CUBE NOTES

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Kinematics: Average Velocity & Average Speed

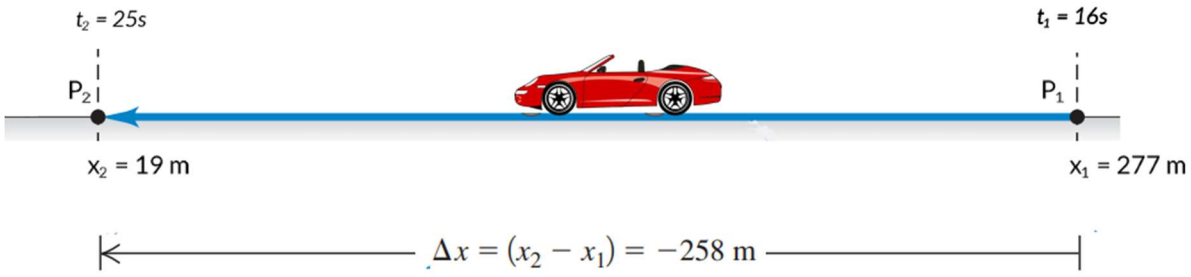
Key Idea

Average Velocity: The average velocity v_{avg} between two points is the displacement divided by the time for displacement.

Since the numerator in the equation is a vector, velocity also becomes a vector quantity. If the two points are (t_1, x_1) and (t_2, x_2) on a graph. Then-

$$v_{avg} = \frac{x_2 - x_1}{t_2 - t_1}$$

Consider the diagram below. The average velocity will be calculated as below-



$$v_{avg} = (x_2 - x_1)/(t_2 - t_1) = (19\,m - 277\,m) / (25\,s - 16\,s) = -258\,m / 9s = -29\,\frac{m}{s}$$

Average Speed: Average speed is a scalar quantity that measures "how fast" an object is moving over a given time. It is different from average velocity because it considers the total distance covered, not just the displacement.

$$S_{avg} = \frac{distance}{time}$$

Key differences Velocity & Speed

S.N.	Difference	Average Velocity	Average Speed
1.	Direction of Motion	The direction of average velocity is always the same as the direction of displacement.	Average speed does not consider direction and is always positive or zero.
2.	Magnitude in a Given Interval	The magnitude of average velocity in a time interval may differ from its average speed in that interval.	Average speed is always equal to or greater than the magnitude of average velocity.
3.	Impact of Constant Motion	If the velocity is constant, the speed must also be constant.	If the speed is constant, the velocity may or may not be constant. (Uniform circular motion is an example where speed is constant, but velocity varies due to changing direction.)
4.	Average Value	Average velocity can be zero if the total displacement is zero (object returns to its initial position).	For a moving body, the average speed must be greater than zero
5.	Multiple Values	The average velocity of an object between two points has a single value for a given time interval.	The average speed can have several values depending on the path taken between the two points, as it considers total distance travelled. (Taking different routes may result in different average speeds.)
6.	Varying Velocity vs. Speed	A particle can have varying velocity without having varying speed. (Uniform circular motion is an example because the velocity changes due to direction changes, but speed remains constant.)	If speed varies, there must be changes in the magnitude of velocity.

List of Equations and Formulas

Concept	Equation	Description
Average Velocity	$Vavg = \frac{x_2 - x_1}{t_2 - t_1}$	Average velocity is the rate of change of an object's displacement over a specific time interval.
Average Speed	$S_{avg} = \frac{Total\ distance\ travelled}{Time\ taken}$	Average speed is the rate of change of an object's total distance covered over a specific time interval.
Interpretation of Slope	$Slope = \frac{x_2 - x_1}{t_2 - t_1}$	The slope of the line connecting two points on a *position-time graph* represents the average velocity between those points.
Relationship between Velocity and Slope	V_{avg} = Slope between two points on a position-time graph	The average velocity between two points on a position-time graph can be visually determined by observing the slope of the connecting line.
Conversion of Slope to Velocity	$v = Tan(\theta)$	In a position-time graph, the slope of the line connecting two points can be converted to velocity by taking the tangent of the angle (θ) the line makes with the *positive x-axis*.

Tips & Tricks (Speed solving problems)

1. Since the displacement (numerator) is a vector in the formula $v_{avg} = \frac{x_2 - x_1}{t_2 - t_1}$, velocity also becomes a vector quantity. T*he Direction of velocity vector will always be the same as that of the displacement vector* $x_2 - x_1$ (the time is just a scalar)
2. *Average Velocity and Slope:* Remember that the average velocity between two points on a position-time graph is equal to the slope of the line connecting those points. Use this shortcut when calculating average velocity from a graph.
3. To find the average velocity between two points using the graph, take Tan of the angle the line makes with the *+X axis*.
4. Positive slope on a position time graph indicates positive average velocity (forward motion), negative slope indicates negative average velocity (backward motion), and a flat line represents zero average velocity (rest).

5. Assign Positive and Negative Signs*:* Be consistent with assigning positive and negative signs for positions and displacements. Stick to one direction as positive throughout the problem.
6. Pay Attention to Signs*:* Double-check signs when calculating displacement or velocity
7. Check for reasonableness*:* After obtaining the result, check if it makes sense in the context of the problem. Does the direction match your expectations? Is the magnitude reasonable based on the given data?