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MECHANICS OF MATERIAL By Beer, Johnston, DeWolf, Mazurek

6^{TH} EDITION

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CHAPTER 1:

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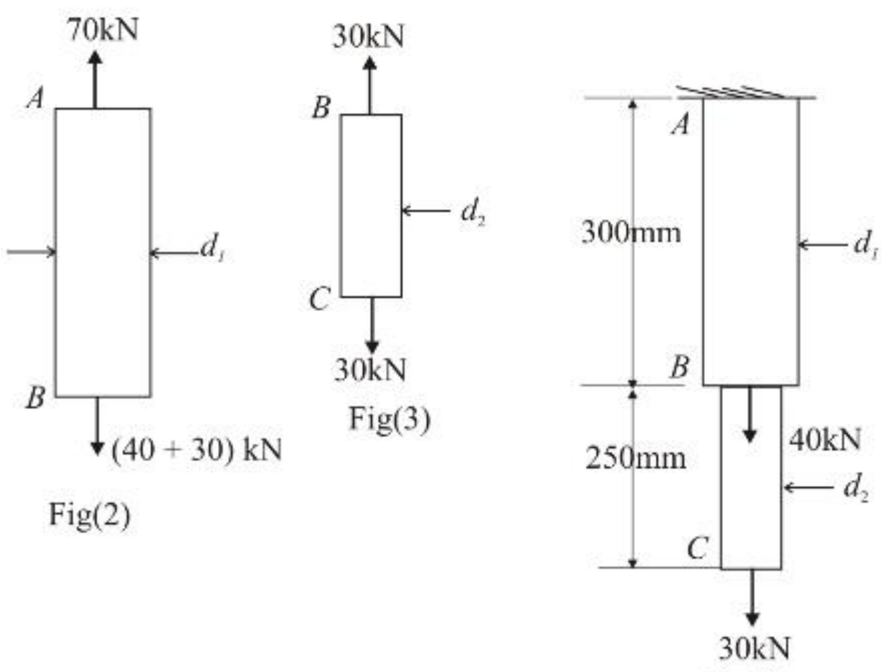

Fig(2) Fig(3) Fig(1)

3-

Given data:

The tensile stress in rod AB = The compressive stress in rod BC

d_1 = diameter of rod AB.

$d_1 = 2$ in

d_2 = diameter of rod BC

$d_2 = 3$in

5-

Given data:

Diameter of steel bolt, $(d_b) = 16$ mm

$= 0.016$ m

Average normal stress in bolts, $(\sigma_b) = 200$ MPa

Average normal stress in spacers, $(\sigma_s) = 130$ MPa

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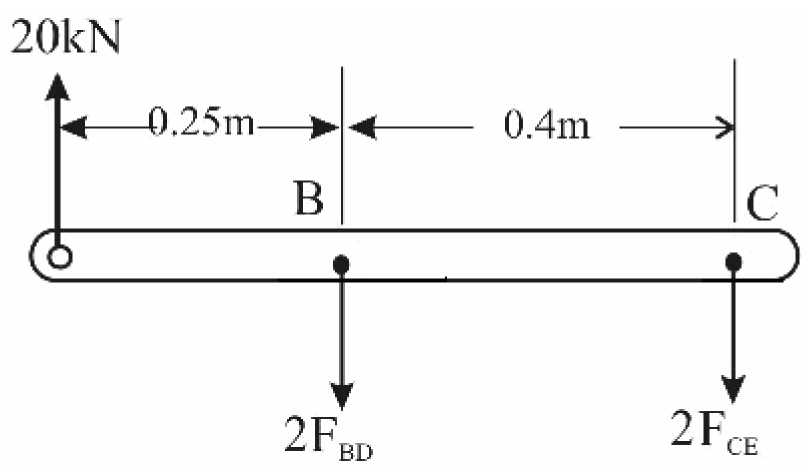
Free body diagram



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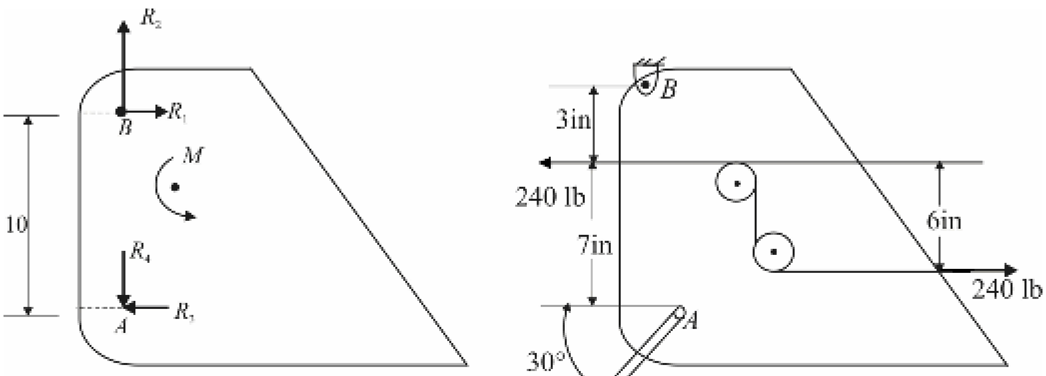
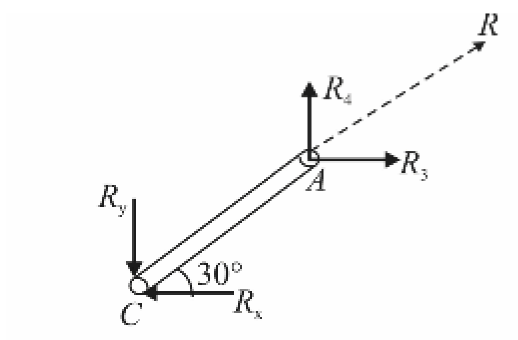


Fig (2) Fig (1)



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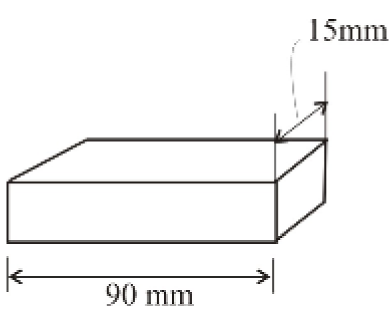

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Given

Maximum shearing stress in steel rod $\tau_s = 18$ ksi

Maximum shearing stress in aluminum plate $\tau_{Al} = 10$ ksi

$$\tau_{Al} = \frac{P}{A}$$

Here A = shear area

= cicumference × thickness

= πd × thickness

$$A = (\pi \times 1.6 \times 0.25) \text{ in}^2$$

$$\tau_{Al} = \frac{P}{A}$$

$$10 = \frac{P}{\pi \times 1.6 \times 0.25}$$

$$P = 12.5 \text{ kips}$$

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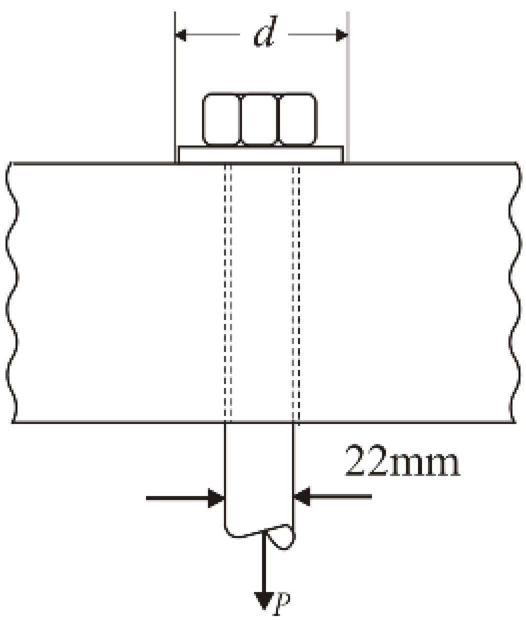

