Vector Kinematics - Example Problems (Write On)

Physics 12

Vector Kinematics in 2 Dimensions

4 basic Kinematic Equations:

\[ a = \frac{\Delta v}{\Delta t} \]

\[ v = v_0 + at \]

\[ v^2 = v_0^2 + 2ad \]

\[ \Delta s = v_0 t + \frac{1}{2} at^2 \]

\[ \frac{d}{t^2} = \frac{v_0 t + \frac{1}{2} at^2}{t^2} \]

\[ \Delta s = v_0 t + \frac{1}{2} at^2 \]

Most common kinematic problems can be solved by applying one or more of these equations.

For example:

1) A car is travelling at a constant speed of 12 m/s for 12 s. How far does it move during this time period?

\[ d = vt \]

\[ d = 12 \times 12 = 144 \text{ m} = 140 \text{ m} \]

2) The car slows down to 6.0 m/s in a time of 5.0 s to enter a curve.

   a. What is the acceleration of the car during this change in speed?

\[ a = \frac{v - v_0}{t} \]

\[ a = \frac{6.0 - 12}{5.0} = -6.0 \text{ m/s}^2 \]

b. What was the car’s average speed during this time period?

\[ v_{ave} = \frac{v_0 + v}{2} \]

\[ v_{ave} = \frac{6.0 + 12}{2} = 9.0 \text{ m/s} \]

c. How far does the car travel during this acceleration?

\[ d = v_{ave} \times t \]

\[ d = 9.0 \times 5.0 = 45 \text{ m} \]

3) After the curve the car speeds up to a final speed of 24 m/s along a straight section of road using an acceleration of 4.5 m/s². What distance does the car travel during this acceleration?

\[ v_f = \sqrt{2ad} \]

\[ d = \frac{v_f^2 - v_0^2}{2a} \]

\[ d = (24^2 - 6^2)/2(4.5) \]

\[ d = 96 \text{ m} + 15 \text{ m} = 111 \text{ m} \]
3) A car accelerates at speeds up to a final speed of 24 m/s along a straight section of road using an acceleration of 4.5 m/s². What distance does the car travel during this acceleration?

\[ a = \frac{v^2 - v_0^2}{2d} \]

\[ \frac{v^2 - v_0^2}{2a} \Rightarrow d = \frac{v^2 - v_0^2}{2a} = \frac{24^2 - 6^2}{2 \times 4.5} \]

\[ d = 60 \text{ m} \]

4) At the end of this straight section the car driver slams on the brakes stopping the car in 43 m.

a. What was the acceleration of the car?

\[ v^2 = v_0^2 + 2ad \Rightarrow a = \frac{v^2 - v_0^2}{2d} = \frac{0 - 24^2}{2 \times 43} \]

\[ a = -6.7 \text{ m/s}^2 \]

b. What time interval does this take?

\[ v = v_0 + at \Rightarrow t = \frac{v - v_0}{a} \]

\[ t = \frac{0 - 24}{-6.7} = 3.6 \text{ s} \]