Experimental Physics

Problem Set 1

One-Dimensional Motion & Vectors

30 Multiple-Choice Questions

Section 1 (Conceptual) One-Dimensional Motion

Questions 1–10

1. Displacement is best defined as:

   A) The total length of the path travelled
   B) The change in an object's position from start to finish
   C) Speed multiplied by time
   D) Distance divided by time
   E) The rate of change of velocity

2. The slope of a velocity-time (v vs. t) graph represents:

   A) Position
   B) Distance
   C) Displacement
   D) Acceleration
   E) Momentum

3. An object moves at *constant* velocity. Its acceleration is:

   A) Increasing over time
   B) Decreasing over time
   C) Zero
   D) Constant but non-zero
   E) Equal in magnitude to the velocity

4. On a position-time (x vs. t) graph, the slope of the line represents:

   A) Acceleration
   B) Distance
   C) Velocity
   D) Force

E) Displacement

5. On a velocity-time (v vs. t) graph, the *area* between the curve and the time axis represents:

   A) Acceleration
   B) Displacement
   C) Average speed
   D) Instantaneous velocity
   E) Force

6. An object is *slowing down*. Which statement must be true?

   A) Its acceleration is zero.
   B) Its velocity is negative.
   C) Its acceleration is negative.
   D) Its velocity and acceleration point in opposite directions.
   E) It is in free fall.

7. A ball is thrown straight upward. At the very top of its path, its velocity is:

   A) 9.8 m/s upward
   B) 9.8 m/s downward
   C) Zero
   D) Equal to its launch speed
   E) Constant

8. The same ball is at the very top of its path. At that instant, its acceleration is:

   A) Zero, because the velocity is zero
   B) 9.8 m/s^2 downward
   C) 9.8 m/s^2 upward
   D) Equal to its launch speed divided by time
   E) Undefined

9. A car drives 60 km due East, then turns and drives 60 km due West, returning to its starting point. Its total *displacement* is:

   A) 120 km East
   B) 120 km West
   C) 60 km
   D) 0 km
   E) It depends on the speed of the car

10. Consider the statement: "Negative acceleration always means an object is slowing down." This statement is:

    A) True in all situations
    B) False — an object with negative acceleration and negative velocity is *speeding up*
    C) True, but only when the object moves in the positive direction
    D) True, because deceleration is always negative
    E) False — negative acceleration means the object is at rest

Section 2 (Numerical) One-Dimensional Motion

Questions 11–20 Use $g = 10\ m/s^2$ where needed.

11. A cyclist covers 120 m in 6 s. What is the average speed?

    A) 6 m/s
    B) 12 m/s
    C) 20 m/s
    D) 30 m/s
    E) 720 m/s

12. A runner starts from rest and accelerates uniformly at 3 m/s^2 for 4 s. What is the final speed?

    A) 3 m/s
    B) 7 m/s
    C) 12 m/s
    D) 16 m/s
    E) 24 m/s

13. A car accelerates from rest to 24 m/s in 8 s. What is its average acceleration?

    A) 2 m/s^2
    B) 3 m/s^2
    C) 8 m/s^2
    D) 24 m/s^2
    E) 192 m/s^2

14. An object is dropped from rest. How fast is it moving after 4 s?

    A) 4 m/s
    B) 10 m/s
    C) 20 m/s
    D) 40 m/s
    E) 80 m/s

15. A car moving at 15 m/s accelerates at 2 m/s^2 for 5 s. What is its final velocity?

    A) 17 m/s
    B) 20 m/s
    C) 25 m/s
    D) 30 m/s
    E) 35 m/s

16. A stone is dropped from rest. How far does it fall in 3 s?

    A) 30 m
    B) 45 m

C) 60 m
D) 90 m
E) 100 m

17. A car slows from 30 m/s to rest in 6 s. What is its acceleration?

A) $+5\ \text{m/s}^2$
B) $-5\ \text{m/s}^2$
C) $-6\ \text{m/s}^2$
D) $-30\ \text{m/s}^2$
E) $+6\ \text{m/s}^2$

18. A car starts from rest and travels 50 m with a constant acceleration of $4\ \text{m/s}^2$. What is the car's speed at the end of those 50 m?

