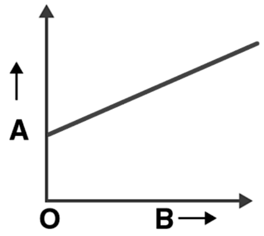
SECTION B: Multiple Choice Questions - II

Question: The variation of quantity A with quantity B, plotted in figure describes the motion of a particle in a straight line.



Answer: (a), (c), and (d)

The linear relationship A ∝ B suggests:

(a) B may represent time: ✓ If B = t, then A = constant × t

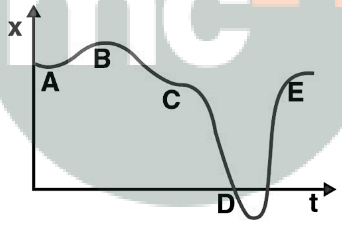
(b) A is velocity if motion is uniform: ✗ For uniform motion, velocity is constant, not linearly increasing with time

(c) A is displacement if motion is uniform: ✓ For uniform motion: $x = x_0 + vt$ (linear relationship)

(d) A is velocity if motion is uniformly accelerated: ✓

For constant acceleration: v = u + at (linear relationship)

Question: A graph of x versus t is shown in the figure. Choose correct alternatives from below.



Answer: (a), (c), and (e)

(a) Particle released from rest at t=0: ✓ At point A, the curve starts with zero slope (zero velocity)

(b) At B, acceleration a>0: ✗

At maximum (point B), slope is zero and curvature is negative, so a<0

(c) At C, velocity and acceleration vanish: ✓ Point C is an inflection point where both first and second derivatives are zero

(d) Average velocity for motion A to D is positive: ✗ Since $x_D < x_A$, net displacement is negative

(e) Speed at D exceeds that at E: ✓ The slope magnitude at D is greater than at E

Question: For the one-dimensional motion described by x = t - sin t

Answer: (a) and (d)

Given: x(t) = t - sin t

Finding velocity: $v(t) = dx/dt = 1 - \cos t$
Finding acceleration: $a(t) = dv/dt = \sin t$
(a) x(t)>0 for all t>0: ✓ Since $\sin t \le 1$, we have $t - \sin t \ge t - 1 > 0$ for $t > 1$
(b) v(t)>0 for all t>0: ✗
$v(t) = 1 - \cos t = 0$ when $\cos t = 1$ (at $t = 2\pi n$)
(c) a(t)>0 for all t>0: ✗ $a(t) = \sin t$ can be negative
(d) v(t) lies between 0 and 2: ✓ Since $-1 \le \cos t \le 1$, we have $0 \le 1 - \cos t \le 2$
Question: A spring with one end attached to a mass and the other to a rigid support is stretched and released.
Answer: (a) and (c)
For simple harmonic motion: $F = -kx$, so $a = -(k/m)x$
(a) Magnitude of acceleration when just released is maximum: ✓ $|a| = k|x|/m$ is maximum when displacement $|x|$ is maximum (at release point)
(b) Magnitude of acceleration at equilibrium is maximum: ✗ At equilibrium, $x = 0$, so $a = 0$
(c) Speed is maximum when mass is at equilibrium position: ✓
By energy conservation, kinetic energy (and hence speed) is maximum when potential energy is minimum (at equilibrium)
(d) Magnitude of displacement is maximum whenever speed is minimum: ✗ Speed is minimum (zero) at maximum displacement, but displacement can be maximum in either direction
Question: A ball bounces elastically with speed 1 m/s between walls of a railway compartment of size 10 m in a direction perpendicular to walls. The train is moving at constant velocity of 10 m/s parallel to the direction of motion of the ball. As seen from the ground:
Answer: (b), (c), and (d)
Ball's motion from ground frame:

- Horizontal component: constant 10 m/s (train's velocity)
- Vertical component: alternates between ±1 m/s

(a) Direction of motion changes every 10 seconds: ✗ Time between wall collisions = 10m ÷ 1m/s = 10s, but direction changes in velocity direction, not motion direction
(b) Speed changes every 10 seconds: ✓ Speed = $\sqrt{10^2 + 1^2} = \sqrt{101}$ m/s when moving toward one wall Speed = $\sqrt{10^2 + (-1)^2} = \sqrt{101}$ m/s when moving toward other wall The speed magnitude remains constant, but velocity direction changes
(c) Average speed over any 20-second interval is fixed: ✓
In 20 seconds, ball completes one full cycle, so average speed is constant
(d) Acceleration is the same as from the train: ✓ Only forces are from wall collisions, which are perpendicular to train's motion