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Given data:

Cross sectional area of the column $A_c = 11.7 \text{ in}^2$

Average normal stress $\sigma = 30$ ksi

Bearing stress in concrete $\sigma_b = 3.0$ ksi

23-

Given

Diameter of rod $d = \frac{5}{8}$ in

Average shearing stress for wood $\tau_{shear} = 100$ psi

27-

Given data:

Diameter of each pin $d = 16$ mm

Let T_{BD} be the force in the link BD

Taking moments about C

$20(0.25+0.4) = T_{BD}(0.4)$

$T_{BD} = 32.5$ kN

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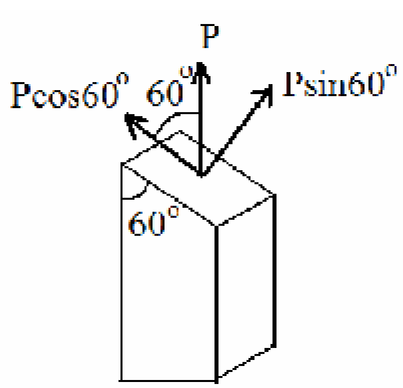

31-

Given that,

$P = 11\text{ kN}$

$\theta = 45°$

Resolving P into components F and V, respectively normal and tangential to the section

Then

$F = P\cos\theta$

$V = P\sin\theta$

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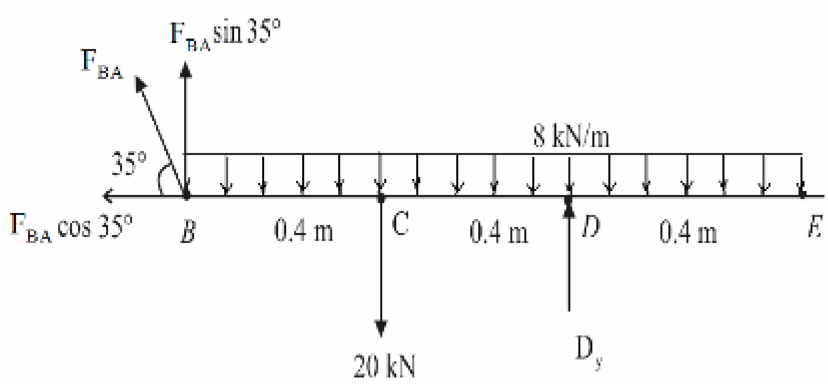
Free body diagram



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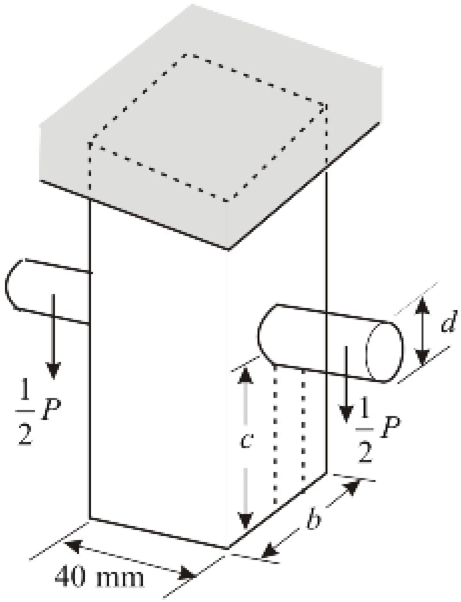

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Given data,

$P = 110$ kN

Ultimate shearing stress $(\tau_u) = 360$ MPa

Factor of safety $(FOS) = 3.35$

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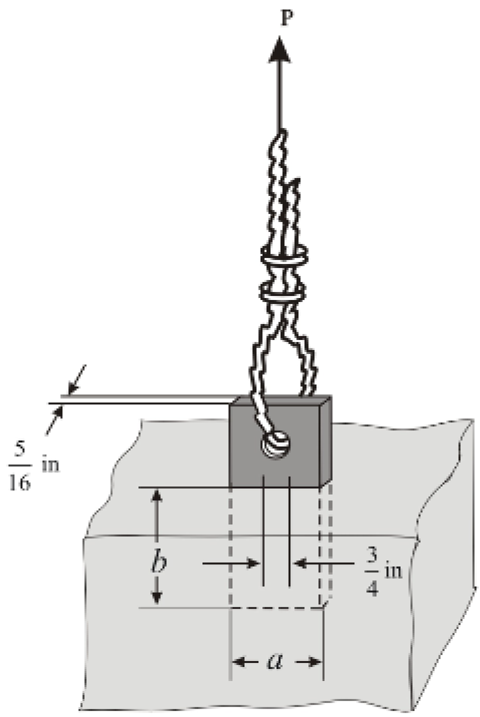

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Given data,
Diameter of the pin at C = 6 mm
Diameter of pins at B and D = 10 mm
Ultimate shearing stress $\tau_u = 150$ MPa
In link BD, Ultimate normal stress $\sigma_u = 400$ MPa
Factor of safety = 3

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Given width of CF member $b = 1\,\text{in}$

Thickness of CF member $t = \frac{1}{4}$ in

Diameter of pins at each end C, F is $d = \frac{1}{2}\text{in}$

For frames ultimate tensile strength is $\sigma_{ult} = 60\,\text{ksi}$

Ultimate shear strength for pins is $\tau_{ult} = 25$ ksi

55-

Given that:
Diameter of the pin at $A = 8$ mm
Diameter of the pins at B and $D = 12$ mm
Ultimate shearing stress, $\tau_u = 100$ MPa
Ultimate normal stress, $\sigma_u = 250$ MPa
Factor of safety = 3.0

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According to load resistance factor design method, the proposed design is acceptable if the following inequality is satisfied

$\gamma_D P_D + \gamma_L P_L \leq \phi P_U$

P_U – Ultimate load

γ_D, γ_L – Coefficients (load factors)

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Given data:
Average normal stress in bone $\sigma = 3.80$ MPa
Force, $P = 1200$ N
Outer diameter $d_O = 25$ mm
$= 0.025$ m

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Given data:
pin diameter $d = 0.8$ in

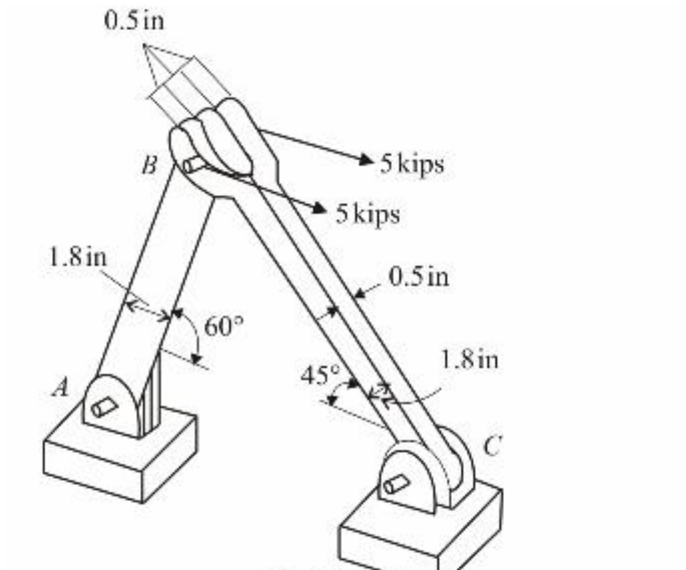


Fig (1)

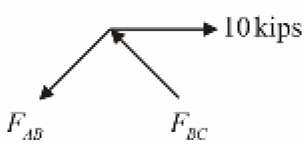


Fig (2)

