

1.

a) Looking @ 'A':

$$v = v_{\max}$$

$$u = 0$$

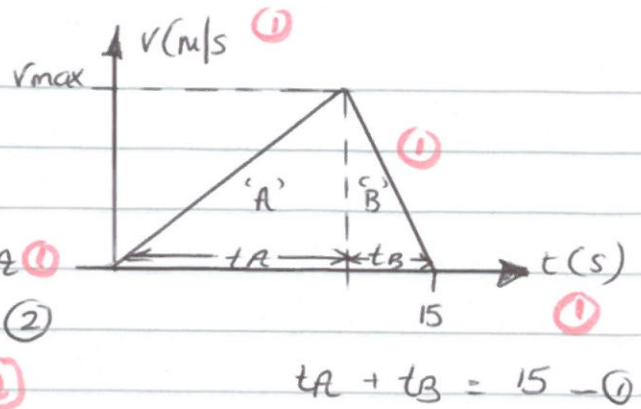
$$a = 1.16 \text{ m/s}^2$$

$$t = t_A$$

$$v = u + at \quad (1)$$

$$v_{\max} = 0 + 1.16 t_A \quad (1)$$

$$t_A = \frac{v_{\max}}{1.16} \quad (2)$$



$$t_A + t_B = 15 \quad (1)$$

Looking @ 'B':

$$v = 0$$

$$u = v_{\max}$$

$$a = -3.22 \text{ m/s}^2$$

$$t = t_B$$

$$v = u + at \quad (1)$$

$$0 = v_{\max} + 3.22 t_B \quad (1)$$

$$t_B = \frac{v_{\max}}{3.22} \quad (3)$$

$$t_A + t_B = 15$$

$$\frac{v_{\max}}{1.16} + \frac{v_{\max}}{3.22} = 15 \quad (1)$$

$$v_{\max} \left(\frac{1}{1.16} + \frac{1}{3.22} \right) = 15 \quad (1)$$

$$1.17 v_{\max} = 15 \quad (1)$$

$$v_{\max} = \frac{15}{1.17} = \underline{\underline{12.82 \text{ m/s}}} \quad (1)$$

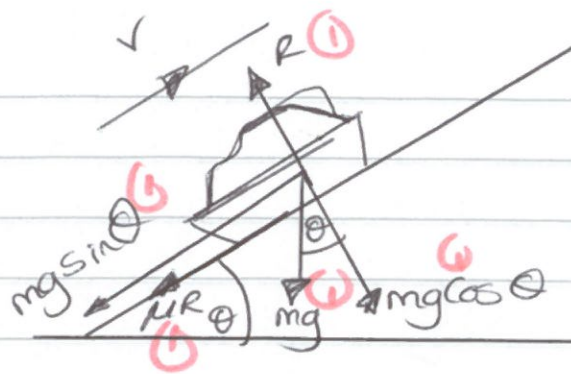
b) $s = \text{Area of graph}$

$$s = \frac{1}{2} b \times h \quad (1)$$

$$s = \frac{1}{2} \times 15 \times 12.82 \quad (1)$$

$$\underline{\underline{s = 96.15 \text{ m}}} \quad (1)$$

2.



$$\sin \theta = \frac{\text{opp}}{\text{hyp}}$$

$$\sin \theta = \frac{1}{4}$$

$$\theta = \sin^{-1}\left(\frac{1}{4}\right)$$

$$\theta = 14.48^\circ$$

$$F = \mu R + mg \sin \theta$$

$$F = \mu mg \cos \theta + mg \sin \theta$$

$$F = (0.2 \times 32000 \times 9.81 \times \cos 14.48) + (32000 \times 9.81 \times \frac{1}{4})$$

$$F = 139269.67 \text{ N}$$

$$P = Fv$$

$$v = \frac{P}{F} = \frac{80000}{139269.67 \text{ N}} = \underline{\underline{0.57 \text{ m/s}}}$$

3.

