

130) given,

Acceleration, $\alpha = 0.8 \text{ km/h/s}$

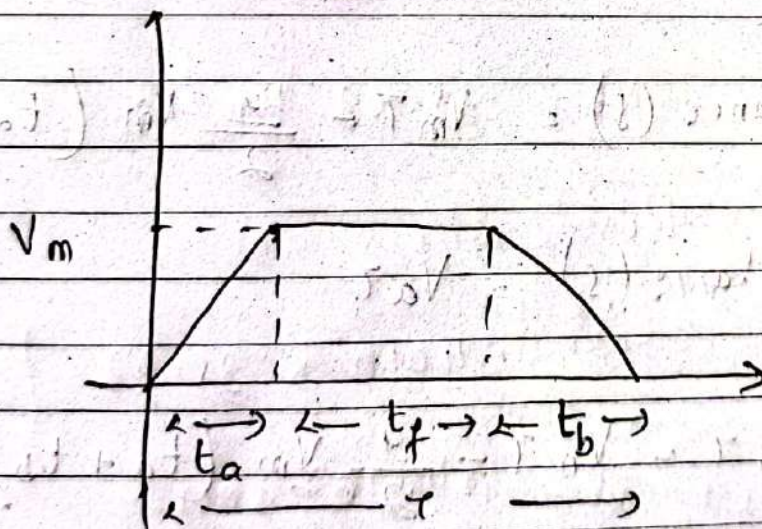
Braking retardation, $\beta = 3.2 \text{ km/h/s}$

$$\frac{V_{\max}}{V_{\text{avg}}} = 1.3$$

Stop time, $t_s = 26 \text{ s}$

Distance between stations = 1.5 km

Now, plotting speed vs. time graph



We have, $t_a = \frac{V_m}{\alpha}$

or, $t_a = \frac{V_m}{0.8}$

also,

$$t_b = \frac{V_m}{\beta}$$

$$\text{or, } t_b = \frac{V_m}{3.2}$$

then,

$$t_a + t_b = V_m \left[\frac{1}{0.8} + \frac{1}{3.2} \right]$$

$$\therefore t_a + t_b = 1.5625 V_m$$

Now,

For a simplified trapezoidal speed-time curve,

$$\text{Distance (s)} = V_m T - \frac{1}{2} V_m (t_a + t_b)$$

But,

$$\text{Distance (s)} = V_a T$$

So,

$$V_a T = V_m T - \frac{1}{2} V_m (t_a + t_b)$$

Dividing by T,

$$\text{or, } V_a = V_m \left[1 - \frac{t_a + t_b}{2T} \right]$$

$$\text{or, } \frac{V_m}{1.3} = V_m \left[1 - \frac{1.5625 V_m}{2T} \right]$$

$$\left[\therefore V_a = \frac{V_m}{1.3} \right]$$

$$\text{or, } \frac{1}{1.3} = \frac{1}{27} - \frac{1.5625 V_m}{27}$$

$$\text{or, } \frac{0.78125 V_m}{1} = 0.23077$$

$$\text{or, } T = 3.3854 V_m \quad \text{--- (1)}$$

Since,

$$V_m = 1.3 V_a$$

$$T = 3.3854 (1.3 V_a)$$

$$\therefore T = 4.4010 V_a \quad \text{--- (2)}$$

Now, We have,

$$V_a = \frac{\text{Distance}}{\text{Running Time}}$$

$$\text{or, } V_a = \frac{S}{(T/3600)}$$

[$\therefore$ since V_a is in cm/h and Time is to be converted into hours]

$$\text{or, } V_a = \frac{3600 \times 1.5}{T}$$

$$\text{or, } V_a T = 5400 \quad \text{--- (iii)}$$

From (ii),

$$T = 4.4010 V_a$$

Substituting in (iii),

$$V_a (4.4010 V_a) = 5400$$

$$\text{or, } 4.4010 V_a^2 = 5400$$

$$\text{or, } V_a^2 = 1226.994$$

$$\therefore V_a = 35.03 \text{ Km/hr}$$

Now, We have,

$$T = 4.4010 \times 35.03 \quad [\text{From (ii)}]$$

$$\therefore T = 154.167 \text{ secs}$$

(which is the required running time)

Then,

for schedule time,

$$t_{\text{schedule}} = \tau + t_s$$

$$= 154.167 + 261$$

$$= 180.165$$

Then,

Calculate Schedule Speed,

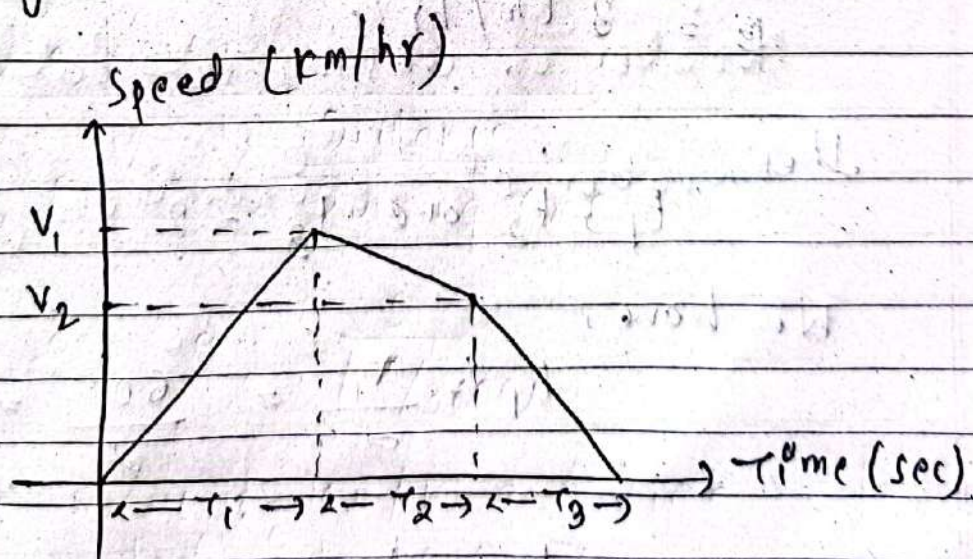
$$V_s = \frac{\text{Distance}}{\text{Schedule Time}}$$

