Problem 4: Two trains A and B leave the same station on parallel lines. Train A starts with uniform acceleration of 1/6 m/sec^2 and attains a speed of 24 Km/hr when a stream is reached to keep the speed constant. Train B leaves 40 seconds after with uniform acceleration of $\frac{1}{3}$ m/sec^2 and attains a maximum speed of 48 Km/hr. When will B over take A.

Solution:

Acceleration of train A, $a_A = \frac{1}{6}\left(\frac{m}{s^2}\right)$

Max-velocity of train A, $V_A = 24$ kmph

$$= 24 \times \left(\frac{5}{18}\right) m/s$$
$$= 6.667 \text{ m/sec}$$

Acceleration of train B, $a_B = \frac{1}{3}\left(\frac{m}{s^2}\right)$

Max-velocity of train B, $V_B = 48$ km/phr

$$= 48 \times \left(\frac{5}{18}\right) m/s$$
$$V_B = 13.33 \text{ m/sec}$$

Let t_A =Time taken by train A to attain its max speed

t_B=Time taken by train B to attain its max. speed

T=Time when train B will overtake train A from its start

We know that

Acceleration, a=velocity/time =V/t

From that $t = \frac{V}{a}$

For train A, $t_A = \frac{V_A}{a_A} = \frac{6.667}{\left(\frac{1}{6}\right)} = 40$ sec

For train B, $t_B = \frac{V_B}{a_B} = \frac{13.334}{\left(\frac{1}{3}\right)} = 40$ sec

Distance travelled by train A before attaining the max. speed

$$S_{A1} = u_A t_A + \frac{1}{2} a_A t_A^2$$

$$= 0 + \frac{1}{2}\left(\frac{1}{6}\right)(40)^2$$
$$S_{A1} = 133.33\text{m}$$

Distance travelled by train B before attaining the max. speed

$$S_{B1} = u_B t_B + \frac{1}{2} a_B t_B^2$$
$$= 0 + \frac{1}{2}\left(\frac{1}{3}\right)(40)^2$$
$$S_{B1} = 266.67\text{m}$$

From the given data we know train A has travelled for (T+40)sec.

Distance travelled by train A before attaining the max. speed

$$S_{A2} = V_A \times \text{time}$$
$$= 6.667 \times (T + 40 - t_A)$$
$$S_{A2} = 6.667T\text{m}$$

Distance travelled by train B before attaining the maximum speed

$$S_{B2} = V_B \times \text{time}$$
$$= 13.33 \times (T - 40) = 13.33T - 533.2$$

For the train B to overtake the train A

$$S_{A1} + S_{A2} = S_{B1} + S_{B2}$$
$$133.33 + 6.667T = 13.33T - 533.2$$
$$T = 100\text{sec}$$