A) 10 m/s
B) 14 m/s
C) 20 m/s
D) 25 m/s
E) 40 m/s

19. A ball is thrown straight upward with an initial speed of 15 m/s. How long does it take to reach its maximum height?

A) 1 s
B) 1.5 s
C) 2 s
D) 3 s
E) 15 s

20. A car travels 30 km in the first hour and 50 km in the second hour. What is its average speed over the entire trip?

A) 30 km/h
B) 40 km/h
C) 50 km/h
D) 80 km/h
E) 20 km/h

Section 3 Vectors

Questions 21–30

21. Which of the following is a *vector* quantity?

    A) Temperature
    B) Mass
    C) Time
    D) Force
    E) Volume

22. Can the magnitude of a vector be negative?

    A) Yes, if the vector points in a negative direction
    B) Yes, if its components are negative
    C) No — magnitude is always a non-negative number
    D) Only in three-dimensional space
    E) Yes, if it represents a quantity like a decrease

23. A book is slid once around the entire perimeter of a rectangular table, ending exactly where it started. The book's total *displacement* is:

    A) Equal to the perimeter of the table
    B) Equal to the length of the longest side
    C) Half the perimeter
    D) Equal to the diagonal of the table
    E) Zero

24. A vector has components $A_x = -4$ m and $A_y = -3$ m. In which quadrant of the xy-plane does this vector lie?

    A) First quadrant (both components positive)
    B) Second quadrant (x negative, y positive)
    C) Third quadrant (both components negative)
    D) Fourth quadrant (x positive, y negative)
    E) It cannot be placed in any single quadrant

25. What is the magnitude of the vector $\vec{A} = (3\hat{i} + 4\hat{j})$ m?

    A) 1 m
    B) 3.5 m
    C) 5 m
    D) 7 m
    E) 25 m

26. Vector $\vec{A} = 7\hat{i} + 2\hat{j}$ and vector $\vec{B} = 3\hat{i} + 5\hat{j}$. What is $\vec{A} - \vec{B}$?

    A) $4\hat{i} - 3\hat{j}$

B) $10\hat{i} + 7\hat{j}$
C) $-4\hat{i} + 3\hat{j}$
D) $4\hat{i} + 3\hat{j}$
E) $4\hat{i} + 7\hat{j}$

27. A person walks 3 km due East, then 4 km due North. What is the *magnitude* of the total displacement?

A) 1 km
B) 3.5 km
C) 5 km
D) 7 km
E) 25 km

28. A vector has magnitude 20 m and is directed at 30° above the horizontal. What is its *horizontal* component?

A) 10 m
B) 17.3 m
C) 20 m
D) 23.1 m
E) 40 m

29. Vector $\vec{A} = 2\hat{i} + 5\hat{j}$ and $\vec{B} = 4\hat{i} - 3\hat{j}$. What is $\vec{A} + \vec{B}$?

A) $6\hat{i} + 2\hat{j}$
B) $6\hat{i} - 2\hat{j}$
C) $2\hat{i} + 2\hat{j}$
D) $-2\hat{i} + 8\hat{j}$
E) $6\hat{i} + 8\hat{j}$

30. The magnitudes of vectors $\vec{A}$ and $\vec{B}$ are 5 m and 12 m, respectively. Which of the following could be a possible magnitude for $\vec{A} + \vec{B}$?

A) 0 m
B) 4 m
C) 10 m
D) 18 m
E) 25 m

Answers & Solutions

Quick Answer Key

Q	Ans	Sec	Q	Ans	Sec	Q	Ans	Sec
1	B	1	11	C	2	21	D	3
2	D	1	12	C	2	22	C	3
3	C	1	13	B	2	23	E	3
4	C	1	14	D	2	24	C	3
5	B	1	15	C	2	25	C	3
6	D	1	16	B	2	26	A	3
7	C	1	17	B	2	27	C	3
8	B	1	18	C	2	28	B	3
9	D	1	19	B	2	29	A	3
10	B	1	20	B	2	30	C	3

Section 1 Solutions: Conceptual 1D Motion

1. **Answer B.** Displacement is the *change in position* ($\Delta x = x_f - x_i$), a vector from the starting point to the ending point. Distance is the actual path length and is always $\geq |\Delta x|$.

2. **Answer D.** The slope of any graph is "rise over run." For a v–t graph the rise is Δv and the run is Δt, so the slope equals $\Delta v/\Delta t$, which is the definition of acceleration.

3. **Answer C.** Acceleration is the rate of change of velocity: $a = \Delta v/\Delta t$. If velocity is constant, $\Delta v = 0$, so $a = 0$.

4. **Answer C.** The slope of an x–t graph is $\Delta x/\Delta t$, which is the definition of (average) velocity.

5. **Answer B.** The area under a v–t graph equals $\int v\,dt$, which is displacement. (Geometrically, area = base × height = time × velocity = displacement.)

6. **Answer D.** "Slowing down" means the *speed is decreasing*, which happens when the velocity and acceleration vectors point in *opposite* directions — regardless of their individual signs.