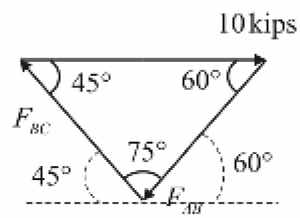
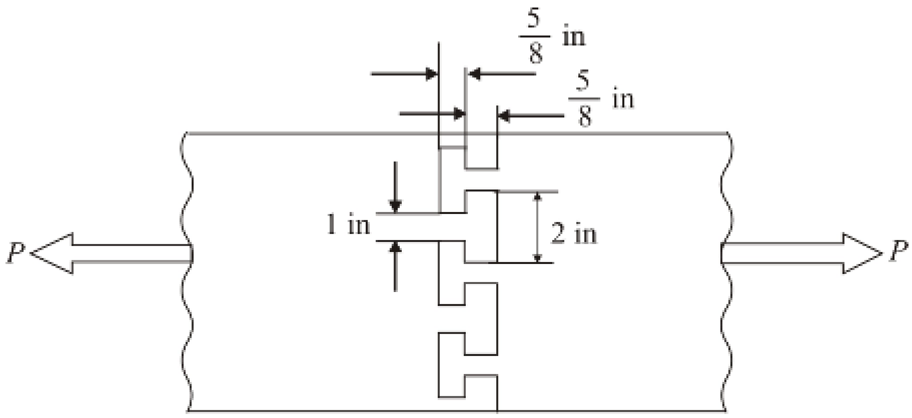


Fig (3)



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Taking moments about C ie.,

$\sum M_C = 0$

$P\cos 40°\times 1.2 + P\sin 40°\times 0.6 - F_{BD}\cos 30°\times 0.6 - F_{BD}\sin 30°\times 0.4 = 0$

$P\times 1.3049 = F_{BD}\times 0.7196$

$F_{BD} = 1.813368.P$

$F_{BD} = 1.813368\times 16\text{ kN}$

$F_{BD} = 29.01\text{ kN}$

$\therefore$ Force in the cable $F_{BD} = 29.013\text{ kN}$

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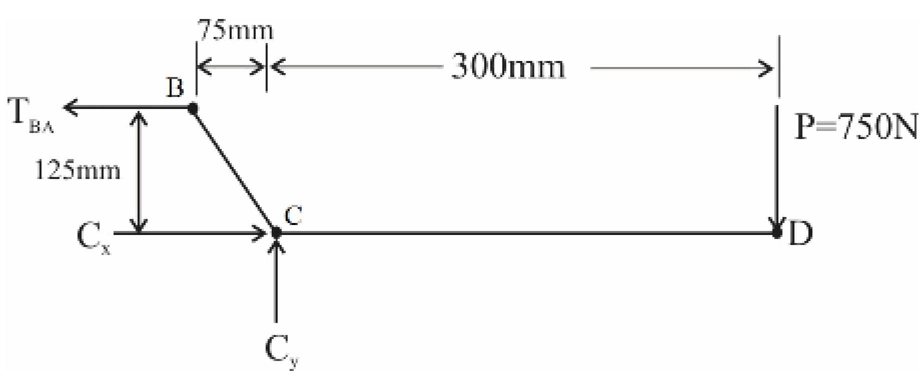

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Given data
Ultimate stress in tension $\sigma_u = 2.5$ ksi
Ultimate stress in shear $\tau_u = 1.3$ ksi
Factor of safety, $F = 3.0$
$P = 2.4$ kips

CHAPTER 2:

1-

Given
Length of the wire
$L = 80\,\text{m}$
Diameter of the wire $d = 5\text{mm}$
Modulus of elasticity $E = 200\,\text{GPa}$
$$E = 200 \times 10^9\ \text{Pa}$$
Ultimate tensile strength $\sigma_{\text{ult}} = 400\,\text{MPa}$
Factor of safety $f_s = 3.2$

3-

Given:
Gauge length $L = 10\,\text{in}$
Diameter of the rod $d = \frac{1}{2}\text{in}$
Modulus of elasticity $E = 10.1 \times 10^6$ psi
Ultimate strength of rod $\sigma_{\text{ult}} = 16\,\text{ksi}$
After loading final gauge length $L_f = 10.009\,\text{in}$
$\therefore$ Elongation in the rod $\delta = L_f - L$
$$= 10.009 - 10$$
$$\delta = 0.009\,\text{in}$$

5-

Given
Length of the rod $L = 12\,\text{in}$
Diameter of the rod $d = 0.5\,\text{in}$
Load on the rod $P = 800\,\text{lb}$
Modulus of elasticity $E = 0.45\times10^6$ psi

7-

Before loading:
Distance between gauge marks $L = 250\,\text{mm}$
Distance of aluminum rod $d = 12\,\text{mm}$
Axial loading $P = 6000\,\text{N}$

9-

Allowable strength of aluminum rod $\sigma_{all} = 22\,\text{ksi}$
Stretch in rod $\delta = 0.08\,\text{in}$
Load applied $P = 500\,\text{lb}$ (tensile)
Modulus of elasticity $E = 10.1\times10^6$ psi

13-

Given that,
The electric motor exerts a torque = 2.8 kN-m

a) Maximum shearing stress in shaft AB, $\tau_{AB} = \dfrac{T_{AB}\times c}{J}$

$T_{AB} = 2.8$ kN

Radius of the shaft AB, $c = \dfrac{56}{2}$ mm

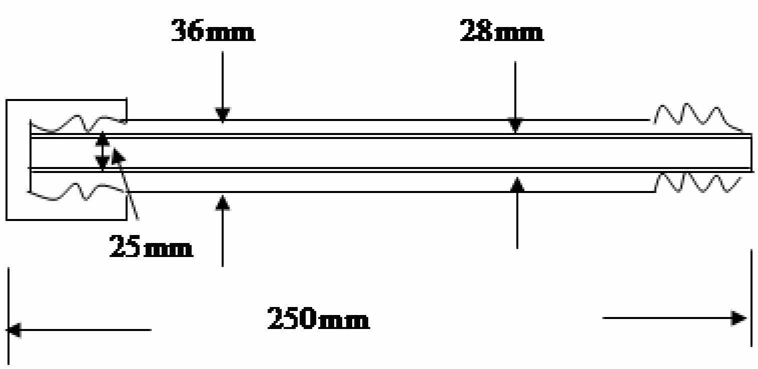
$c = 0.028$ m

Polar moment of inertia, $J = \dfrac{\pi}{2}c^4$

$J = \dfrac{\pi}{2}(0.028)^4$

17-

Given that

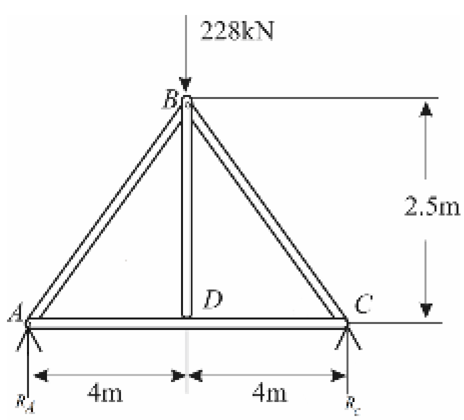


For aluminum $E = 70\text{GPa}$
For steel $E = 105\text{GPa}$

19-

Given that:
Modulus of elasticity, $E = 70\text{GPa}$
Load, $P = 4\text{kN}$
We know that
$1\text{GPa} = 10^9 \dfrac{\text{N}}{\text{m}^2}$
$1\text{kN} = 10^3\text{N}$

