Q- At t=0, car A starts from rest at point 1. It moves towards the right with an acceleration of 0.4t m/s2. At the same time car B starts from point 2 with a constant acceleration of 2 m/s^2 to the right. Find:

A) Speed of car 1 at the end of 200 m section.

B) Time to travel of 200 meters by car A.

C) Magnitude of car A's acceleration as it reached point 2.

D) How far has car B moved when car A has reached point 2?

E) Relative velocity and acceleration of car B with respect to car A when car A is at point 2.

A) & B) The acceleration of the car is not constant and hence we cannot use equations of motion.

The acceleration is the rate change of velocity and hence we can write

$a = dv/dt = 0.4*t$

Integrating the equation gives us velocity as a function of time as

$$\int_0^v dv = \int_0^t 0.4t * dt$$

Or $v = 0.4*(t^2/2) = 0.2\ t^2$ ---------- (1)

Now as v is the rate of change of displacement, we can find the displacement as a function of time by integrating above equation 1

$v = dx/dt = 0.2\ t^2$

Or $$\int_0^x dx = \int_0^t 0.2 * t^2 * dt$$

Or $x = 0.2*(t^3/3)$

Or $x = 0.0667*t^3$ ---------- (2)

Time taken to reach 200 m is given by

$200 = 0.0667*t^3$

Or $t^3 = 3000.0$

Or $t = 14.38$ s

And velocity at this time is given by equation 1 as

$v = 0.4*(t^2/2) = 0.2\ t^2 = 0.2\ (14.39)^2 = 41.38$ m/s

C) Acceleration at the time car 1 reaches 200 m is given by

$a = 0.4*t = 0.4*14.38 = 5.75$ m/s^2

D) Distance covered by car 2 when car 1 reaches point 2 (200 m) (constant acceleration)

$[x_2 = u*t + ½\ a*t^2]$

or $x_2 = 0 + 0.5*2*(14.38)^2 = 206.78$ m

E) Velocity of car B when A reaches point 2 is given by

$v_B = u + a*t = 0 + 2*14.38 = 28.76$ m/s

Hence velocity of B relative to car A is given by

$v_{BA} = v_B - v_A = 28.76 - 41.38 = -12.62$ m/s

Acceleration of car B relative to A is given by

$a_{BA} = a_B - a_A = 2 - 5.75 = -3.75$ m/s^2.

(Negative sign shows the direction opposite to that of motion.