1. The position of a particle moving along the $x$ axis is given by 
   \[ x = (21 + 22t - 6.0t^2) \, \text{m} \], where $t$ is in s. What is the average velocity during the 
time interval $t = 1.0 \, \text{s}$ to $t = 3.0 \, \text{s}$?
   a. $-6.0 \, \text{m/s}$ 
   b. $-4.0 \, \text{m/s}$ 
   c. $-2.0 \, \text{m/s}$ 
   d. $-8.0 \, \text{m/s}$ 
   e. $8.0 \, \text{m/s}$

2. The three forces shown act on a particle. What is the magnitude of the resultant 
of these three forces?
   
   ![Diagram of forces](https://via.placeholder.com/150)
   
   a. $27.0 \, \text{N}$ 
   b. $33.2 \, \text{N}$ 
   c. $36.3 \, \text{N}$ 
   d. $\boxed{23.8} \, \text{N}$ 
   e. $105 \, \text{N}$
3. A particle leaves the origin with a velocity of 7.2 m/s in the positive y direction and moves in the xy plane with a constant acceleration of \((3.0 i - 2.0 j) \text{ m/s}^2\). At the instant the particle moves back across the x axis \((y = 0)\), what is the value of its x coordinate?

a. 65 m  
b. 91 m  
c. 54 m  
d. \textbf{78 m}  
e. 86 m

4. The equation for the change of position of a train starting at \(x = 0 \text{ m}\) is given by \(x = \frac{1}{2} at^2 + bt^3\). The dimensions of \(b\) are

a. \(T^{-3}\)  
b. \(LT^{-3}\)  
c. \(LT^{-2}\)  
d. \(LT^{-1}\)  
e. \(L^3T^{-1}\)

5. Which of the following products of ratios gives the conversion factors to convert meters per second \(\left(\frac{\text{m}}{\text{s}}\right)\) to miles per hour \(\left(\frac{\text{mi}}{\text{h}}\right)\)?

a. \[
\frac{5280 \text{ ft}}{\text{mi}} \cdot \frac{12 \text{ in}}{\text{ft}} \cdot \frac{2.54 \text{ cm}}{1 \text{ in}} \cdot \frac{100 \text{ cm}}{1 \text{ m}} \cdot \frac{3600 \text{ s}}{1 \text{ h}}
\]

b. \[
\frac{5280 \text{ ft}}{\text{mi}} \cdot \frac{12 \text{ in}}{\text{ft}} \cdot \frac{1 \text{ in}}{1 \text{ m}} \cdot \frac{100 \text{ cm}}{1 \text{ m}} \cdot \frac{3600 \text{ s}}{1 \text{ h}}
\]

c. \[
\frac{5280 \text{ ft}}{\text{mi}} \cdot \frac{12 \text{ in}}{\text{ft}} \cdot \frac{2.54 \text{ cm}}{1 \text{ m}} \cdot \frac{100 \text{ cm}}{1 \text{ h}}
\]

d. \[
\frac{1 \text{ mi}}{5280 \text{ ft}} \cdot \frac{1 \text{ in}}{1 \text{ ft}} \cdot \frac{1 \text{ in}}{100 \text{ cm}} \cdot \frac{3600 \text{ s}}{1 \text{ h}}
\]

e. \[
\frac{1 \text{ mi}}{5280 \text{ ft}} \cdot \frac{1 \text{ in}}{1 \text{ ft}} \cdot \frac{2.54 \text{ cm}}{1 \text{ in}} \cdot \frac{100 \text{ cm}}{1 \text{ h}}
\]
6. A rocket, initially at rest, is fired vertically with an upward acceleration of 10 m/s\(^2\). At an altitude of 0.50 km, the engine of the rocket cuts off. What is the maximum altitude it achieves?
   a. 1.9 km  
   b. 1.3 km  
   c. 1.6 km  
   d. 1.0 km  
   e. 2.1 km

7. A race car moving with a constant speed of 60 m/s completes one lap around a circular track in 50 s. What is the magnitude of the acceleration of the race car?
   a. 8.8 m/s\(^2\)  
   b. 7.5 m/s\(^2\)  
   c. 9.4 m/s\(^2\)  
   d. 6.3 m/s\(^2\)  
   e. 5.3 m/s\(^2\)