23-



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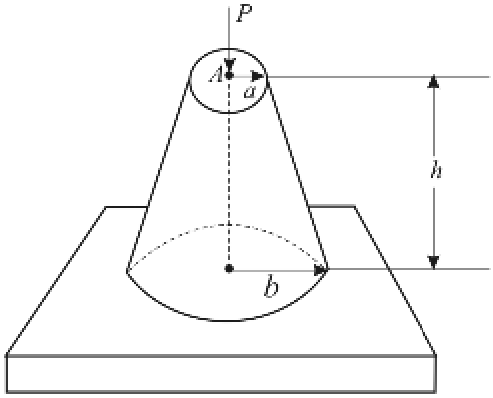

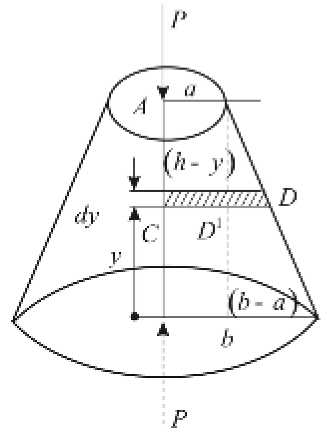

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It is given that volume of tensile specimen is constant while plastic deformation occurs.
Initial diameter $= d_1$
Final diameter $= d$

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Let P_1 and P_2 are loads shared by aluminum and brass rods

$\therefore P_1 + P_2 = P = 45\,\text{kN} \rightarrow (1)$

Deformations in the members

For Aluminium: $\delta_1 = \dfrac{P_1 L_1}{A_1 E_1}$

For Brass: $\delta_2 = \dfrac{P_2 L_2}{A_2 E_2}$

But deformations should be same for whole system

$\therefore \delta_1 = \delta_2$

$$\Rightarrow \frac{P_1 L_1}{A_1 E_1} = \frac{P_2 L_2}{A_2 E_2} \quad (\because L_1 = L_2)$$

$$P_1 = \frac{A_1 E_1}{A_2 E_2} P_2 \rightarrow (2)$$

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Diameter of wires used at A and B are

$$d_A = d_B = \frac{1}{8}\text{in}$$

diameter of Wire at C $d_C = \frac{1}{12}\text{in}$

Modulus of elasticity of aluminum $E_{Al} = 10.4 \times 10^6$ psi

Modulus of elasticity of Steel $E_{st} = 29 \times 10^6$ psi

Maximum allowable stress in aluminum $\sigma_{Al} = 14$ ksi

Maximum allowable stress in steel will $\sigma_{st} = 18$ ksi

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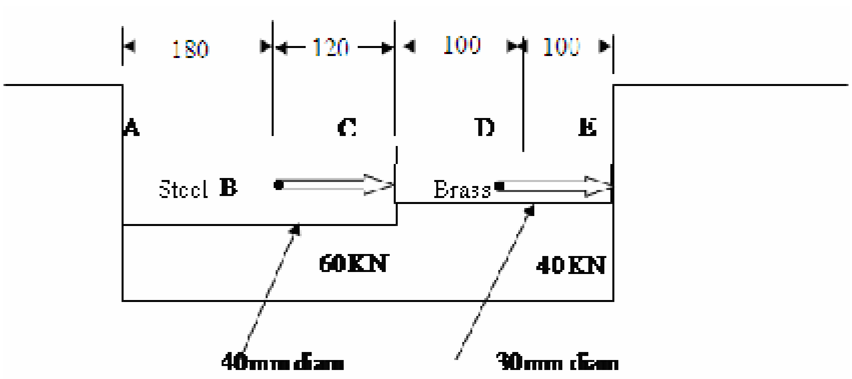

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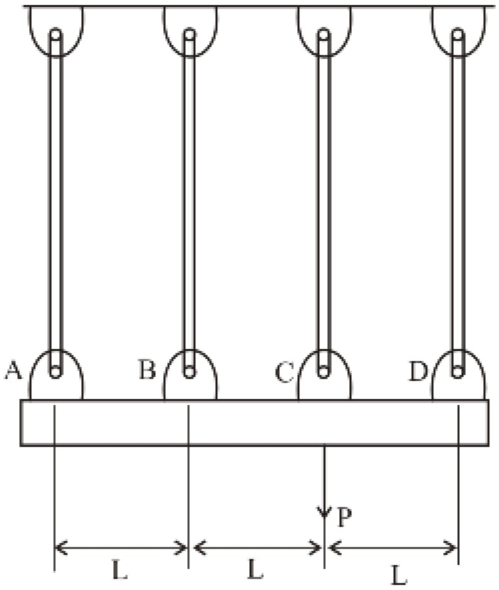

Fig 1

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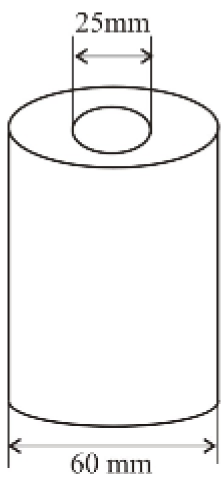

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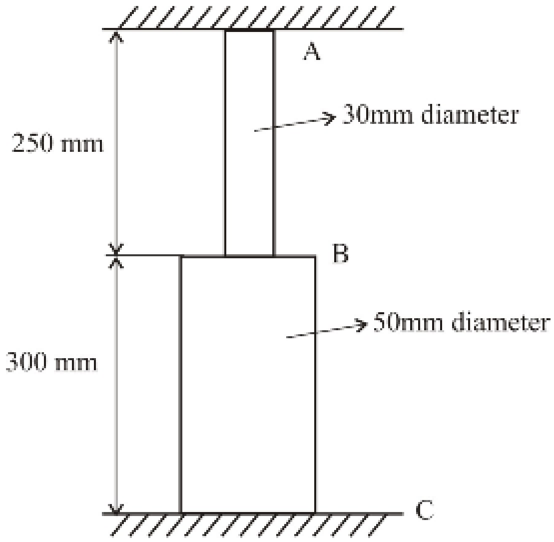
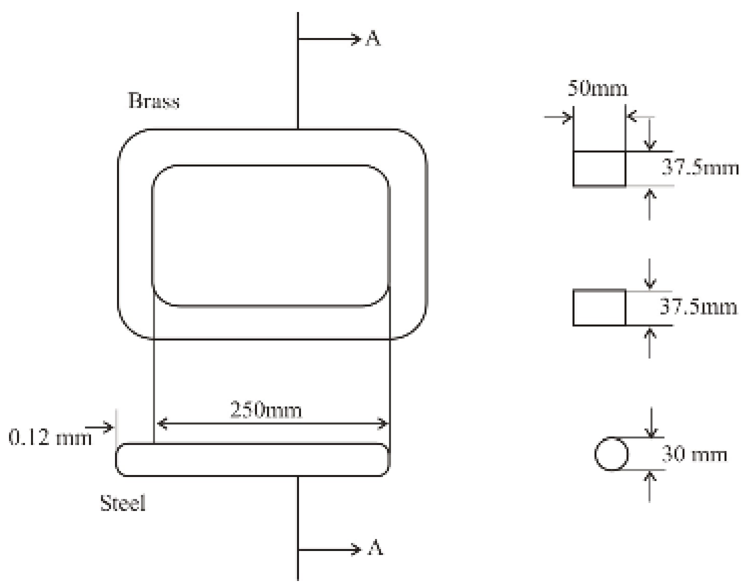