$$= \frac{1.5 \times 3600}{180.16}$$

$$= 29.973 \text{ km/hr}$$

$$\approx 30 \text{ km/hr}$$

131) Here, given,



Here,

$$V_1 = 60 \text{ km/hr}$$

$$S = 2 \text{ km}$$

$$V_{\text{avg}} = 40 \text{ km/hr}$$

s.e.

$$\frac{S}{\left(\frac{t}{3600}\right)} = 40$$

$$\text{or, } \frac{S \times 3600}{t} = 40$$

$$\text{or, } \frac{2 \times 3600}{t} = 40$$

$$\therefore t = 180 \text{ sec}$$

$$\alpha = 2 \text{ km/hr/s}$$

$$\beta_c = 0.45 \text{ km/hr/s}$$

$$\beta = 3 \text{ km/hr/s}$$

Then,

$$t_1, t_2 \text{ and } t_3 = ?$$

We have,

$$t_1 = \frac{V_1}{\alpha} = \frac{60}{2} = 30 \text{ sec}$$

$$t_3 = \frac{V_2}{\beta}$$

So, We have to find V_2

Then,

$$t_2 = \frac{V_1 - V_2}{\beta_c}$$

$$\text{or, } \beta_c t_2 = V_1 - V_2$$

$$\text{or, } \beta_c (\tau - t_1 - t_3) = V_1 - V_2$$

$$\text{or, } \beta_c \left[\tau - \frac{V_1}{\alpha} - \frac{V_2}{\beta} \right] = V_1 - V_2$$

$$\text{or, } \beta_c \tau - \frac{\beta_c V_1}{\alpha} - \frac{\beta_c V_2}{\beta} = V_1 - V_2$$

$$\text{or, } V_2 - \beta_c \frac{V_2}{\beta} = V_1 - \beta_c \tau + \frac{\beta_c V_1}{\alpha}$$

$$\text{or, } V_2 \left[1 - \frac{\beta_c}{\beta} \right] = V_1 - \beta_c \tau + \frac{\beta_c V_1}{\alpha}$$

$$\text{or, } V_2 = \frac{V_1 - \beta_c \tau + \frac{\beta_c V_1}{\alpha}}{\left[1 - \frac{\beta_c}{\beta} \right]}$$

$$\left[1 - \frac{\beta_c}{\beta} \right]$$

$$\text{or, } V_2 = \frac{60 - 0.15 \times 180 + \frac{0.15 \times 60}{2}}{\left[1 - \frac{0.15}{2} \right]}$$

$$\therefore V_2 = 39.47 \text{ sec}$$

then,

$$t_3 = \frac{V_2}{\beta} = \frac{39.47}{3} = 13.157 \text{ sec}$$

then,

$$t_2 = \frac{V_1 - V_2}{\beta_c}$$

$$\therefore t_2 = \frac{60 - 39.47}{0.15}$$

$$\therefore t_2 = 136.867 \text{ sec}$$

Hence

Duration of accelⁿ, $t_1 = 30 \text{ sec}$

Duration of coasting retardation, $t_2 = 136.867 \text{ sec}$

Duration of retardation, $t_3 = 13.157 \text{ sec}$

132)

given,

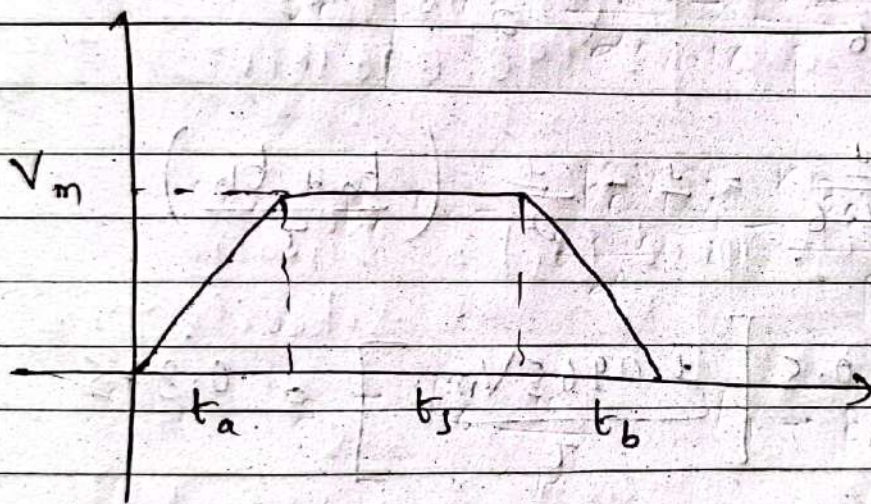
$$A_{acc} (\alpha) = 1.2 \text{ km/h/s}$$