8. A rifle is aimed horizontally at the center of a large target 60 m away. The initial speed of the bullet is 240 m/s. What is the distance from the center of the target to the point where the bullet strikes the target?
   a. 48 cm  
   b. 17 cm  
   c. **31 cm**  
   d. 69 cm  
   e. 52 cm

9. A bullet is fired through a board, 14.0 cm thick, with its line of motion perpendicular to the face of the board. If it enters with a speed of 450 m/s and emerges with a speed of 220 m/s, what is the bullet’s acceleration as it passes through the board?
   a. -500 km/s\(^2\)  
   b. -550 km/s\(^2\)  
   c. -360 km/s\(^2\)  
   d. -520 km/s\(^2\)  
   e. -275 km/s\(^2\)
10. A car travels in a due northerly direction at a speed of 55 km/h. The traces of rain on the side windows of the car make an angle of 60 degrees with respect to the horizontal. If the rain is falling vertically with respect to the earth, what is the speed of the rain with respect to the earth?

a. 48 km/h  
b. 95 km/h  
c. 58 km/h  
d. 32 km/h  
e. 80 km/h

11. A baseball is hit at ground level. The ball is observed to reach its maximum height above ground level 3.0 s after being hit. And 2.5 s after reaching this maximum height, the ball is observed to barely clear a fence that is 97.5 m from where it was hit. How high is the fence?

a. 8.2 m  
b. 15.8 m  
c. 13.4 m  
d. 11.0 m  
e. 4.9 m

12. Two identical balls are at rest and side by side at the top of a hill. You let one ball, A, start rolling down the hill. A little later you start the second ball, B, down the hill by giving it a shove. The second ball rolls down the hill along a line parallel to the path of the first ball and passes it. At the instant ball B passes ball A:

a. it has the same position and the same velocity as A.  
b. it has the same position and the same acceleration as A.  
c. it has the same velocity and the same acceleration as A.  
d. it has the same displacement and the same velocity as A.  
e. it has the same position, displacement and velocity as A.

13. Two children start at one end of a street, the origin, run to the other end, then head back. On the way back Joan is ahead of Mike. Which statement is correct about the distances run and the displacements from the origin?

a. Joan has run a greater distance and her displacement is greater than Mike’s.  
b. Mike has run a greater distance and his displacement is greater than Joan’s.  
c. Joan has run a greater distance, but her displacement is less than Mike’s.  
d. Mike has run a greater distance, but his displacement is less than Joan’s.  
e. Mike has run a shorter distance, and his displacement is less than Joan’s.
14. A student in the front of a school bus tosses a ball to another student in the back of the bus while the bus is moving forward at constant velocity. The speed 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. is greater than that observed inside the bus.
   d. may be either greater or smaller than that observed inside the bus.
   e. may be either greater, smaller, or equal to that observed inside the bus.

15. The vector \( \mathbf{r} \) indicates the instantaneous displacement of a projectile from the origin. At the instant when the projectile is at \( \mathbf{r} \), its velocity and acceleration vectors are \( \mathbf{v} \) and \( \mathbf{a} \). Which statement is correct?
   a. \( \mathbf{v} \) is always perpendicular to \( \mathbf{r} \).
   b. \( \mathbf{a} \) is always perpendicular to \( \mathbf{r} \).
   c. \( \mathbf{a} \) is always perpendicular to \( \mathbf{v} \).
   d. \( \mathbf{a} \) is always perpendicular to \( \mathbf{v}_x \).
   e. \( \mathbf{a} \) is always perpendicular to \( \mathbf{v}_y \).

16. One mole of the carbon-12 isotope contains \( 6.022 \times 10^{23} \) atoms. What volume in \( \text{m}^3 \) would be needed to store one mole of cube-shaped children’s blocks 2.00 cm long on each side?
   a. \( 4.8 \times 10^{18} \)
   b. \( 1.2 \times 10^{22} \)
   c. \( 6.0 \times 10^{23} \)
   d. \( 1.2 \times 10^{24} \)
   e. \( 4.8 \times 10^{24} \)