A
30mm diameter
250 mm
B
50mm diameter
300 mm
C

55-


A
Brass
50mm
37.5mm
37.5mm
250mm
0.12 mm
30 mm
Steel
A

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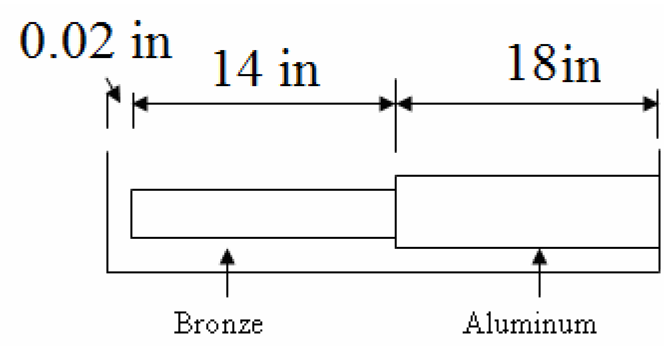

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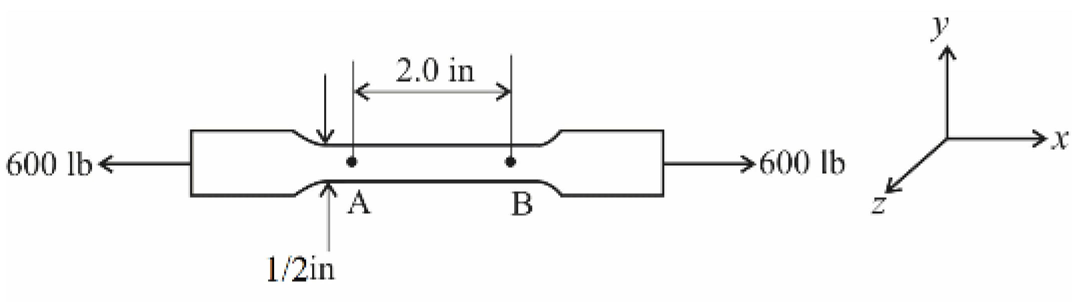

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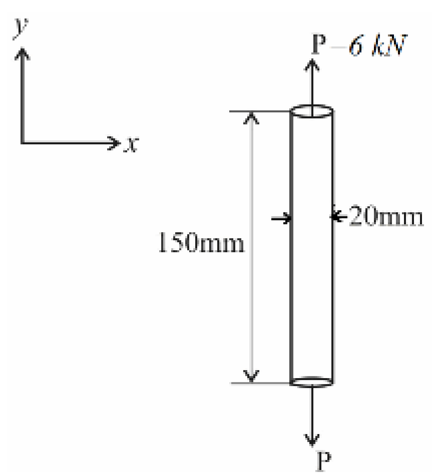

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Length of the block in x-direction $L_x = 100\text{mm}$

Length of the block in z-direction $L_z = 25\text{mm}$

Height h=40 mm

Normal stress in x-direction $\sigma_x = -180\text{MPa}$

Poisson's ratio $\upsilon = 0.35$

Modulus of elasticity $E = 45\text{GPa}$

$\sigma_z = 0$

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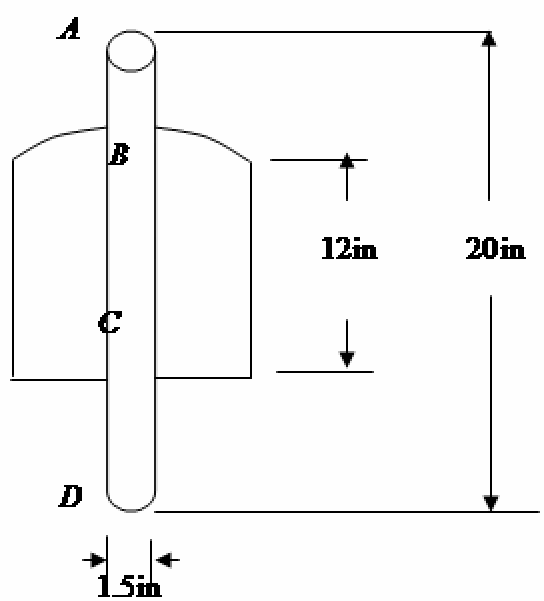
We are given that



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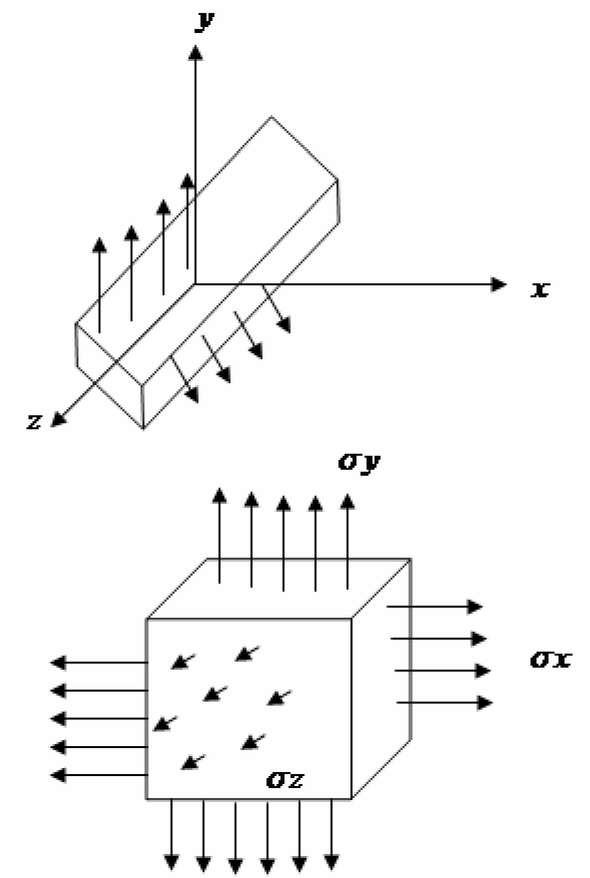

$\epsilon_z = 0$

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Modulus of Rigidity $G = 55\,\text{ksi}$

Shearing force $P = 9\times10^3\,\text{lb}$ (for block)

Length of the block =5.5 in

Breadth of the block = 3.5 in

Area of shearing $A = 3.5\times5.5$

$= 19.25\text{in}^2$

Shearing stress $\tau = \dfrac{P}{A}$

$= \dfrac{9\times10^3}{19.25}$

$= 467.52\,\text{psi}$

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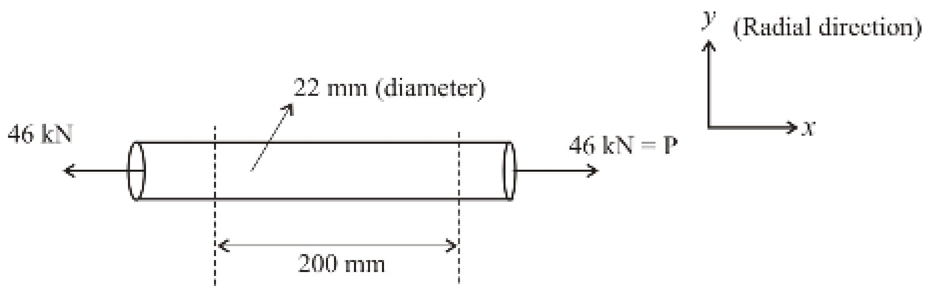

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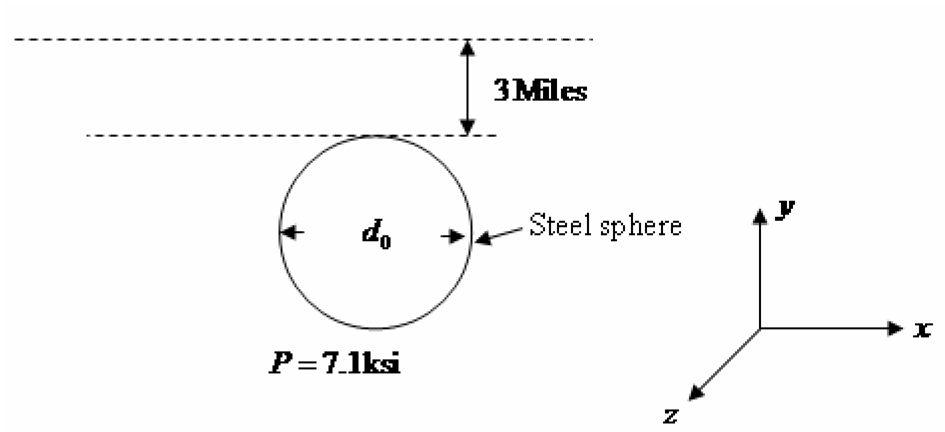