$$a) \quad k = 0.6 \text{ m} = 600 \text{ mm} \quad (1)$$

$$T = 4114 \text{ Nm} \quad (1)$$

$$\omega_1 = 0 \quad (1)$$

$$\omega_2 = 1600 \text{ rpm} \times \frac{2\pi}{60} = 167.55 \text{ rad/s} \quad (1)$$

$$t = 8 \text{ s} \quad (1)$$

$$\alpha = ? \quad (1)$$

$$\omega_2 = \omega_1 + \alpha t \quad (1)$$

$$\alpha = \frac{\omega_2 - \omega_1}{t} \quad (1)$$

$$\alpha = \frac{167.55}{8} \quad (1)$$

$$\alpha = 20.94 \text{ rad/s}^2 \quad (1)$$

$$T = I\alpha$$

$$I = \frac{T}{\alpha} = \frac{4114}{20.94} = 196.47 \text{ kgm}^2 \quad (1)$$

$$b) \quad I = mk^2$$

$$m = \frac{I}{k^2} = \frac{196.47}{0.6^2} = 545.75 \text{ kg} \quad (1)$$

$$c) \quad P = T\omega = 4114 \times 167.55 = 689300.7 \text{ W} \quad (1)$$

$$= 689.3 \text{ kW} \quad (1)$$

$$d) \quad P = T\omega$$

$$T = \frac{P}{\omega} \quad (1)$$

$$\omega = 1800 \text{ rpm} \times \frac{2\pi}{60} = 188.50 \text{ rad/s} \quad (1)$$

$$P =$$

$$T = \frac{746.5 \times 10^3}{188.5} = 3960.2 \text{ Nm} \quad (1)$$

$$e) \quad KE = \frac{1}{2} I\omega^2 = \frac{1}{2} \times 196.47 \times 188.5^2 = 3.49 \text{ MJ} \quad (2)$$

4.

$$\text{Bore} = 145\text{mm} = 0.145\text{m} \quad (1)$$

$$\text{Stroke} = 183\text{mm} = 0.183\text{m} \quad (1)$$

$$V_1 = \frac{\pi d^2}{4} \times h = \frac{\pi \times 0.145^2}{4} \times 0.198 = 3.27 \times 10^{-3} \text{m}^3 \quad (1)$$

$$V_2 = \frac{\pi d^2}{4} \times h = \frac{\pi \times 0.145^2}{4} \times 0.015 = 2.48 \times 10^{-4} \text{m}^3 \quad (1)$$

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2} \quad (1)$$

$$P_1 = 1.013 \times 10^5 \text{Pa} \quad (1)$$

$$P_2 = 0.38 \times 10^5 \text{Pa} \quad (1)$$

$$T_2 = (655 + 273) \text{K} \quad (1)$$

$$T_1 = \frac{V_1 P_1 T_2}{V_2 P_2} = \frac{3.27 \times 10^{-3} \times 1.013 \times 10^5 \times (655 + 273)}{(2.48 \times 10^{-4} \times 0.38 \times 10^5)} \quad (1)$$

$$\underline{\underline{T_1 = 326.19 \text{K}}} \quad (1)$$

5.

$$\rho = 885 \text{ kg/m}^3$$

$$d_1 = 0.05 \text{ m} = 50 \text{ mm}$$

$$d_2 = 25 \text{ mm} = 0.025 \text{ m}$$

$$\Delta P = 3.5 \text{ kPa} = 3.5 \times 10^3 \text{ Pa}$$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times 0.05^2}{4} = 1.96 \times 10^{-3} \text{ m}^2$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times 0.025^2}{4} = 4.91 \times 10^{-4} \text{ m}^2$$

$$H = \frac{(P_1 - P_2)}{\rho g} = \frac{3.5 \times 10^3}{(885 \times 9.81)} = 0.40 \text{ m}$$

$$Q = 1.96 \times 10^{-3} \sqrt{\frac{(2 \times 9.81 \times 0.4)}{[(1.96 \times 10^{-3} / 4.91 \times 10^{-4})^2 - 1]}} = 4.49 \times 10^{-4} \text{ m}^3/\text{s}$$

