1a). A uniform solid sphere has a radius of 21 cm and a mass of 1.9 kg. Its mass density is about:

\[ \rho = \frac{m}{V} = \frac{m}{\frac{4}{3} \pi R^3} = \frac{1.9 \text{ kg}}{\frac{4}{3} \pi (0.21)^3 \text{ m}^3} \]

\[ = 49 \text{ kg/m}^3 \]

2. Which of the above five graphs of position, \( x \), versus time, \( t \), represents the motion of an object moving with a constant nonzero speed?

(1) \[ \]
(2) \[ \]
(3) \[ \]
(4) \[ \]
(5) \[ \]

Only (1) and (3) have the form \( v = \text{const.} \) (slope doesn't change).

Only (1) has nonzero slope.

3a). Two trains are headed toward each other on the same straight track. At \( t = 0 \) the two trains are 200 meters apart and both have a speed of 30 m/s. If one train is traveling at a constant speed and the speed of the other train is increasing at a rate of 10 m/s², when do the two trains collide?

(1) \( t = 2.7 \text{ s} \)  (2) \( t = 3.3 \text{ s} \)  (3) \( t = 1.5 \text{ s} \)  (4) \( t = 6.6 \text{ s} \)  (5) \( t = 5.4 \text{ s} \)

\[ x_1 = 30t + \frac{1}{2} (10)t^2 \]

\[ x_2 = 200 - 30t \]

When \( x_1 = x_2 \)

\[ 30t + 5t^2 = 200 - 30t \]

\[ 5t^2 + 60t - 200 = 0 \]

\[ t = \frac{-60 \pm \sqrt{3600 + 4(5)(200)}}{2(5)} + \text{ root gives } t \approx 2.72 \]
4a). There are two forces on the 5.0 kg box in the overhead view of the figure. If \( \vec{F}_1 \) points in the positive x-direction and if \( |\vec{F}_1| = 10N \), \( |\vec{a}| = 12m/s^2 \), and \( \theta = 30^\circ \), as shown in the figure, what is the magnitude of \( \vec{F}_2 \)?

\[
\begin{align*}
F_{1x} + F_{2x} &= ma_x = -ma \sin \theta = -(6)(12)(0.5) = -30N \\
F_{1x} &= 10N \Rightarrow F_{2x} = -30N - 10N = -40N
\end{align*}
\]

\[
F_{2y} = ma_y = -ma \cos \theta = -(5)(12)(0.866) = -51.9N
\]

\[
|\vec{F}_2| = \sqrt{F_{1x}^2 + F_{2x}^2} = 65.5N
\]

5. The figure shows two blocks with masses \( m_1 \) and \( m_2 \) connected by a cord (of negligible mass) that passes over a frictionless pulley (also of negligible mass). If when released from rest block 2 accelerates upward at \( g/2 \), what is the mass of block 1?

\[
\begin{align*}
\text{(1) } 3m_2 & \quad \text{(2) } 4m_2 & \quad \text{(3) } 6m_2 & \quad \text{(4) } 2m_2 & \quad \text{(5) } 5m_2 \\
\text{Newtons: } & \quad T - m_2g = m_2a = m_2\frac{g}{2} \\
& \quad m_1g - T = m_1a = m_1\frac{g}{2}
\end{align*}
\]

\[
\begin{align*}
T &= \frac{3m_2g}{2} \\
\frac{1}{2}m_1 &= \frac{3}{2}m_2
\end{align*}
\]

\( m_1 = 3m_2 \)

6a. A 1000-kg elevator is rising and its speed is increasing at 3 m/s². The tension in the elevator cable is:
(1) 12800 N  (2) 6800 N  (3) 9800 N  (4) 3000 N  (5) 1000 N

\[ T - mg = ma \]
\[ T = m(a + g) \]
\[ = (10.0)(3.98) \]
\[ = 12800 \text{ N} \]

7. Two blocks with masses \( m \) and \( M \) are pushed along a horizontal frictionless surface by a horizontal applied force \( F \) as shown. The magnitude of the force of either of these blocks on the other is:

(1) \( mF/(m + M) \)  (2) \( mF/M \)  (3) \( mF/(M - m) \)  (4) \( MF/(M + m) \)  (5) \( MF/m \)

\text{Force on combined system:} \quad F = (M + m)a \quad (1)

\text{Force on } m: \quad F_{12} = ma \quad (2)

\text{From (1),} \quad a = \frac{F}{M + m} \quad \Rightarrow \quad F_{12} = \frac{mF}{M + m}
8a. A 10 kg bucket with water is suspended midway between two walls 10 m apart by a rope under tension which passes through the handle of the bucket. Each section of the rope makes an angle of 30° with the horizontal. Find the tension in the rope.

(1) 98 N  (2) 78 N  (3) 72 N  (4) 48 N  (5) 64 N

\[ F_y = 2T \sin \theta - mg = ma = 0 \]
\[ T = \frac{mg}{2 \sin \theta} = \frac{10 \cdot 9.8}{2 \cdot 0.5} = 98 N \]

9. The figure shows three blocks of masses \( m, 2m, \) and \( 3m, \) respectively from the left. These are connected with 2 massless strings, as shown. The middle block is on a frictionless table, and the other two hang over the edge by means of frictionless pulleys. What is the magnitude of the acceleration of the middle block?

(1) \( g/3 \)  (2) \( g \)  (3) \( g/2 \)  (4) \( g/6 \)  (5) \( 2g/3 \)

\[ \begin{align*}
(2T_2 - T_1) &= 2ma \\
3mg - T_2 &= 3ma \\
T_1 - mg &= ma
\end{align*} \]

(1) \( T_2 = T_1 \)  (2) \( T_2 = 3m(a+g) \)  (3) \( T_2 - T_1 = 2ma = 2m(g-2a) \)

10. Identical guns fire identical bullets horizontally at the same speed from the same height above level planes, one on the Earth and one on the Moon. Which of the following three statements is/are true?

I. The horizontal distance traveled by the bullet is greater for the Moon.
II. The flight time is less for the bullet on the Earth.
III. The velocities of the bullets at impact are the same.

(1) I and II only  (2) III only  (3) I and III only  (4) II and III only  (5) I, II, III
The range and time before impact of a projectile depend on \( g \).

For horizontal firing,

\[
\text{time} = \sqrt{\frac{2h}{g}} \quad \text{range} = \frac{v_0}{g} \sqrt{2h/g}
\]

On moon, \( g \) is smaller than on earth, so time and range are longer. \( \Rightarrow \text{III OK} \)

III is wrong because the initial potential energies \( mgh \) for the two cases are different \( \Rightarrow \) final kinetic energies are different \( \Rightarrow \) final velocities are different.

Or, you can say \( v_x \) is the same for both, \( +v_y \) at impact:

\[
v_y = -gt = -g \sqrt{\frac{2h}{g}}
\]

will be large on the earth.