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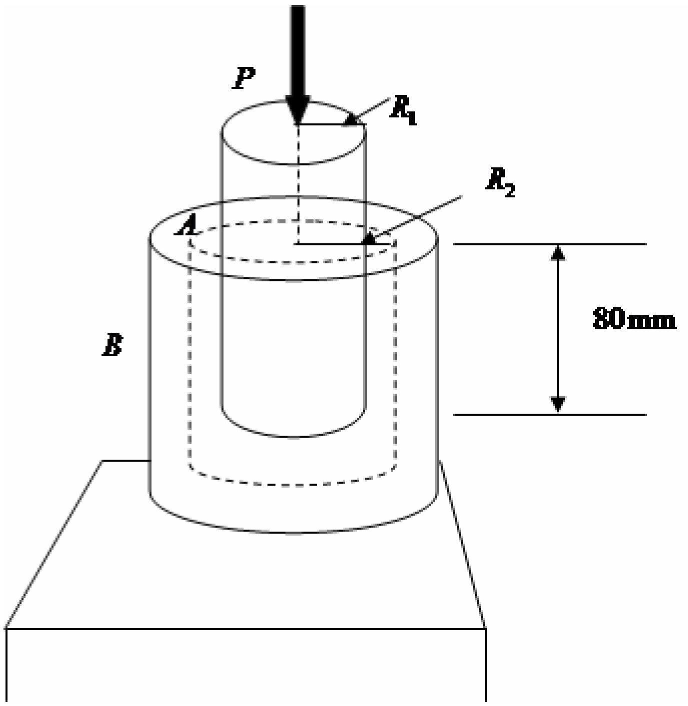

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Given that

$$k = \frac{E}{3(1-2\upsilon)} \quad (1)$$

$$G = \frac{E}{2(1+\upsilon)} \quad (2)$$

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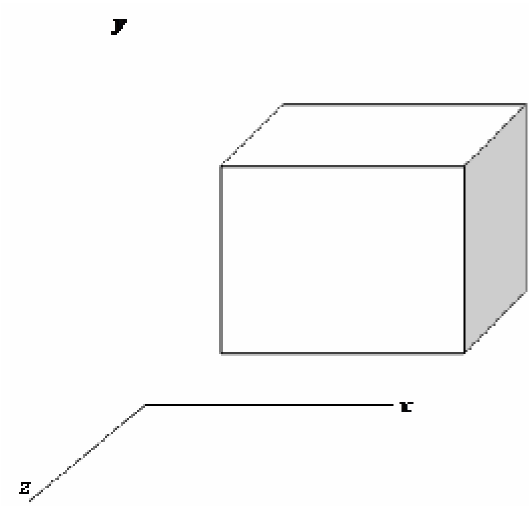

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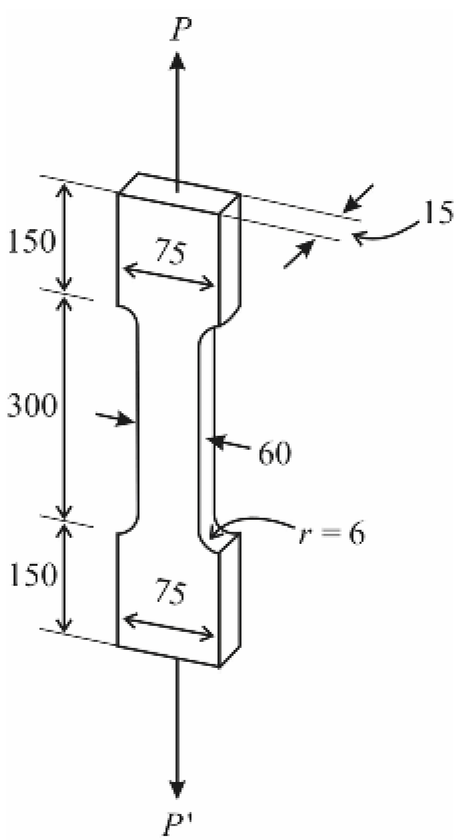

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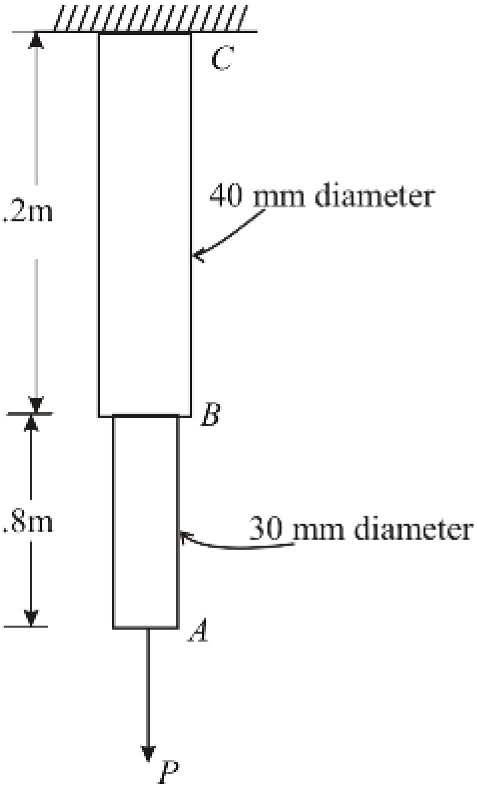

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Length of bar $L = 2.2$ m
Area $A = 30 \times 30$
$= 900\ \text{mm}^2$
Modulus of elasticity $E = 200$ GPa,
Yield Stress $\sigma_Y = 345$ MPa

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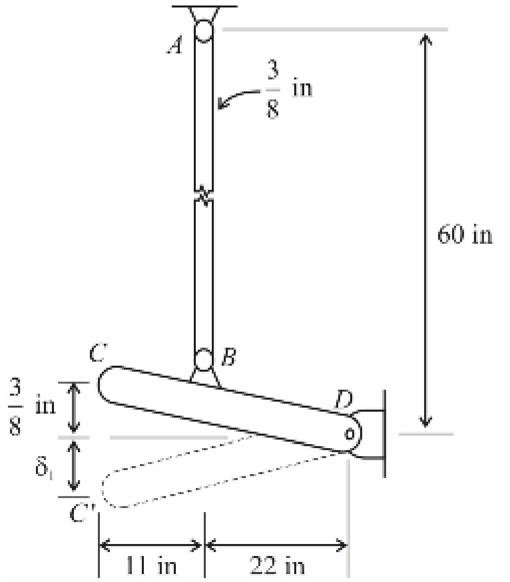

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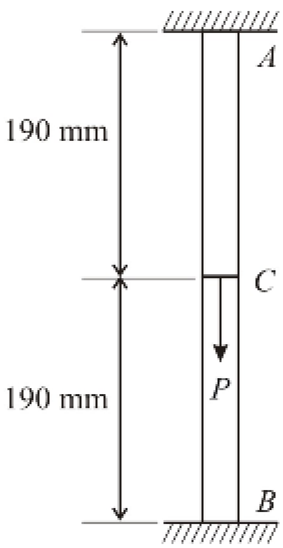

