

Question 1

$$v_0 = 30 \frac{km}{Hr} = 8.33 \frac{m}{s}$$

$$x_0 = 0.00 \text{ m}$$

Interval $0 \leq t \leq 5 \text{ s}$

$$\frac{dv}{dt} = a = 0.4t \text{ m/s}^2, \text{ therefore by integration: } v \text{ (m/s)} = 0.2t^2 + 8.33$$

$$\frac{dx}{dt} = v, \text{ therefore by integration: } x \text{ (m)} = 0.067t^3 + 8.33t + 0.0$$

$$\text{When } t = 5\text{s} \Rightarrow v(5) = 13.33 \text{ m/s and } x(5) = 50.02 \text{ m}$$

Interval $5 \leq t \leq 15 \text{ s}$ or $0 \leq t - 5 \leq 10 \text{ s}$

$$\frac{dv}{dt} = a = 2.0 \text{ m/s}^2, \text{ therefore by integration: } v \text{ (m/s)} = 2(t - 5) + 13.33$$

$$\frac{dx}{dt} = v, \text{ therefore by integration: } x \text{ (m)} = 2 \frac{(t-5)^2}{2} + 13.33(t - 5) + 50.02$$

$$\text{When } t = 15\text{s} \Rightarrow v(15) = 33.33 \text{ m/s and } x(15) = 283.32 \text{ m.}$$

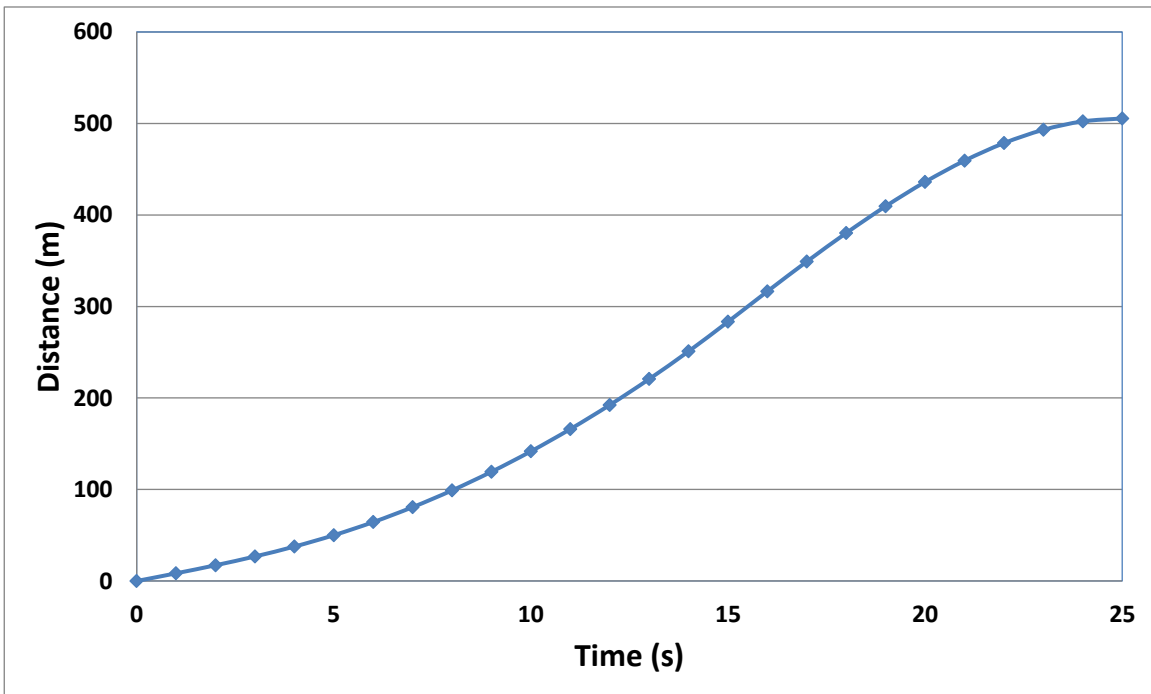
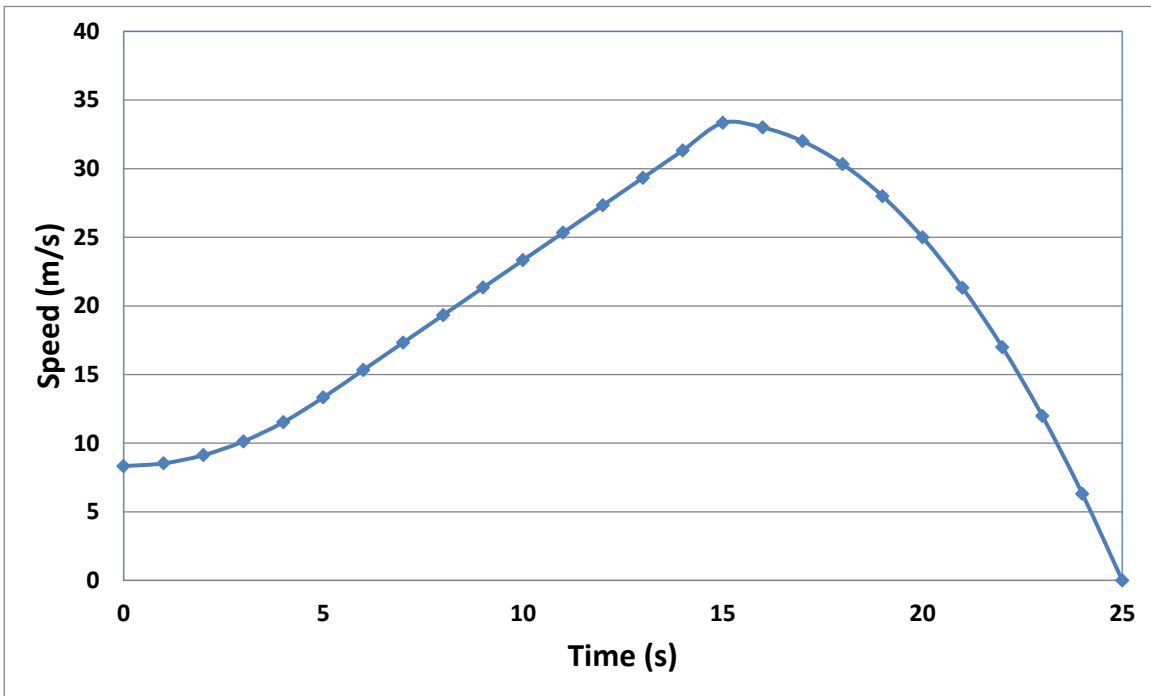
Interval $15 \leq t \leq 25\text{s}$ or $0 \leq t - 15 \leq 10\text{s}$

