ID # 15349

Question # 1 Solution

Given data

$F = RN = 15349\ N$

$E = 223 \times 10^6\ KPa$

Elastic limit = 207,000 KPa

n = 0 . first two digit of R.

n = 0.15

N = 1

Dimension X = 1st two digit of R + 5cm

X = 15 + 5 = 20cm

Y = 15

Diameter of shaft d = ???

Solution: Maximum shear stress theory

$$\tau_{max} = \left\{ \frac{\sigma_{max} - \sigma_{min}}{2} \right\}$$

$$\tau_{yp} = \frac{\sigma_{yp}}{2}$$

$\Sigma M_B = 0$

$-15 \times 0.6 + F_{CD} \times 0.2 = 0$

$\Rightarrow \boxed{F_{CD} = 45 kN}$

$\Sigma M_D = 0$

$-(15 \times 0.4) - F_{AB} \times 0.2 = 0$

$\Rightarrow \boxed{F_{AB} = -30 kN}$

$\therefore$ Displacemt at B $\Rightarrow \delta_B = \dfrac{PL}{AE}$

$$\delta_B = \frac{-30 \times 10^3 \times 0.3}{5 \times 10^{-6} \times 70 \times 10^9}$$

$$\boxed{\delta_B = -0.0257 m}$$

Displacement at D

$$\delta_D = \frac{PL}{AE}$$

$$\delta_D = \frac{45 \times 10^3 \times 0.4}{60 \times 10^{-6} \times 200 \times 10^9}$$

$$\boxed{\delta_D = 0.0015 m}$$

Displacemt at E

$$\delta_E = \frac{PL}{AE}$$

$$= \frac{15 \times 0.3 + 0.4}{A \times E}$$

$$\boxed{\delta_E = 0.0046 m}$$

(P.t.o)

$\Rightarrow I = I_{web} + 2 I_{flange}$

$\Rightarrow I = \frac{1}{12} t h^3 + 2\left[\frac{1}{12} b t^3 + b t \left(\frac{h}{2}\right)^2\right]$

$\Rightarrow I = \frac{1}{12} t h^2 (6b + h)$

$\therefore e = \frac{b}{2 + \frac{h}{3b}} = \frac{4}{2 + \frac{6}{3(4in)}}$

$\Rightarrow$ $e = 1.6 \text{ in}$

Shear stress distribution for V = R+3 Kips

$\Rightarrow V = 15 + 3$

$V = 18 \text{ kips}$

$\therefore$ Shear stress in the flanges

$\Rightarrow \tau = \frac{VQ}{It} = \frac{Vh}{2I} s$

$\Rightarrow \tau_B = \frac{Vhb}{2\left(\frac{1}{12} th^2\right)(6b+h)} = \frac{6Vb}{th(6b+h)}$

$\Rightarrow \tau_B = \frac{6(18)(4)}{(0.15)(6)(6 \times 4 + 6)} =$ 16 Ksi

Shearing stress in the web.