$$\text{Braking retardation } (\beta) = 3.8 \text{ km/h/s}$$

$$\frac{V_m}{V_a} = 1.6$$

$$t_s = 45 \text{ sec}$$

$$S = 2.5 \text{ km}$$



We have,

$$t_a = \frac{V_m}{\alpha} = \frac{V_m}{1.2}$$

$$t_b = \frac{V_m}{\beta} = \frac{V_m}{3.8}$$

then,

$$t_a + t_b = V_m \left[\frac{1}{1.2} + \frac{1}{3.8} \right] = 1.0965 V_m$$

For a simplified trapezoidal speed time - curve,

$$S = V_m T - \frac{1}{2} V_m (t_a + t_b)$$

But,

$$S = V_a T$$

So,

$$V_a T = V_m T - \frac{1}{2} V_m (t_a + t_b)$$

$$\text{or, } \frac{V_m T}{1.6} = V_m T - \frac{1}{2} V_m (t_a + t_b)$$

$$\text{or, } \frac{1}{1.6} = 1 - \frac{1}{2} \left(\frac{t_a + t_b}{T} \right)$$

$$\text{or, } 0.5 \left[\frac{1.0965 V_m}{T} \right] = 0.375$$

$$\text{or, } \frac{V_m}{T} = 0.68399$$

$$\text{or, } T = 1.462 V_m \quad \text{①}$$

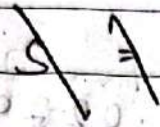
Hence,

$$V_m = 1.6 V_a$$

$$\text{or, } T = 1.462 (1.6 V_a)$$

$$\therefore T = 2.3392 V_a \quad \text{②}$$

Now, We have,



$$V_a = \frac{\text{Distance}}{\text{Running Time}}$$

$$\text{or, } V_a = \frac{S}{(\tau/3600)}$$

$$\text{or, } V_a = \frac{S \times 3600}{\tau}$$

$$\text{or, } V_a = \frac{2.5 \times 3600}{\tau} = \frac{9000}{\tau}$$

$$\text{or, } V_a \tau = 9000 \quad \text{--- (iii)}$$

then, from (ii),

$$V_a (2.3392 V_a) = 9000$$

$$\text{or, } V_a^2 = 3847.469$$

$$\therefore V_a = 62.0279 \text{ km/h}$$

Then, from (10),

$$T = 2.3392 \times 62.0279$$

$$T = 145.096 \text{ secs}$$

Then,

$$T_{\text{schedule}} = T + t_s$$

$$= 145.096 + 45$$

$$= 190.096 \text{ secs}$$

Then,

$$\text{Schedule speed } (V_s) = \frac{\text{Distance}}{\text{Schedule Time}}$$

$$= \frac{2.5}{\left(\frac{190.096}{3600} \right)}$$

$$= 47.344 \text{ km/hr}$$

133)

given,

Dead Weight, $W = 150 \text{ t}$

Rotational Inertial allowance = 10 %

So,

Effective mass, $M_e = 150 \times 1.1$
 $= 165 \text{ t}$ Distance (D) = 4 kmAverage speed (V_a) = 60 km/hrAcceleration (α) = 1.5 km/h/sRetardation (β) = 2 km/h/sGradient, $G = 1.5 \% (\text{up})$ Track resistance, $r = 40 \text{ N/t}$ Efficiency, $\eta = 65 \%$

We have,

$$\tau = \frac{D}{V_a} = \frac{4}{60} = \frac{1}{15} \text{ hour}$$

$$= \frac{1}{15} \times 3600$$

$$= 240 \text{ secs}$$

simplified

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For a trapezoidal speed time curve,

the distance is,

$$D \text{ (km)} = \frac{1}{3600} \left[V_m T - \frac{1}{2} V_m (t_a + t_b) \right]$$

$$D = \frac{1}{3600} \left[V_m T - \frac{1}{2} V_m \left[\frac{V_m}{\alpha} + \frac{V_m}{\beta} \right] \right]$$

$$\text{or, } D = \frac{1}{3600} \left[V_m T - \frac{V_m^2}{2} \left[\frac{1}{\alpha} + \frac{1}{\beta} \right] \right]$$

$$\text{or, } 4 = \frac{1}{3600} \left[V_m \times 240 - \frac{V_m^2}{2} \left[\frac{1}{1.5} + \frac{1}{2} \right] \right]$$

$$\text{or, } 14400 = 240 V_m - 0.5833 V_m^2$$

$$\text{or, } 0.5833 V_m^2 - 240 V_m + 14400 = 0$$

Solving, above quadratic equation. We get,

$$V_m = 338.53 \text{ km/hr (Impossible)}$$

$$V_m = 72.93 \text{ km/hr } (\checkmark)$$

Now,

For tractive effort in each phase

a) Force for accelⁿ

$$F_a = M \times a$$

$$= 165 \times 10^3 \times 1.5 \times \frac{1000}{3600}$$

$$= 68,750 \text{ N}$$

b) Track resistance (uses actual dead weight)

