Physics-145 Summer 2019

Homework No. 1

Q1) A particle moves in a straight line according to the equation $x = 50t^2 - 10t^3$ where x is in meters and t in seconds.

(a) Calculate the average velocity of the particle in the time interval $t = 0$ s and $t = 3$ s.

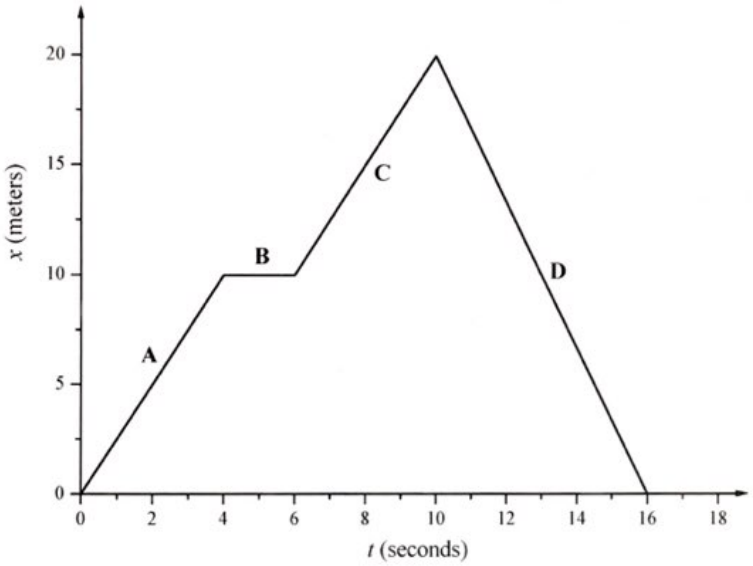
$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x(3) - x(0)}{3 - 0} = \frac{(50)(3)^2 - 10(3)^3}{3} = \frac{450 - 270}{3} = 60 \text{ m/s}$$

(b) Calculate the acceleration of the particle at $t = 2$ s.

$$a = \frac{dv}{dt} = \frac{dx^2}{dt^2} = 100 - 60t$$

At $t = 2$ sec, $a = 100 - 60(2) = -20 \text{ m/s}^2$.

Q2) The graph below shows the position-time graph of a particle.



From the graph, find the following:

(a) The distance moved in the time interval **C** (between $t = 6$ s to $t = 10$ s).

distance = 20 − 10 = 10 m.

(b) The displacement moved in the time interval **C**.

$\Delta x = 20 - 10 = 10$ m.

(c) The average velocity in the time interval **C**.

$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{10}{4} = 2.5$ m/s.

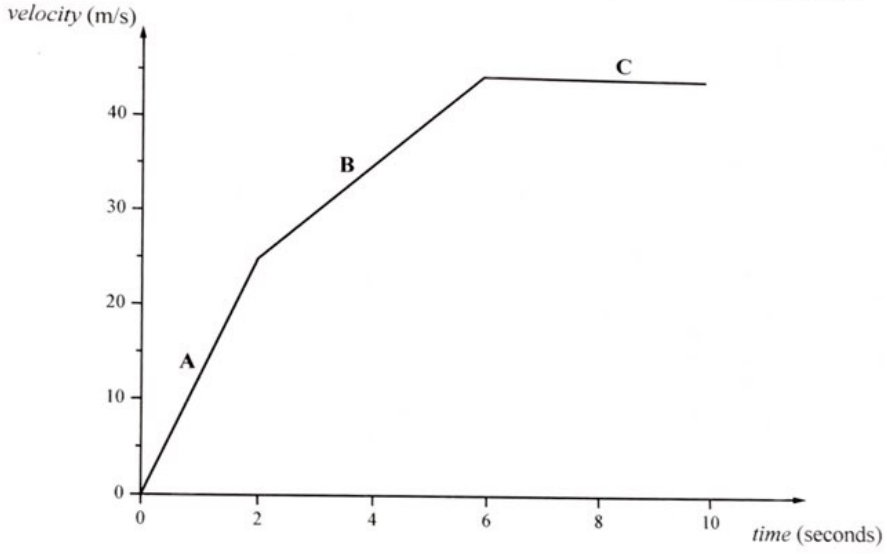
(d) The *total* distance moved by the particle.

total distance = $\overset{A}{10} + \overset{B}{0} + \overset{C}{10} + \overset{D}{20} = 40$ m

(e) The average ~~velocity~~ Speed for the whole journey.

Average speed = $\frac{\text{total distance}}{\text{elapsed time}} = \frac{40}{16} = 2.5$ m/s.

Q3) The graph below shows the first 10 seconds velocity-time graph of a Tesla car journey.



From the graph, find the following:

(a) The car's acceleration in the first two seconds.

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{25-0}{2-0} = 12.5 \text{ m/s}^2.$$

(b) The car's acceleration in the time interval between $t = 2$ s to $t = 6$ s.

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{45-25}{6-2} = 5 \text{ m/s}^2.$$

(c) How far did the car move before reaching the speed of 45 m/s?

$$\Delta x = \frac{1}{2}(v_0 + v)\Delta t$$

$$\therefore (\Delta x)_A = \frac{1}{2}(0+25)(2) = 25 \text{ m}.$$

$$(\Delta x)_B = \frac{1}{2}(25+45)(4) = 140 \text{ m}.$$

$$(\Delta x)_{\text{total}} = (\Delta x)_A + (\Delta x)_B = 165 \text{ m}.$$

Q4) A particle accelerates from rest with a constant acceleration of 15 m/s^2. How far the particle moves before it reaches a speed of 60 m/s?

$$v^2 - v_0^2 = 2a\Delta x$$

$$60^2 - 0^2 = 2(15)\Delta x$$

$$\Rightarrow \Delta x = \frac{60^2}{2(15)} = 120 \text{ m}.$$

Q5) A car starts from rest until it reaches a speed of 25 m/s with an acceleration of 2 m/s^2. After that, the car decelerates (slows down) with deceleration of 1 m/s^2 until it stops. How much time elapsed from start to stop?

Trip 1: $v_0 = 0$, $v = 25$ m/s, $a = 2$ m/s^2

$v = v_0 + a\Delta t$

$25 = 0 + 2\Delta t \Rightarrow \boxed{\Delta t = 12.5 \text{ sec}}$

Trip 2: $v_0 = 25$ m/s, $v = 0$, $a = -1$ m/s^2.

$v = v_0 + a\Delta t$

$0 = 25 - \Delta t \Rightarrow \boxed{\Delta t = 25 \text{ sec}}$

$\Rightarrow$ total time elapsed $= 12.5 + 25 = 37.5$ sec.

Q6) Consider the following three vectors: $\mathbf{A} = 2\mathbf{i} - 4\mathbf{j}$, $\mathbf{B} = 5\mathbf{j}$, $\mathbf{C} = 3\mathbf{i} + 3\mathbf{j}$.

(a) Calculate $\mathbf{R} = 2\mathbf{A} - \mathbf{C} + 10\mathbf{B}$.

$$\vec{R} = \hat{i} + 39\hat{j}$$

(b) What angle **R** makes with the positive *x*-axis?

$$\theta = \tan^{-1}\left(\frac{39}{1}\right) = 88.53^\circ$$

(c) What is the length of **R**?

$$|\vec{R}| = \sqrt{1^2 + 39^2} = 39.01$$