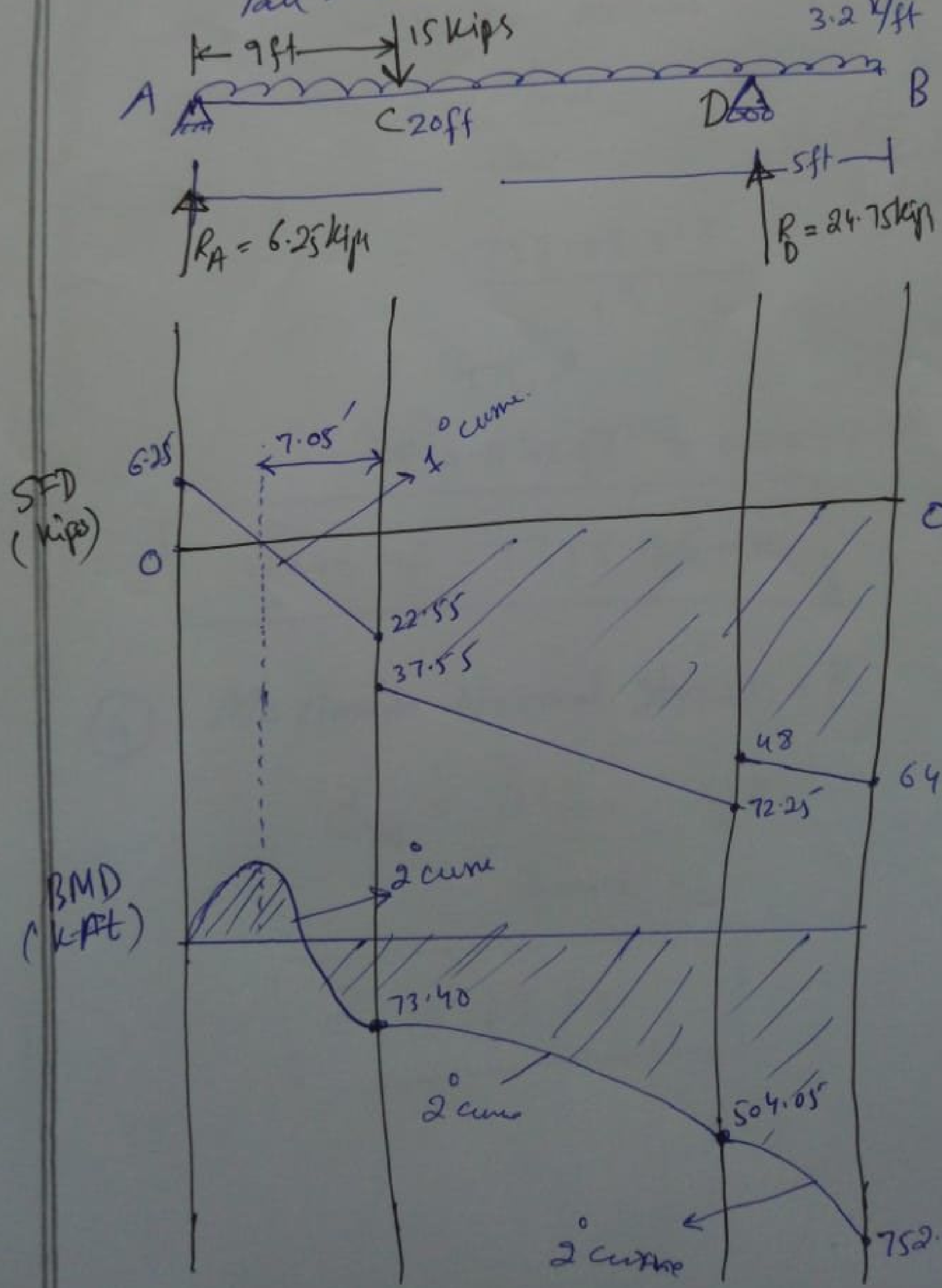
$\tau_{max} = \frac{VQ}{It} = \frac{3V(4b+h)}{2th(6b+h)}$

$\tau_{max} = \frac{3 \times 18 (4 \times 4 + 6)}{2(0.15)(6)(6 \times 6 + 6)} =$ 15.71 Ksi

(P.t.o)

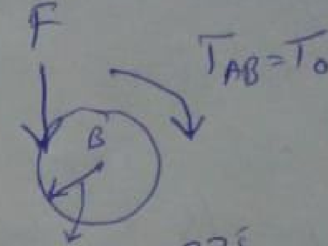
(2) Determine maximum shear and bending moment from shear and bending moment diagram.