$$F_r = r \times W$$

$$= 40 \times 150$$

$$= 6000 \text{ N}$$

c) Gradient resistance,

$$F_g = W \times \frac{G}{100}$$

$$= 150 \times 10^3 \times 9.81 \times \frac{1.5}{100}$$

$$= 22,072.5 \text{ N}$$

Then,

⇒ Tractive effort during accelⁿ,

$$P_{t1} = P_a + F_r + F_g$$

$$= 68,750 + 6000 + 22,072.5$$

$$= 96,822.5 \text{ N}$$

⇒ Tractive effort during free running,

$$P_{t2} = F_r + F_g$$

$$= 6000 + 22,072.5$$

$$= 28,072.5 \text{ N}$$

Now,

We have,

$$t_1 = \frac{V_m}{\alpha} = \frac{72.93}{1.5}$$

$$= 48.62 \text{ s}$$

Then,

$$d_1 = \frac{1}{2} V_m t_1$$

$$= \frac{1}{2} \times 72.93 \times 48.62$$

We have,

$$V_m = 72.93 \text{ km/hr}$$

$$= \frac{72.93 \times 1000}{3600}$$

$$= 20.258 \text{ m/s}$$

Then,

$$d_1 = \frac{1}{2} \times V_m \times t_1$$

$$= \frac{1}{2} \times 20.258 \times 48.62$$

$$= 492.47 \text{ m}$$

Similarly,

$$t_3 = \frac{V_m}{a} = \frac{72.93}{20.258} = 36.465 \text{ sec}$$

Then,

$$t_2 = T - t_1 - t_3$$

$$= 240 - 48.62 - 36.465$$

$$= 154.915 \text{ sec}$$

Then,

$$d_2 = V_m t_2$$

$$= 20.258 \times 154.915$$

$$= 3138.268 \text{ m}$$

then,

i) Total Energy o/p at the driving axle

$$W_{out} = F_{t1} d_1 + F_{t2} d_2$$

$$= 96,822.5 \times 492.47 +$$

$$28,072.5 \times 3138.$$

$$268$$

$$= 135.78 \text{ MJ}$$

So, here,

$$1 \text{ kWh} = 3.6 \text{ MJ}$$

$$W_{out} = \frac{135.78}{3.6}$$

$$= 37.72 \text{ kWh}$$

ii) Total Energy Consumption,

$$W_{in} = \frac{W_{out}}{\eta}$$

$$= \frac{37.72}{0.65}$$

$$= 58.031 \text{ kWh}$$

ii) ~~Total~~ Specific Energy Consumption,

$$S_e = \frac{\text{Total Energy Consumption (Wh)}}{\text{Dead Weight (t)} \times \text{Distance (km)}}$$

$$= \frac{58.031 \times 10^3}{150 \times 4}$$

$$= 96.72 \text{ Wh/tonne-km}$$

134) Here,

No train weight (W) is given. So, carrying out the whole calculation per tonne of the dead weight (i.e. set $W = 1t$).

Now, given,

$$\alpha = 2 \text{ km/h/s}$$

$$t_1 = 10s$$

$$\text{Coasting period, } t_2 = 50s$$

$$\text{Braking period, } t_3 = 15s$$

$$\text{Gradient (G)} = 1\% \text{ (down)}$$

tractive resistance, $r = 40 \text{ N/t}$

Rotational Inertia = 10%

So,

Effective mass, $M_e = 1.1W$

Duration of stop, $t_s = 15 \text{ s}$

Overall efficiency (η) = 75%

Now,

$$\alpha = \frac{V_m}{t_1}$$

$$\text{or, } V_m = \alpha t_1$$

$$= 2 \times 10$$

$$= 20 \text{ km/hr}$$

$$= 20 \times \frac{1000}{3600}$$

$$= 5.556 \text{ m/s}$$

Now,

Distance covered during accelⁿ,

$$s_1 = \frac{1}{2} V_m t_1$$

$$= \frac{1}{2} \times 5.556 \times 10$$

$$= 27.78 \text{ m}$$

Coasting phase

During coasting, the traction motor is switched off ($F_t = 0$). The train's speed is then governed solely by the net of gradient force and resistance.

Forces (per tonne, $W = 1 \text{ t}$):

Track resistance, $F_r = rW$

$$= 40 \times 1$$

$$= 40 \text{ N}$$

Gradient force,

$$F_g = 98.1 \times W \times G$$

$$= 98.1 \times 1 \times 1$$

$$= 98.1 \text{ N}$$

Since,

$F_g (98.1 \text{ N}) > F_r (40 \text{ N})$, the net force is forward. i.e. the train speeds up while coasting.

So,

$$F_{net} = F_g - F_r$$

$$= 98.1 - 40$$

$$= 58.1 \text{ N}$$

Now,

Effective mass,

$$M_e = 1.1 W$$

$$= 21.1 \times 1000$$

$$= 1100 \text{ kg}$$

Then,

Coasting accⁿ

$$a_c = \frac{F_{net}}{M_e}$$

Me

$$= \frac{58.1}{1100}$$

$$= 0.052818 \frac{\text{m}}{\text{s}^2}$$

$$= \frac{0.052818}{1000} \frac{\text{km}}{\text{hr}^2}$$

$$= \frac{1}{(3600)^2}$$

$$= 0.19014 \text{ km/hr/sec}$$

Now,

Speed at the end of coasting,

$$V_{\text{coast}} = V_m + \alpha_c \times t_2$$

$$= 20 + 0.19014 \times 50$$

$$= 29.51 \text{ km/hr}$$

$$= 29.51 \times \frac{1000}{3600}$$

$$= 8.1972 \text{ m/s}$$

Now,

Distance during coasting,

$$d_2 = \left(\frac{V_m + V_{\text{coast}}}{2} \right) \times t_2$$

$$= \left(\frac{5.556 + 8.1972}{2} \right) \times 50$$

$$= 849.83 \text{ m}$$

Braking phase

The train decelerates from $V_{\text{coast}} = 8.1972 \text{ m/s}$ to rest in $t_3 = 15 \text{ sec}$.