or 0.00045 m/s

$$6. \text{ Area of fins} = \frac{\pi(d_o^2 - d_i^2)}{4} \quad \begin{matrix} d_o = 2 \times 0.08 = 0.16 \text{ m} \\ d_i = 2 \times 0.07 = 0.14 \text{ m} \end{matrix}$$

$$= \frac{\pi(0.16^2 - 0.14^2)}{4}$$

$$= 4.71 \times 10^{-3} \text{ m}^2$$

$$\text{2 sides to each fin} = 2 \times 4.71 \times 10^{-3}$$

$$\text{8 fins} = 8 \times 2 \times 4.71 \times 10^{-3}$$

$$= \underline{0.075 \text{ m}^2}$$

$$Q = 56.7 \epsilon A \left[\left(\frac{T_2}{1000} \right)^4 - \left(\frac{T_1}{1000} \right)^4 \right]$$

$$\frac{Q}{56.7 \epsilon A} = \left(\frac{T_2}{1000} \right)^4 - \left(\frac{T_1}{1000} \right)^4$$

$$\frac{Q}{56.7 \epsilon A} + \left(\frac{T_1}{1000} \right)^4 = \left(\frac{T_2}{1000} \right)^4$$

$$\sqrt[4]{\frac{Q}{56.7 \epsilon A} + \left(\frac{T_1}{1000} \right)^4} = \frac{T_2}{1000}$$

$$T_2 = 1000 \sqrt[4]{\frac{Q}{56.7 \epsilon A} + \left(\frac{T_1}{1000} \right)^4}$$

$$T_2 = 1000 \sqrt[4]{\frac{1.2}{(56.7 \times 0.7 \times 0.075)} + \left(\frac{288}{1000} \right)^4}$$

$$T_2 = \underline{\underline{800.20 \text{ K.}}}$$

17.

$$D = 60\text{mm} = 0.06\text{m} \quad \therefore y = \frac{D}{2} = \frac{0.06}{2} = 0.03\text{m}$$

$$R = 1850\text{m}$$

$$E = 95\text{GN/m}^2 = 95 \times 10^9 \text{N/m}^2$$

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R} \quad \therefore \frac{\sigma}{y} = \frac{E}{R} \quad \sigma = \frac{Ey}{R}$$

$$\sigma = \frac{95 \times 10^9 \times 0.03}{1850}$$

$$\sigma = 1.54 \times 10^6 \text{N/m}^2$$

$$\sigma = 1.54 \text{ MN/m}^2$$

$$I = \frac{\pi D^4}{64}$$

$$\frac{M}{I} = \frac{E}{R}$$

$$M = \frac{EI}{R} = \frac{E \cdot \pi D^4}{64 R}$$

$$M = \left[\frac{95 \times 10^9}{1850} \right] \times \left[\frac{\pi \times 0.06^4}{64} \right] = 32.67 \text{ Nm}$$

$$8. \quad D = 40 \text{ mm} = 0.04 \text{ m} \quad \therefore r = \frac{D}{2} = \frac{0.04}{2} = 0.02 \text{ m}$$

$$G = 110 \times 10^9 \text{ N/m}^2$$

$$T = 560 \text{ Nm} \quad l = 800 \text{ mm} = 0.8 \text{ m}$$

$$\frac{T}{J} = \frac{\tau}{r} \quad \therefore \tau = \frac{T r}{J} = \frac{T r}{\left(\frac{\pi D^4}{32}\right)}$$

$$\tau = \frac{(560 \times 0.02)}{\left(\frac{\pi \times 0.04^4}{32}\right)} = \frac{44.56 \times 10^6 \text{ N/m}^2}{44.56 \text{ MN/m}^2}$$

$$\frac{T}{J} = \frac{G \theta}{l}$$

$$\theta = \frac{T l}{J G} = \frac{T l}{\left(\frac{\pi D^4}{32}\right) \cdot G} = \frac{(560 \times 0.8)}{\left[\left(\frac{\pi \times 0.04^4}{32}\right) \times 110 \times 10^9\right]}$$

$$\theta = 0.016 \text{ radians} \times \frac{360}{2\pi}$$

$$\underline{\underline{\theta = 0.93^\circ}}$$