$\sigma_{all} = 15+4 = 19$ ksi
$\tau_{all} = 15+1 = 16$ ksi



$\Sigma M_B = 0 \Rightarrow F \times (0.875) - T_0$

$\Sigma M_C = 0 \Rightarrow F \times (2.45) - T_{CD}$

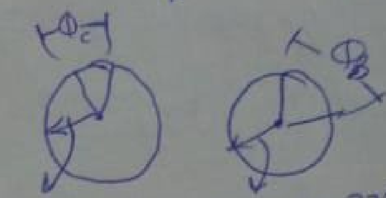


$$\boxed{T_{CD} = 2.8 T_0}$$

$\therefore r_B \phi_B = r_C \phi_C$

$\Rightarrow \phi_B = \frac{r_C}{r_B} + \phi_C$

$\Rightarrow \phi_B = \frac{2.45}{0.875} \cdot \phi_C$



$\phi_B = 2.8 \phi_C$

Find $T_0 = ??$

$\tau_{max} = \frac{T_{AB} c}{J_{AB}} \Rightarrow 10000 = \frac{T_0 + 0.875}{\frac{\pi}{2} \times (0.875)^4}$

$$\boxed{T_0 = 4267 \text{ lb-inch}}$$

$\tau_{max} = \frac{T_{CD} c}{J_{CD}} \Rightarrow 10000 = \frac{2.8 T_0 + (0.5)}{\frac{\pi}{2} + (0.8)^4}$

$$\Rightarrow \boxed{T_0 = 284.35 \text{ lb-in}}$$

→ find Corresponding agle of twist

$\phi_{A/B} = \frac{T_{AB} L}{J_{AB} G} \Rightarrow \phi_{A/B} = 0.0146 \text{ rad} = 0.84°$

$\therefore \phi_{C/D} = \frac{T_{CD} L}{J_{CD} G} = 0.013 \text{ rad} = 0.744°$

$\therefore \phi_B = 2.8 \phi_C = 2.8 \times 0.744 = 2.08°$

$\phi_A = \phi_B + \phi_{A/B} = 2.08 + 0.84 = 2.92°$

$$\boxed{\phi_A = 2.92°}$$

Question # 4

Given data:

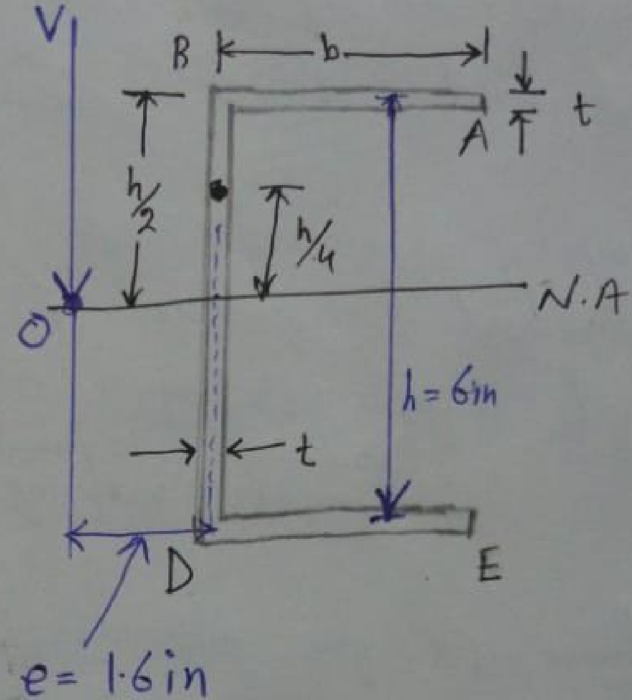
$b = 4\ in$

$h = 6\ in$

$t = 0.15\ in$

$V = 15 + 3$

$V = 18\ Kips$



Required: Shear Stress distribution for V ???

Location of shear center of the channel

Solution

$\because e = \frac{Fh}{I}$

$\therefore F = \frac{Vthb^2}{4I}$

P.t.o

(3) Calculate Required section modulus and select appropriate beam section.