So,

$$\beta = \frac{V_{\text{coast}}}{t_3}$$

$$= \frac{8.1972}{15}$$

$$= 0.54648 \text{ m/s}^2$$

$$= 0.54648 \times \frac{3600}{1000} \text{ km/h/s}$$

$$= 1.9673 \text{ km/h/s}$$

Now,

Distance during braking,

$$d_3 = \frac{1}{2} V_{\text{coast}} \times t_3$$

$$= \frac{1}{2} \times 8.1972 \times 15$$

$$= 61.479 \text{ m}$$

then,

$$\text{Total distance, } D = d_1 + d_2 + d_3$$

$$= 27.78 + 343.83 + 61.479$$

$$= 493.089 \text{ m}$$

$$= 0.4931 \text{ km}$$

Also,

total running time,

$$t_{sch} = t_{run} + t_{stop}$$

$$t_{run} = t_1 + t_2 + t_3$$

$$= 10 + 50 + 15$$

$$= 75 \text{ sec}$$

Total schedule time,

$$t_{schedule} = t_{run} + t_s$$

$$= 75 + 15$$

$$= 90 \text{ sec}$$

$$= 0.025 \text{ hours}$$

then,

$$\text{Schedule speed, } V_{sch} = \frac{D}{t_{sch}} = \frac{0.4931}{0.025}$$

$$= 17.324 \text{ km/hr}$$

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Here, given,

$$S = 2.5 \text{ km}$$

$$\alpha = 2 \text{ km/hr/sec}$$

$$\beta = 3 \text{ km/hr/sec}$$

$$V_m = 0$$

During accelⁿ

Then,

$$t_1 = \frac{V_m}{\alpha}$$

$$D_1 = \frac{1}{2} V_m \times \frac{t_1}{3600}$$

$$= \frac{1}{2} \times V_m \times \frac{V_m}{\alpha} \times \frac{1}{3600}$$

$$\therefore D_1 = \frac{V_m^2}{7200\alpha}$$

again,

During retardation,

$$t_3 = \frac{V_m}{\beta}$$

$$D_3 = \frac{1}{2} \times V_m \times \frac{t_3}{3600}$$

$$\therefore D_3 = \frac{V_m^2}{7200\beta}$$

Then,

Total Distance,

$$D = D_1 + D_3$$

$$\text{or, } 2.5 = \frac{V_m^2}{7200} \left[\frac{1}{2} + \frac{1}{3} \right]$$

$$\text{or, } 2.5 = \frac{V_m^2}{7200} \left[\frac{1}{2} + \frac{1}{3} \right]$$

$$\text{or, } 2.5 = V_m^2 \times \frac{1}{8640}$$

$$\text{or, } V_m^2 = 21600$$

$$\therefore V_m = 146.97 \text{ km/hr}$$

$$\approx 147 \text{ km/hr}$$

Then,

$$t_1 = \frac{V_m}{\alpha} = \frac{147}{2} = 73.5 \text{ sec}$$

$$t_3 = \frac{V_m}{\beta} = \frac{147}{3} = 49 \text{ sec}$$

Then,

$$\tau = t_1 + t_3$$

$$= 73.5 + 49$$

$$= 122.5 \text{ sec}$$

Then,

Distance travelled before brakes applied,

$$D_1 = \frac{V_m^2}{7200 \alpha}$$

$$= \frac{147^2}{7200 \times 2}$$

$$= 1.5 \text{ km}$$

Then,

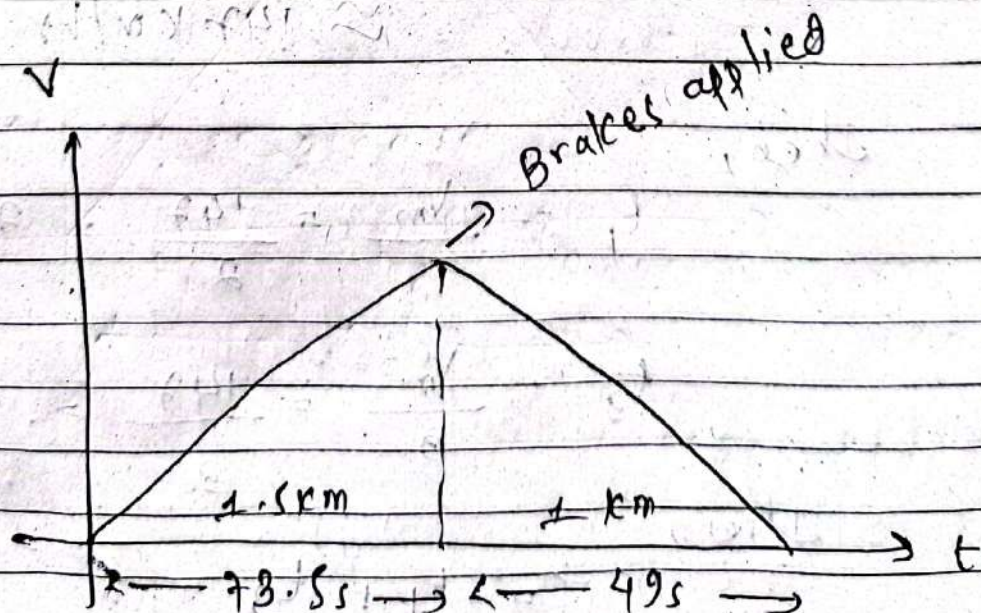
$$D_2 = D - D_1$$

$$0.5 = 2.5 - 1.5$$

$$= 1 \text{ km}$$

Then,

Speed time curve is,



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given,

$$V_{\text{schedule}} = 60 \text{ km/hr}$$

$$S = 6 \text{ km}$$

$$V_m = 0$$

$$\alpha = 2 \text{ km/hr/s}$$

$$\beta = 3 \text{ km/hr/s}$$

$$t_s = 60 \text{ sec}$$

Now, we have,

$$V_{\text{schedule}} = \frac{S}{\tau + t_s}$$

$$\text{or, } 60 = \frac{6 \times 3600}{\tau + 60}$$

$$\text{or, } \tau + 60 = 360$$

$$\therefore \tau = 300 \text{ sec}$$

Now, simplified

For a trapezoidal speed curve,
we have,

$$\text{Distance (D)} = \frac{1}{3600} \left[V_m \tau - \frac{V_m^2}{2} \left(\frac{1}{a} + \frac{1}{b} \right) \right]$$

