \text{ J} \)
   c) \( 3.5 \times 10^{29} \text{ J} \)
   d) \( 5.2 \times 10^{29} \text{ J} \)
   e) \( 2.6 \times 10^{29} \text{ J} \)

20. You have a machine which can accelerate pucks from rest on frictionless ice. In time \( t \) the puck travels a distance \( x \) if a constant force \( F \) is applied. If instead force \( 3F \) is applied, in time \( t \) the distance the puck travels is:
   
   a) \( x \)
   b) \( \frac{3}{2}x \)
   c) \( \frac{9}{2}x \)
   d) \( \frac{9}{2}x \)
   e) \( \frac{9}{2}x \)

21. Which of the following is represented by a vector?
   
   a) wind speed
   b) temperature
   c) acceleration
   d) distance travelled
   e) density

22. A small car has a mass of 1000 kg, and an SUV has a mass of 2000 kg. They both have the same coefficient of kinetic friction with the road when braking. Starting at the same initial velocity, both vehicles brake hard by locking the wheels, and skid to a stop. Which statement is true?
   
   a) The small car travels 1/4 as far as the SUV does before stopping.
   b) The small car travels 1/2 as far as the SUV does before stopping.
   c) The small car and SUV travel the same distance before stopping.
   d) The small car travels two times as far as the SUV does before stopping.
   e) The small car travels four times as far as the SUV does before stopping.

   \[ a = \frac{F}{m} = \frac{\mu mg}{m} = \mu g \]

   \[ a_1 = 9.2 \]
23. A wheel starts from rest and rotates with a constant angular acceleration about a fixed axis. It completes the first revolution 4.0 s after it started. How long after it completes the first revolution will the wheel complete the second revolution?
   a) 1.1 s
   b) 7.8 s
   c) 8.5 s
   d) 9.2 s
   e) 1.7 s

   \[ 2\pi = \frac{1}{2} \alpha t^2 \]
   \[ \alpha = \frac{4\pi}{t^2} \]

24. A projectile is fired at a speed of 400 m/s at an angle of 60° above the horizontal. At the highest point of its trajectory, the projectile is broken into two equal pieces by an internal explosion. Just after the explosion, one of the two pieces is known to be traveling vertically downward at a speed of 300 m/s. The magnitude of the velocity of the other half of the projectile is
   a) 500 m/s
   b) 1.50 km/s
   c) 400 m/s
   d) 710 m/s
   e) 123 m/s

25. A pitcher throws a baseball with a velocity of 27 m/s. After being struck by a bat the ball travels in the opposite direction with a velocity of 40 m/s. If the ball has a mass of 0.11 kg and is in contact with the bat for 3.0 ms, the average force exerted by the bat on the ball is
   a) 0.99 kN
   b) 4.8 kN
   c) 1.5 kN
   d) 7.4 kN
   e) 2.5 kN

   \[ F = \frac{\Delta P}{\Delta t} = \frac{m \Delta v}{\Delta t} = \frac{0.11(27 + 40)}{3 \times 10^{-3}} \]

26. A 2.0-kg object moving with a velocity of 5.0 m/s in the positive x direction strikes and sticks to a 3.0-kg object moving with a speed of 2.0 m/s in the same direction. How much kinetic energy is lost in this collision?
   a) 2.4 J
   b) 9.6 J
   c) 5.4 J
   d) 0.6 J
   e) 6.0 J

   \[ \frac{1}{2} m_1 v_1 + \frac{1}{2} m_2 v_2 = \frac{1}{2} (m_1 v_1^2 + m_2 v_2^2 - (m_1 + m_2) V^2) \]

27. A rock of mass m and a rock of mass 2m are both released from rest at the same height, and feel no air resistance as they fall. Which of these statements is true?
   a) When they reach the ground, the lighter rock has twice the kinetic energy of the heavier rock
   b) Both have the same kinetic energy when they reach the ground
   c) When they reach the ground, the heavier rock has twice the kinetic energy of the lighter one
   d) When they reach the ground, the lighter rock has twice the velocity of the heavier one
   e) Both have the same initial gravitational potential energy

28. A string with negligible mass is wrapped around a cylinder of radius 0.10 m and moment of inertia 2.0 kg-m² which can spin freely about an axis through its center. The string is pulled with a constant force of 5.0 N. The angular acceleration (in rad/s²) of the cylinder is closest to:
   a) 1.0
   b) 100
   c) 0.25
   d) 0.50
   e) 20

   \[ \alpha = \frac{F}{I} = \frac{F L}{I} = \frac{5 \times 0.1}{2} = 0.25 \text{ rad/s}^2 \]
29. A block of mass $M$ is hanging from the middle of a horizontal bar of length $L$ as shown in the figure. One end of the bar is held on the edge of a desk and the other end is held up by a rope vertically. What is the magnitude of the torque exerted by the rope about the edge of the desk? Assume that the mass of the bar is negligible.

- a) $MgL$
- b) $2MgL$
- c) $MgL/2$
- d) $MgL/4$
- e) The answer depends on the length of the rope.

![Diagram of a block hanging from a bar with a rope]

30. A 2.0 kg block is at rest on a frictionless patch of ice on a sidewalk. A 1.0 kg snowball, thrown horizontally with a speed of 6.0 m/s hits and sticks to the block. The coefficient of kinetic friction between the block and the sidewalk is $\mu_k = 0.25$. How far (in m) from the edge of the ice patch does the block come to rest?

- a) 0.20
- b) 1.2
- c) 0.80
- d) 0.60
- e) need to know the size of the ice patch

After collision, $v = \frac{m}{m+m}\cdot v_0 = \frac{1}{3}\cdot v_0 = 2\ m/s$

Then, $\frac{1}{2}(m+m)v^2 = F_f \cdot L = \mu_k (m+m)g \cdot L$

$$L = \frac{v^2}{2\mu_k g} = \frac{4}{2\cdot0.25 \cdot 9.8} = 0.8 \text{ m}$$