Solution

Minimum acceptable beam Section Modulus

$$S_{min} = \frac{|M|_{max}}{\sigma_{all}}$$

For section selection I will select $W_{18} \times 76$.

$$= \frac{752.05 \times 12}{19}$$

$$= 475 \, in^3$$

$$\simeq 0.275 \, ft^3 \doteq 0.0078 \, m^3$$

$$\boxed{S_{min} \simeq 7785.96 \, mm^3}$$

(4) Maximum Normal Stress = ??

$$\sigma_m = \frac{|M|_{max}}{S_{min}} = \frac{752.05 \times 12}{475}$$

$$\boxed{\sigma_m \equiv 19 \, ksi}$$

Maximum Octahedral shearing stress theory

$$\tau_{oct} = \frac{1}{3}\sqrt{2(\sigma_x^2 - \sigma_x\sigma_y + \sigma_y^2 + 6\tau_{xy}^2}$$

$\because \quad A = \frac{\pi}{4} d^2$

$\Rightarrow d = \sqrt{\frac{4A}{\pi}}$

$\Rightarrow$ For uniaxial stress case

$$\tau_{oct} = \sqrt{2}\left(\frac{\sigma_{yp}}{3}\right) = 0.471\,\sigma_{yp}$$

$\Rightarrow \sigma_{od} = \frac{F}{A}$

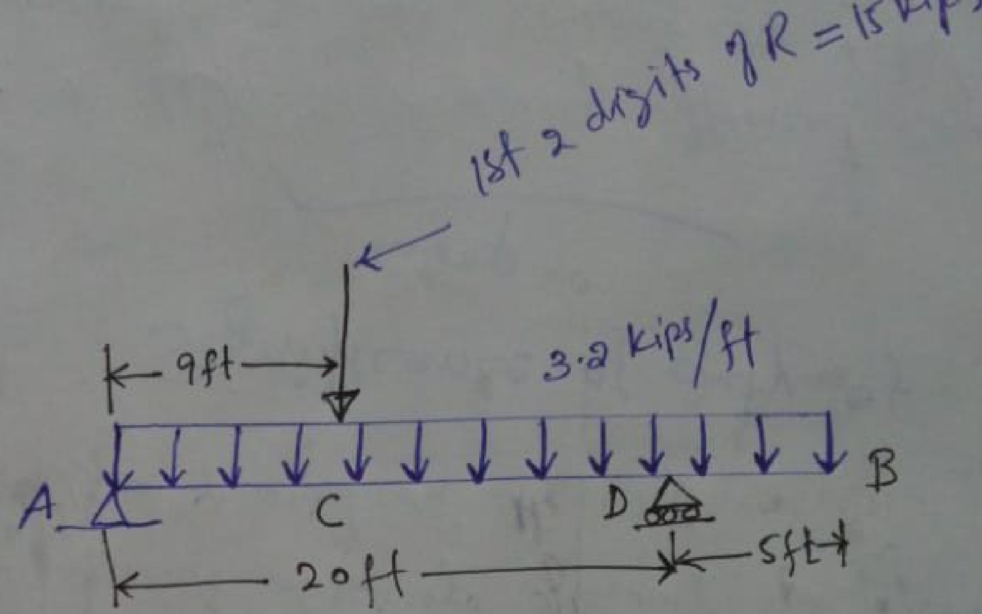
$$\Rightarrow \frac{1}{3}\sqrt{2(\sigma_x^2 - \sigma_x\sigma_y\,\sigma_y^2 + 6\tau_{xy}^2} = \frac{15349}{\frac{\pi}{4}d^2}$$

$\Rightarrow$ $\boxed{d = 0.24m}$

End

Question # 5

Given data



Required (a) R_A and R_D

$\therefore \sum M_D = 0$ (+ clockwise)