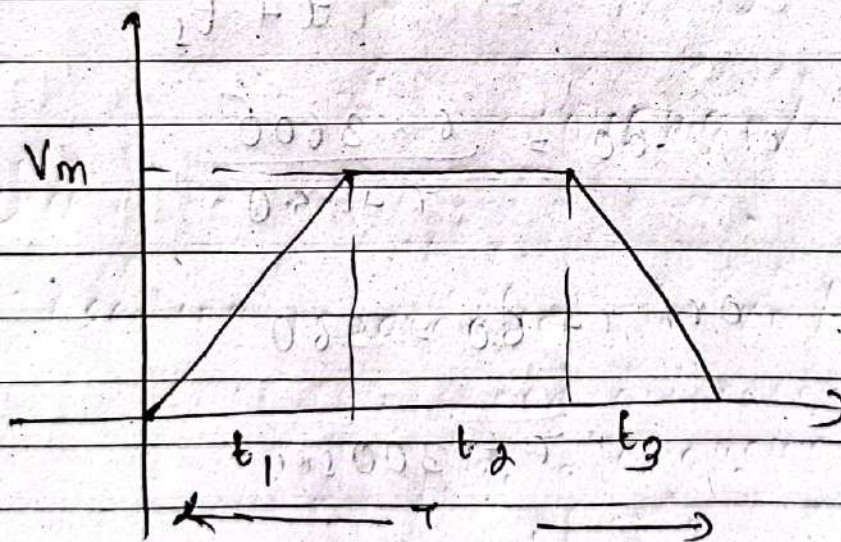
$$\text{or, } 6 = \frac{1}{3600} \left[V_m \times 900 - \frac{V_m^2}{2} \left[\frac{1}{2} + \frac{1}{3} \right] \right]$$

$$\text{or, } 21,600 = 900 V_m - 0.4167 V_m^2$$

$$\text{or, } 0.4167 V_m^2 - 900 V_m + 21,600 = 0$$

Solving,

$$V_m = 81.146 \text{ km/hr}$$



137) Here, given,

$$V_m = 48 \text{ km/hr}$$

$$t_1 = 24 \text{ s}$$

$$t_2 = 60 \text{ s}$$

then,

train resistance during coasting,

$$r = 50 \text{ N/tonne}$$

$$\text{Braking retardation } (b) = 3.3 \text{ km/h/s}$$

$$t_3 = 10 \text{ s}$$

rotational inertia allowance = 10%

$$t_5 = 20 \text{ s}$$

then,

We have,

$$\alpha = \frac{V_m - 0}{t_1}$$

$$= \frac{48}{24}$$

$$= 2 \text{ km/h/s}$$

Considering rotational inertia

$$m_e = 1.1 \times 1000 \\ = 1100 \text{ kg/tonne}$$

Then,

We have,

Coasting retardation,

$$\rho_c = \frac{r}{m_e}$$

$$= \frac{50 \text{ N/tonne}}{1100 \text{ kg/tonne}}$$

$$= 0.04545 \text{ m/s}^2$$

Then,

Coasting retardation in km/h/s

$$\rho_c = 0.04545 \times \frac{3600}{1000}$$

$$= 0.16362 \text{ km/h/s}$$

then,

$$\beta_c = \frac{V_1 - V_2}{t_2}$$

$$\text{or, } \beta_c t_2 = V_1 - V_2$$

$$\text{or, } V_2 = V_1 - \beta_c t_2$$

$$= 48 - (0.16362 \times 60)$$

$$= 38.182 \text{ km/hr}$$

then, we have,

$$t_3 = \frac{V_2}{\beta}$$

$$= \frac{38.182}{3.3}$$

$$= 11.57 \text{ sec}$$

Here, the question mentions 10 seconds, but this conflicts with the calculated coasting end speed.

For a physically consistent curve, 11.57 s is obtained from the calculated braking start speed and the given braking retardation.