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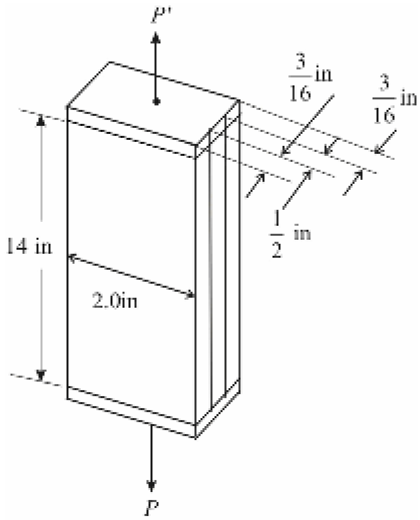

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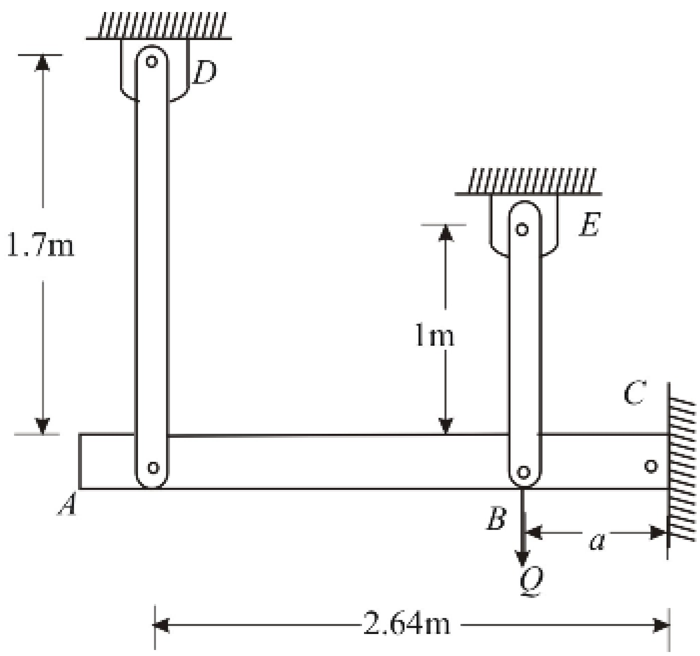

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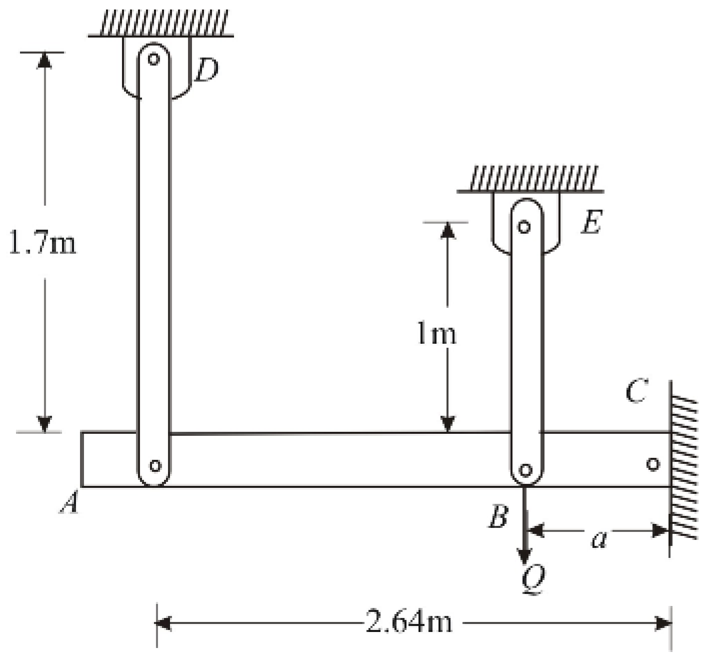

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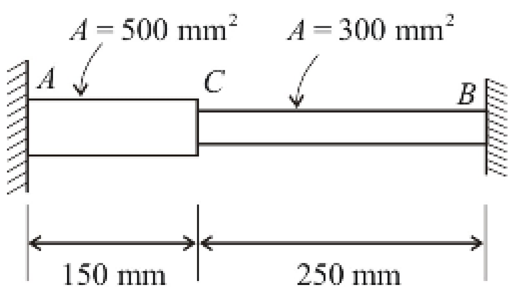

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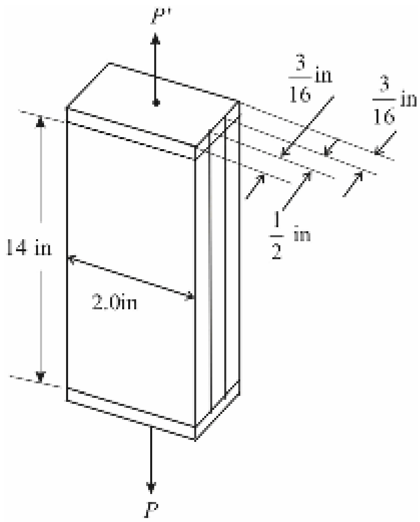

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Given

Initial temperature $T_1 = 70°F$

Residual stress in the aluminum = 58 ksi

Coefficient of thermal expansion for aluminum $\alpha_a = 12.8\times10^{-6}$ / °F

Coefficient of thermal expansion for steel $\alpha_s = 6.5\times10^{-6}$ / °F

Young's modulus $E = 10.9\times10^{6}$ psi

Yield stress $\sigma_Y = 58$ ksi

$\sigma_Y = 58\times10^{3}$ psi

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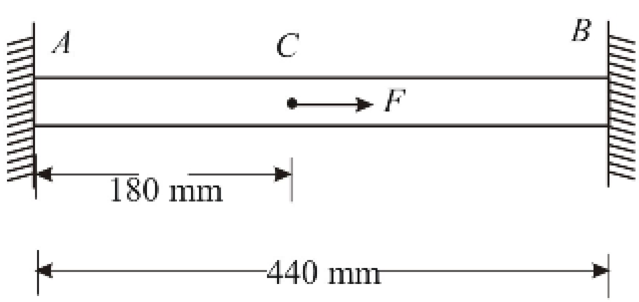

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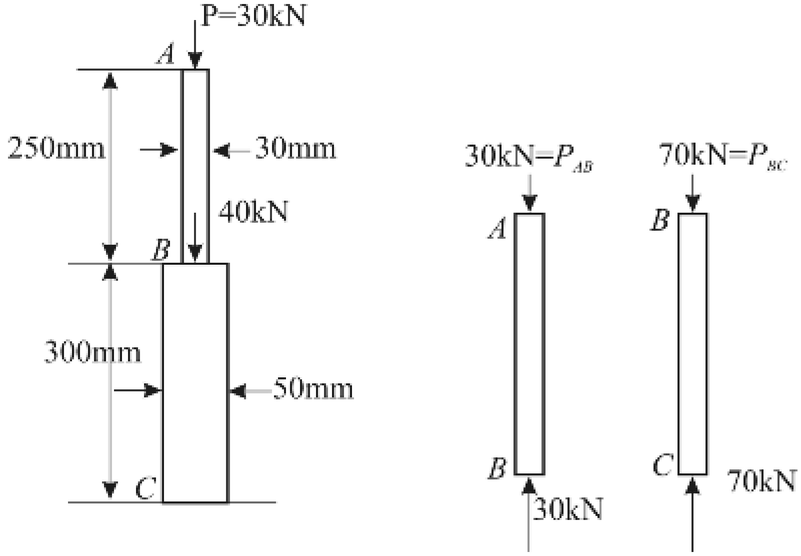

fig(i) Fig(ii) Fig(iii)