$\Rightarrow R_A \times 20 - 15 \times 11 + 3.2 \times 5 \times 2.5 = 0$

$\Rightarrow R_A \times 20 = 125$

$\Rightarrow \boxed{R_A = 6.25K}$

$\therefore R_A + R_D = 15 + 3.2 \times 5$

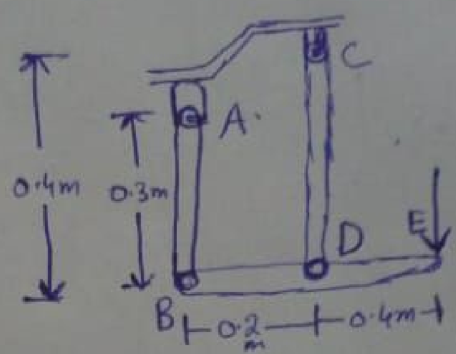
$\Rightarrow 6.25 + R_D = 15 + 3.2 \times 5$

$\Rightarrow \boxed{R_D = 24.75\ kip}$

(P.T.O)

Question # 2

Given data :



For link AB

$E = 70 \text{ GPa}$

$A = 5 \text{ mm}^2$

For link CD

$E = 200 \text{ GPa}$

$A = 60 \text{ mm}^2$

F = First two digit of R

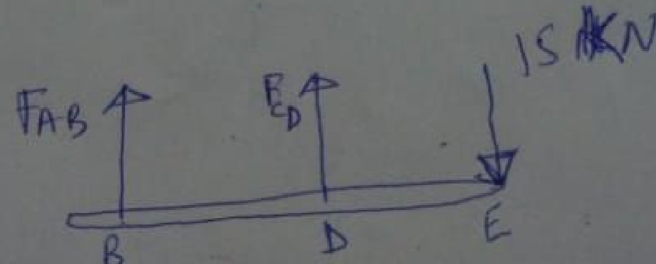
$\Rightarrow F = 15 \text{ N}$

Required Deflections = ??

at B = ?? at D = ?? at E = ??

Solution :

Free body Diagram for BDF



P.T.O

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Question # 3

Given data :-

G for 1st shaft = 15×10^6 psi

G for 2nd shaft = 15×10^6 psi

$\tau_a = 10$ ksi

Dimension X = First two digit of R+10

$\Rightarrow X = 15 + 10$

$X = 25$ in

Required :-

(a) $T_0 = ??$ max torque at the end of shaft AB

(b) The correspondence angle through which end A of shaft AB rotates

Solution :-

$G = 15 \times 10^6$ Pa

$X = 15 + 10 = 25$

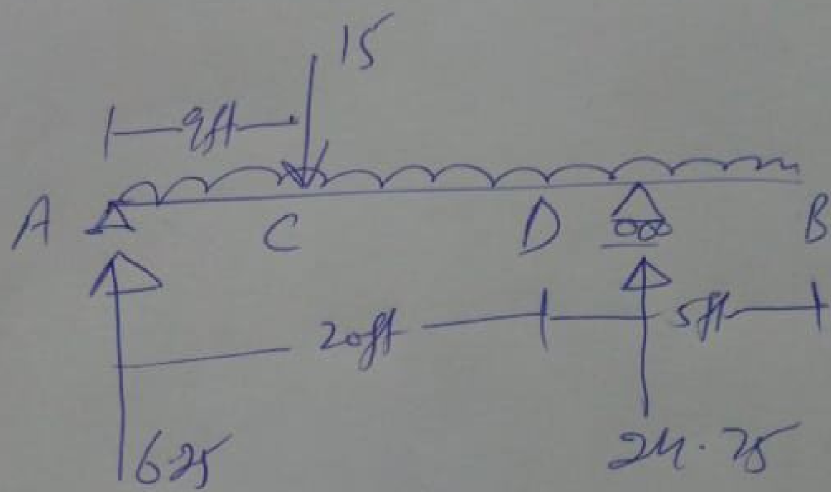
$\tau_{max} = 10$ ksi

$C = 2.45''$

$r_B = 0.875''$

(5) Maximum shearing stress

$$\tau_{max} = \frac{V}{A}$$



$V = 15 + 3.2 \times 25 - 6.25 - 24.75$

$V = 64 kips$

$\tau_{max} = 1224.5$ ksi