Then,

$$D_1 = \frac{1}{2} V_m t_1$$

$$= \frac{1}{2} \times 48 \times \frac{24}{3600}$$

$$= 0.16 \text{ km}$$

During coasting, speed decreases uniformly from

$$48 \text{ km/hr to } 38.182 \text{ km/hr}$$

So,

$$V_{\text{avg}} = \frac{48 + 38.182}{2}$$

$$= 43.091$$

$$= 43.091 \text{ km/hr}$$

then,

$$D_2 = V_{\text{avg}} \times t_2$$

$$= 43.091 \times \frac{60}{3600}$$

$$= 0.7182 \text{ km}$$

Then,

$$D_3 = \frac{1}{2} \times V_2 \times \frac{t_3}{3600}$$

$$= \frac{1}{2} \times 38.182 \times \frac{11.57}{3600}$$

$$= 0.0614 \text{ km}$$

Then,

Total distance,

$$D = 0.16 + 0.7182 + 0.0614 \\ = 0.9396 \text{ km}$$

Then,

$$\text{Running time } (T_r) = t_a + t_b + t_c$$

$$= 24 + 60 + 11.57 \\ = 95.57 \text{ s}$$

Then,

Including station stop,

$$T_s = 95.57 + 20$$

$$= 115.57 \text{ sec}$$

Then,

Scheduled speed,

$$V_s = \frac{D}{(T_s / 3600)}$$

$$= \frac{0.9396}{(115.57 / 3600)}$$

$$= 29.28 \text{ km/hr}$$

Now,

New scheduled time,

$$t_{s, \text{new}} = 95.57 + 15$$

$$\text{Then, } = 110.57 \text{ s}$$

$$V_{s, \text{new}} = \frac{0.9396}{(110.57 / 3600)}$$

$$= 30.592 \text{ km/hr}$$

Effect of reducing stop time,

$$V_s = 29.28 \text{ km/hr}$$

then,

$$V_{s, \text{new}} = 30.60 \text{ km/hr}$$

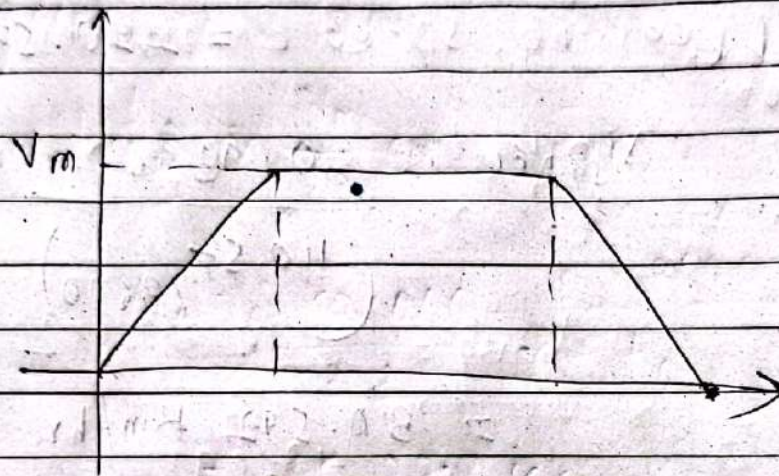
then,

$$\Delta V_s = 30.60 - 29.28$$

$$= 1.32 \text{ km/hr}$$

Then,

$$\begin{aligned}\% \text{ Increase} &= \frac{1.32}{29.28} \times 100 \% \\ &= 4.508 \%\end{aligned}$$



138) Here, given,

$$\text{Average speed} = 42 \text{ km/hr.}$$

$$S = 1400 \text{ m}$$

$$\alpha = 1.7 \text{ km/h/s}$$

$$\beta = 3.9 \text{ km/h/s}$$

Then,

$$S = V_a \left(\tau / 3600 \right)$$

$$\text{or } 1.4 = \frac{3600 \times V_a}{\tau}$$

~~$$\text{or, } \tau = \frac{3600 \times 42}{1.4}$$~~

$$\text{or, } \tau = \frac{S \times 3600}{V_a}$$

$$= \frac{1.4}{42} \times 3600$$

$$= 120 \text{ sec}$$

Then, We have,

$$D = \frac{1}{3600} \left[V_m \tau - \frac{V_m^2}{2} \left[\frac{1}{a} + \frac{1}{b} \right] \right]$$

$$\text{or, } 1.4 = \frac{1}{3600} \left[120 V_m - V_m^2 \times \frac{1}{2} \left(\frac{1}{1.7} + \frac{1}{3.3} \right) \right]$$

