

# Midterm 1

Step-by-step solutions with brief concept explanations

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## Question 1

**Question:** Two displacement vectors of 5 m due east and 12 m due north are added. What is the magnitude of their resultant displacement?

- A. 15 m
- B. 8 m
- C. 169 m
- D. 13 m
- E. 17 m

**Solution:**

1. The vectors are perpendicular, so use Pythagoras:

$$R = \sqrt{5^2 + 12^2} = \sqrt{25 + 144} = \sqrt{169} = 13 \text{ m}$$

2. **Answer: 13 m.**

*Concept note:* Perpendicular vector addition forms a right triangle.

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## Question 2

**Question:** An object is dropped from a height of 45 m. How long does it take to reach the ground? (Assume  $g = 9.8 \text{ m/s}^2$ .)

- A. 2.8 s
- B. 3.8 s
- C. 3.5 s
- D. 3.2 s
- E. 3.0 s

**Solution:**

1. For free fall from rest:  $h = \frac{1}{2}gt^2$ .

2. Solve for time:

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \cdot 45}{9.8}} = \sqrt{9.1837} \approx 3.03 \text{ s}$$

3. Closest option is **3.0 s**.

*Concept note:* When an object is dropped, initial velocity is zero.

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### Question 3

**Question:** A cyclist covers 15 km in 50 minutes. What is the cyclist's average speed in m/s?

- A. 0.30 m/s
- B. 5.0 m/s
- C. 5.5 m/s
- D. 6.0 m/s
- E. 4.5 m/s

**Solution:**

1. Convert units: 15 km = 15000 m and 50 min = 3000 s.
2. Average speed:

$$v_{\text{avg}} = \frac{d}{t} = \frac{15000}{3000} = 5.0 \text{ m/s}$$

3. **Answer: 5.0 m/s.**

*Concept note:* Always convert to SI units before calculating.

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### Question 4

**Question:** A car travels 100 m under uniform acceleration. If its final velocity is 30 m/s and the acceleration is 3 m/s<sup>2</sup>, what was its initial velocity?

- A. 18.6 m/s
- B. 16.2 m/s
- C. 17.3 m/s
- D. 20.0 m/s

E. 15.0 m/s

**Solution:**

1. Use  $v^2 = u^2 + 2as$ .

2. Substitute:

$$30^2 = u^2 + 2(3)(100) \Rightarrow 900 = u^2 + 600$$

3. So

$$u^2 = 300, \quad u = \sqrt{300} \approx 17.32 \text{ m/s}$$

4. **Answer: 17.3 m/s.**

*Concept note:* This equation avoids needing time when acceleration is constant.

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## Question 5

**Question:** A train decelerates from 30 m/s to 10 m/s in 10 seconds. What is its acceleration?

A. -3 m/s<sup>2</sup>

B. 2 m/s<sup>2</sup>

C. -2 m/s<sup>2</sup>

D. -1 m/s<sup>2</sup>

E. 3 m/s<sup>2</sup>

**Solution:**

1. Use  $a = \frac{v-u}{t}$ :

$$a = \frac{10 - 30}{10} = \frac{-20}{10} = -2 \text{ m/s}^2$$

2. **Answer: -2 m/s<sup>2</sup>.**

*Concept note:* Negative acceleration means velocity is decreasing in the chosen positive direction.

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## Question 6

**Question:** A gun shoots a bullet vertically up, the acceleration on the bullet is:

- A. Dependent on mass.
- B. Zero.
- C. Constant downward.
- D. Increasing with time.
- E. upwards at  $10\text{m/s}^2$

**Solution:**

1. Ignoring air resistance, only gravity acts after release.
2. Gravity provides constant downward acceleration  $g$ .
3. **Answer: Constant downward.**

*Concept note:* Free-fall acceleration near Earth is approximately constant and downward.

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## Question 7

**Question:** When a ball is thrown straight up, the velocity at the topmost point of its trajectory is:

- A. Equal to initial velocity.
- B. Negative.
- C. Zero.
- D. Maximum.
- E. Equal to acceleration.

**Solution:**

1. At the highest point, the ball changes direction.
2. Instantaneous vertical velocity there is zero.
3. **Answer: Zero.**

*Concept note:* Velocity can be zero at an instant while acceleration is still nonzero.

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## Question 8

**Question:** A vector has Cartesian components  $(-8.0, 6.0)$  m. Express it in polar form (magnitude and angle measured counterclockwise from the positive x-axis).

- A. -2 m,  $126.9^\circ$
- B. 14 m,  $53.1^\circ$
- C. 14 m,  $153.1^\circ$
- D. 10 m,  $143.1^\circ$
- E. 10 m,  $36.9^\circ$

**Solution:**

1. Magnitude:

$$|\vec{v}| = \sqrt{(-8)^2 + 6^2} = \sqrt{64 + 36} = 10 \text{ m}$$

2. Reference angle:

$$\tan \theta_r = \frac{6}{8} \Rightarrow \theta_r \approx 36.9^\circ$$

3. Vector is in Quadrant II ( $x < 0, y > 0$ ), so

$$\theta = 180^\circ - 36.9^\circ = 143.1^\circ$$

4. **Answer: 10 m,  $143.1^\circ$ .**

*Concept note:* Use signs of components to choose the correct quadrant for angle.

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## Question 9

**Question:** Which of the following is a vector quantity?

- A. Speed
- B. Distance
- C. Time
- D. Velocity
- E. Mass

**Solution:**

1. A vector has both magnitude and direction.
2. Among the options, only velocity includes direction.
3. **Answer: Velocity.**

*Concept note:* Speed is scalar; velocity is vector.

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## Question 10

**Question:** An object is slowing down. This means:

- A. Its velocity is always negative
- B. Its acceleration is always negative
- C. Its velocity and acceleration are in opposite directions
- D. Its velocity and acceleration are in the same direction
- E. Its acceleration is zero

**Solution:**

1. Speed decreases when acceleration acts opposite to the velocity direction.
2. This is true regardless of sign convention.
3. **Answer: Its velocity and acceleration are in opposite directions.**

*Concept note:* Negative acceleration does not always mean slowing down; direction matters.

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## Question 11

**Question:** If an object moves with constant velocity, its acceleration is:

- A. Increasing
- B. Decreasing
- C. Zero
- D. Constant but non-zero
- E. Equal to the velocity

**Solution:**

1. Constant velocity means no change in speed and no change in direction.
2. Therefore  $\Delta\vec{v} = 0$ , so acceleration is zero.
3. **Answer: Zero.**

*Concept note:* Acceleration measures change in velocity, not velocity itself.