$$\frac{dv}{dt} = a \text{ (m/s}^2) = \frac{-x}{10}(t - 15), \text{ therefore by integration: } v \text{ (m/s)} = \frac{-x}{10} \frac{(t-15)^2}{2} + 33.33$$

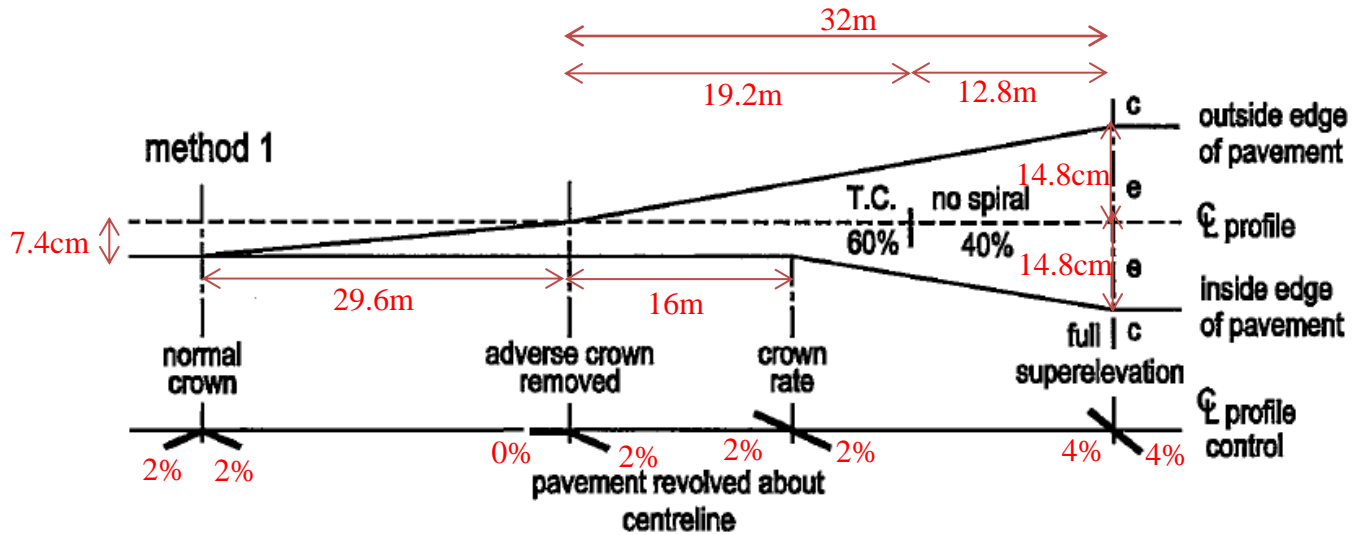
$$\text{When } t = 25 \Rightarrow v = 0; x = 6.67 \text{ m/s}^2$$