$$\text{or, } 5040 = 120 V_m - 0.4456 V_m^2$$

$$\text{or, } 0.4456 V_m^2 - 120 V_m + 5040 = 0$$

Solving,

$$V_m = 52.066 \text{ Km/hr}$$

Then,

$$t_1 = \frac{V_m}{\alpha}$$

$$= \frac{52.066}{1.7}$$

$$= 30.627 \text{ sec}$$

again,

$$t_3 = \frac{V_m}{\beta}$$

$$= \frac{52.066}{3.3}$$

$$= 15.778 \text{ sec}$$

Then,

$$b_2 = T - t_1 - t_3$$

$$= 120 - 30.627 - 15.778$$

$$= 73.595 \text{ sec}$$

Then,

$$D_1 = \frac{1}{2} V_m \times t_1$$

$$= \frac{1}{2} \times 52.066 \times \frac{30.627}{3600}$$

$$= 0.2215 \text{ km}$$

$$D_2 = V_m t_2$$

$$= 52.066 \times \frac{73.595}{3600}$$

$$= 1.0644 \text{ km}$$

$$D_3 = \frac{1}{2} V_m t_3$$

$$= \frac{1}{2} \times 52.066 \times \frac{15.778}{3600}$$

$$= 0.11409 \text{ km}$$

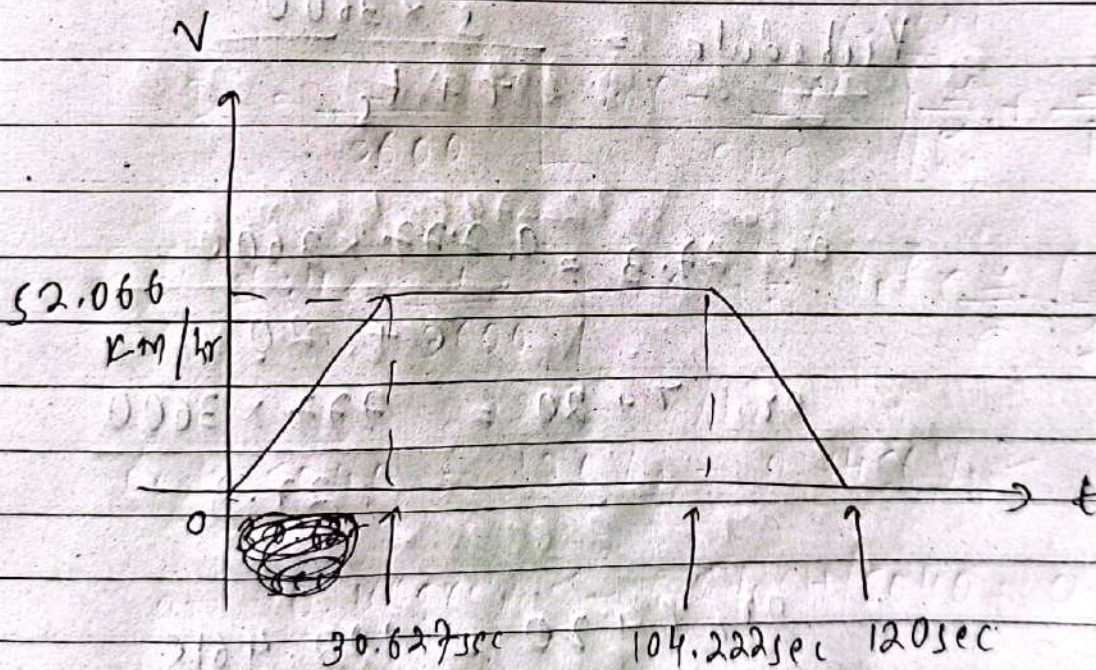


Fig.: Speed-Time Curve

140) given,

$$s = 777 \text{ m} = 0.777 \text{ km}$$

$$V_{\text{schedule}} = 27.3 \text{ km/hr}$$

$$V_m = 3.20 \text{ Va}$$

$$\beta = 3.22 \text{ km/h/s}$$

$$t_s = 20 \text{ s}$$

then, We know,

$$V_{\text{schedule}} = \frac{s \times 3600}{\tau + t_s}$$

$$\text{or, } 27.3 = \frac{0.777 \times 3600}{\tau + 20}$$

$$\text{or, } \tau + 20 = \frac{777 \times 3600}{27.3}$$

$$\text{or, } \tau + 20 = 102.4615$$

$$\therefore \tau = 82.4615 \text{ sec}$$

then,

We have,

$$D = \frac{1}{3600} \left[V_m T - \frac{V_m^2}{2} \left[\frac{1}{\alpha} + \frac{1}{\beta} \right] \right]$$

$$\text{or, } 0.777 = \frac{1}{3600} \left[\right]$$

We have,

$$11.572 = \frac{V_a T}{3600}$$

$$\text{or, } 0.777 = \frac{V_a \times 82.4615}{3600}$$

$$\therefore V_a = 33.921 \text{ km/hr}$$

Then,

$$V_m = 1.20 V_a$$

$$\text{or, } V_m = 1.20 \times 33.921$$

$$\therefore V_m = 40.7052 \text{ km/hr}$$

Then,

$$D = \frac{1}{3600} \left[V_m T - \frac{V_m^2}{2} \left[\frac{1}{\alpha} + \frac{1}{\beta} \right] \right]$$

$$\text{or, } 0.777 \times 3600 = 40.7052 \times 82.4615$$

$$- \frac{40.7052^2}{2} \left[\frac{1}{2} + \frac{1}{8.22} \right]$$

$$\text{or, } 2797.2 = 3356.61 - 828.46 \left[\frac{1}{2} + 0.311 \right]$$

$$\text{or, } 828.46 \left[\frac{1}{2} + 0.311 \right] = 559.41$$

$$\text{or, } \frac{1}{2} + 0.311 = \frac{559.41}{828.46}$$

$$\text{or, } \frac{1}{2} = 0.3692$$

$$\text{or, } 2.745 \text{ km/h/s}$$

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Given,

$$S = 1.5 \text{ km}$$

$$\frac{V_m}{V_a} = 1.25$$

$$\beta = 3.6 \text{ km/h/s}$$

$$\alpha = 1.8 \text{ km/h/s}$$

$$t_s = 2 \text{ sec}$$

We have,

$$0.15 D = \frac{1}{3600} \left[V_m T - \frac{V_m^2}{2} \left[\frac{1}{\alpha} + \frac{1}{\beta} \right] \right]$$

$$\text{or, } \frac{V_a T}{3600} = \frac{1}{3600} \left[V_m T - \frac{V_m^2}{2} \left[\frac{1}{\alpha} + \frac{1}{\beta} \right] \right]$$

$$\text{or, } \frac{V_m T}{1.25} = V_m T - \frac{V_m^2}{2} \left[\frac{1}{\alpha} + \frac{1}{\beta} \right]$$

$$\text{or, } \frac{1}{1.25} = 1 - \frac{V_m}{2T} \left[\frac{1}{\alpha} + \frac{1}{\beta} \right]$$

$$\text{or, } \frac{V_m}{2T} \left[\frac{1}{1.8} + \frac{1}{3.6} \right] = 1 - \frac{1}{1.25}$$

$$\text{or, } \frac{0.4167 V_m}{\tau} = 0.2$$

$$\text{or, } \tau = 2.0835 V_m$$

then,

$$S = \frac{V_a \tau}{3600}$$

$$\text{or, } 1.5 \times 3600 = \frac{V_m}{1.25} \times \tau$$

$$\text{or, } 6750 = V_m \tau$$

$$\text{or, } V_m (2.0835 V_m) = 6750$$

$$\text{or, } V_m^2 = 3239.7408$$

$$\therefore V_m = 56.92 \text{ km/hr}$$

then,

$$\tau = 2.0835 \times 56.92$$

$$\therefore \tau = 118.593 \text{ sec}$$

then,

$$\begin{aligned} \tau_{\text{schedule}} &= \tau + t_s \\ &= 118.593 + 21 \\ &= 139.593 \text{ sec} \end{aligned}$$

then,

$$V_{\text{schedule}} = \frac{D \times 3600}{T_{\text{schedule}}}$$

$$= \frac{1.5 \times 3600}{13.9593}$$

$$= 38.684 \text{ km/hr}$$