7. **Answer C.** At the top of the trajectory the ball momentarily stops before reversing direction, so $v = 0$. This is often a surprise: zero velocity does *not* mean zero acceleration.

8. **Answer B.** Gravity acts continuously and does not "switch off" at the top. The acceleration is $g \approx 9.8$ m/s^2 directed downward throughout the entire flight.

9. **Answer D.** The car ends exactly where it started, so the net change in position is zero. Total distance is $60 + 60 = 120$ km, but displacement = 0 km.

10. **Answer B.** Consider a ball falling downward: if we take downward as negative, the ball has a negative velocity *and* a negative acceleration ($-g$), so it is *speeding up*, not slowing down. The sign of acceleration alone does not tell you whether the object is decelerating.

Section 2 Solutions: Numerical 1D Motion

11. **Answer C.** $v_{\text{avg}} = d/t = 120 \text{ m}/6 \text{ s} = 20 \text{ m/s}$.

12. **Answer C.** $v = v_0 + at = 0 + (3)(4) = 12 \text{ m/s}$.

13. **Answer B.** $a = \Delta v/\Delta t = (24 - 0)/8 = 3 \text{ m/s}^2$.

14. **Answer D.** Free fall from rest: $v = gt = (10)(4) = 40 \text{ m/s}$.

15. **Answer C.** $v = v_0 + at = 15 + (2)(5) = 15 + 10 = 25 \text{ m/s}$.

16. **Answer B.** $y = \frac{1}{2}gt^2 = \frac{1}{2}(10)(3^2) = 5 \times 9 = 45 \text{ m}$.

17. **Answer B.** $a = (v_f - v_i)/t = (0 - 30)/6 = -5 \text{ m/s}^2$. The negative sign indicates the acceleration opposes the motion.

18. **Answer C.** Use $v^2 = v_0^2 + 2ax = 0 + 2(4)(50) = 400$, so $v = \sqrt{400} = 20 \text{ m/s}$. (Note: time was not given, so this kinematic equation — which does not involve t — is the right tool.)

19. **Answer B.** At maximum height $v = 0$. Using $v = v_0 - gt$: $0 = 15 - (10)t \Rightarrow t = 1.5 \text{ s}$.

20. **Answer B.** Total distance $= 30 + 50 = 80$ km. Total time $= 1 + 1 = 2$ h.
Average speed $= 80/2 = 40$ km/h.

Section 3 Solutions: Vectors

21. **Answer D.** Force has both magnitude (how strong) and direction (which way), making it a vector. Temperature, mass, time, and volume are scalars.

22. **Answer C.** Magnitude is defined as $|\vec{A}| = \sqrt{A_x^2 + A_y^2}$, which is a square root and therefore always ≥ 0. The *components* can be negative, but the magnitude cannot.

23. **Answer E.** Displacement depends only on the start and end points. Because the book returns to its starting position, $\Delta\vec{r} = \vec{0}$, regardless of the path length.

24. **Answer C.** Both components are negative (-4 m and -3 m), which places the vector in the *third* quadrant, where $x < 0$ and $y < 0$.

25. **Answer C.** $|\vec{A}| = \sqrt{3^2 + 4^2} = \sqrt{9 + 16} = \sqrt{25} = 5 \text{ m}$. (This is a 3-4-5 right triangle.)

26. **Answer A.** Subtract component by component: $\vec{A} - \vec{B} = (7-3)\hat{i} + (2-5)\hat{j} = 4\hat{i} + (-3)\hat{j} = 4\hat{i} - 3\hat{j}$. Distractor C is $\vec{B} - \vec{A}$ (sign reversed), distractor D drops the sign on the $\hat{j}$ component.

27. **Answer C.** East and North are perpendicular, giving a 3-4-5 right triangle: $|\vec{d}| = \sqrt{3^2 + 4^2} = 5$ km.

28. **Answer B.** The horizontal component of a vector of magnitude r at angle θ above the horizontal is $r\cos\theta = 20\cos 30^\circ = 20 \times 0.866 \approx 17.3$ m.

29. **Answer A.** Add component by component: $(2+4)\hat{i} + (5+(-3))\hat{j} = 6\hat{i} + 2\hat{j}$.

30. **Answer C.** The magnitude of a vector sum must lie between $||\vec{A}| - |\vec{B}||$ and $|\vec{A}| + |\vec{B}|$, i.e. between $|12-5| = 7$ m and $12+5 = 17$ m. Only 10 m falls in the range $[7, 17]$. Choices A (0), B (4), D (18), and E (25) are all outside this range and are therefore impossible.