$$\frac{dx}{dt} = v, \text{ therefore by integration: } x \text{ (m)} = \frac{-6.67}{10} \frac{(t-15)^3}{6} + 33.33(t - 15) + 283.32$$

The relationships between speed-time and distance-time are plotted below.



Question 2



$$2\% \times 3.7m = 7.4cm$$

$$4\% \times 3.7m = 14.8cm$$

Length of superlevation runoff = 32.0m

$$\text{Length of tangent run out} = 400m \times 0.074 = 29.6m$$

Question 3

(a)

$$v_0 = 110 \frac{\text{km}}{\text{hr}} = 30.55 \frac{\text{m}}{\text{s}}$$

$$e_{\max} = 0.06 \text{ and } f_{(\max)} = 0.1$$

$$R_{\min} = \frac{v^2}{g(e_{\max} + f_{(\max)})} = \frac{30.55^2}{9.81(0.06 + 0.1)} = 594.61 \text{ m}$$

$$R_{\text{design}} = 1.25R_{\min} = 1.25 \times 594.61 = 743.26 \text{ m}$$

$$e_{\text{des}} = \frac{v^2}{gR} - f_{(\max)} = \frac{30.55^2}{9.81 \times 746.26} - 0.1 = 0.208 - 0.1 = 0.028$$

(b)

$$D = \left(\frac{5729.58}{R(ft)} \right)^{\circ} = \left(\frac{1746.4}{R(m)} \right)^{\circ} = \left(\frac{1746.4}{743.26} \right)^{\circ} = 2.35^{\circ}$$

$$E = R \left(\frac{1}{\cos \frac{50}{2}} - 1 \right) = 743.26 \times \left(\frac{1}{\cos \frac{50}{2}} - 1 \right) = 76.83 \text{ m}$$

$$M = R \left(1 - \cos \frac{\Delta}{2} \right) = 743.26 \times \left(1 - \cos \frac{50}{2} \right) = 70 \text{ m}$$

$$T = R \tan \frac{\Delta}{2} = 743.26 \times \tan \frac{50}{2} = 347 \text{ m}$$

$$L = 100(ft) \frac{\Delta}{D} = 30.48(m) \frac{50}{2.35} = 648.5 \text{ m}$$

$$LC = 2R \sin \frac{\Delta}{2} = 2 \times 743.26 \times \sin \frac{50}{2} = 628.2 \text{ m}$$

Question 4

$$z = (75 + 40) - (75 + 00) = 40m$$

$$\text{Tangent elevation} = 50.9 + (40 \times -1.2\%) = 50.42m$$

$$\text{Roadway elevation} = 51.1 + 0.8 = 51.90m$$

$$y = 51.90 - 50.42 = 1.48m$$

$$E = \frac{AL}{800} = \frac{(0.8 - (-1.2)) \times L}{800} = \frac{L}{400}$$

$$y = 4E \left(\frac{x}{L}\right)^2 = 4\left(\frac{L}{400}\right) \times \left(\frac{\frac{L}{z} + 40}{L}\right)^2 = 1.48 \quad \Rightarrow \quad L = 416.7m$$