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Let

P_{AB} = Tension in portion AB

P_{BC} = Tension in portion BC

Since P is applied at the midpoint of wire therefore by law of statics we have

$P_{AB} = P_{BC}$ ....(i)

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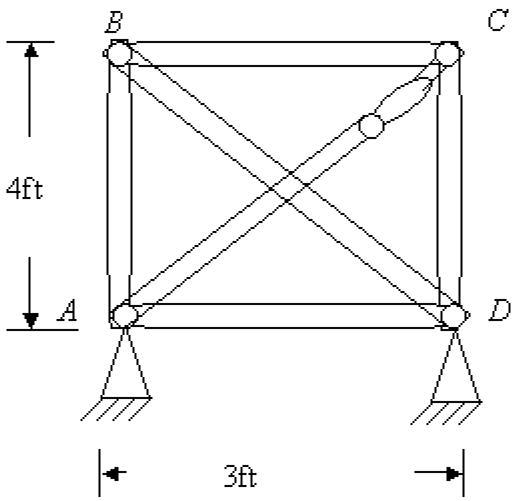
We are given with a structure



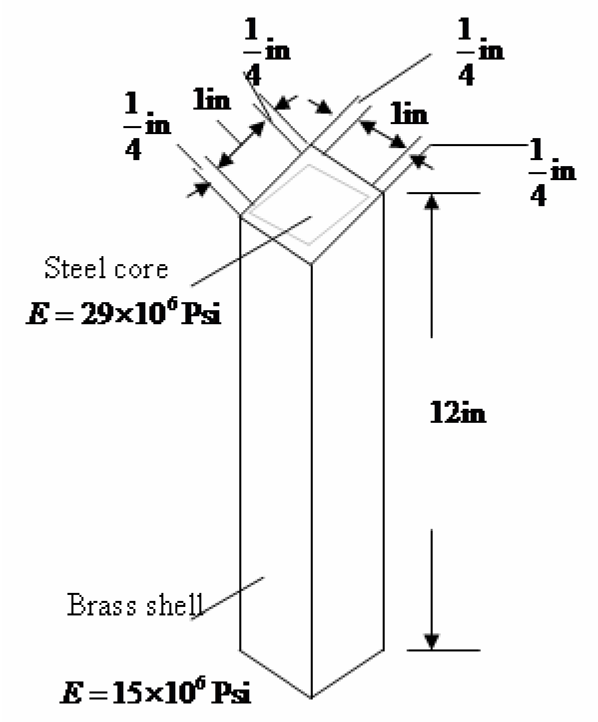
$E = 29\times10^{6}$ psi

Diameter of AB and CD steel rods $= 1\frac{1}{8}$ in

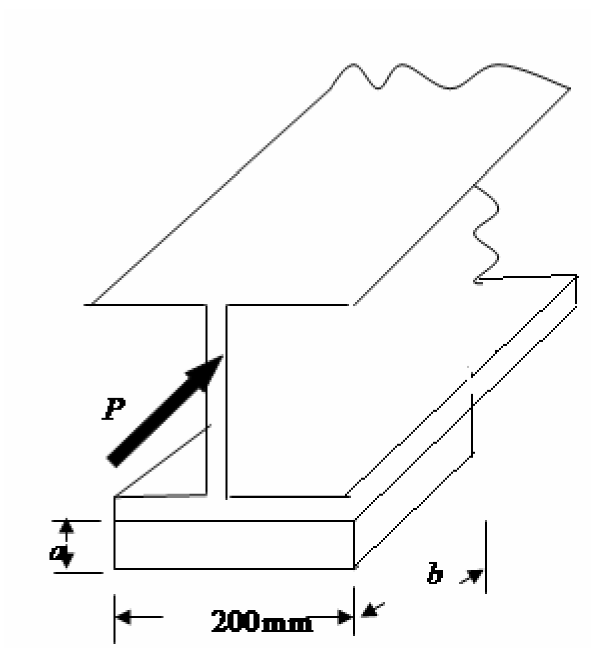
Diameter of BC and AD steel rods $= \frac{7}{8}$ in

$\delta_{CD} = \delta_{AB} = 0\cdot04$ in

131-



133-



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CHAPTER 3:

3-

Given $d = 1.2$ in
Outer diameter $= 1.6$ in
Inner radius $C_1 = 0.6$ in
Outer radius $C_2 = 0.8$ in
Maximum shearing stress $\tau = 7.5$ ksi

5-

Given data:
Torque, $T = 3$ kN-m
Outer diameter, $d = 60$ mm
Diameter at point D, $d_D = 30$ mm

9-

Given data:
Diameter of the shaft AB, $d_{AB} = 30$ mm
Radius of the shaft AB, $c_{AB} = 15$ mm
Diameter of the shaft BC, $d_{BC} = 46$ mm
Radius of the shaft BC, $c_{BC} = 23$ mm

15-

Given data:
Allowable shearing stress in each shaft $\tau_{max} = 15$ ksi
Diameter of rod AB is $d_{AB} = 1.5$ in
Diameter of rod BC is $d_{BC} = 1.8$ in

25-

Given that:

The magnitude of the torque at C, $T_C = 5$ kip-in

Allowable shearing stress in the shafts, $\tau = 8500$ psi

Radius of the gear A, $r_A = 4$ in

Radius of the gear D, $r_D = 2.5$ in

From the relation between the torques and the radius of the gears, $\frac{T_1}{T_2} = \frac{r_1}{r_2}$

$$\therefore \frac{T_F}{T_C} = \frac{r_D}{r_A}$$

$$\frac{T_F}{5} = \frac{2.5}{4}$$

$$T_F = 3.125 \text{ kip-in}$$

27-

Given data:

Torque applied at shaft AB $T_{AB} = 100$ N-m

Diameter of shaft AB, $d_{AB} = 21$ mm

Radius, $c_{AB} = 10.5$ mm

Diameter of shaft CD, $d_{CD} = 30$ mm

Radius, $c_{CD} = 15$ mm

Diameter of shaft EF, $d_{EF} = 40$ mm

Radius, $c_{EF} = 20$ mm

Radius of the gear B, $r_B = 25$ mm

Radius of the gear C, $r_C = 60$ mm

Radius of the gear D, $r_D = 30$ mm

Radius of the gear E, $r_E = 75$ mm

29-

a)

For hollow shaft

Allowable shearing stress, $\tau_m = \dfrac{Tc_2}{J}$

Torque $T = \dfrac{\tau_m J}{c_2}$

Polar moment of inertia, $J = \dfrac{\pi}{2}\left(c_2^4 - c_1^4\right)$

31-

Given data:

Modulus of rigidity, $G = 77\times10^9$ Pa

Applied torque, $T = 250$ N-m

Outer diameter of the shaft, $d = 30$ mm

Inner diameter of the shaft, $d_i = 20$ mm

Length of the shaft, $l = 1.8$ m

35-

Given data:

Torque developed by electric motor $T = 500$ N-m

Modulus of rigidity, $G = 27$ GPa

37-

Given data:

Modulus of rigidity of aluminum rod BC, $G_{Al} = 26$ GPa

Modulus of rigidity of aluminum rod AB, $G_{br} = 39$ GPa

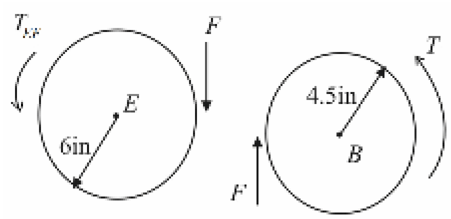
Diameter of solid shaft $d = 12$ mm

$\therefore$ Radius of shaft $c = 6$ mm

Length of brass rod AB, $L_{AB} = 200$ mm

Length of brass rod BC, $L_{BC} = 300$ mm

41-



43-

Given that:
Radius of gears E and C is 'r'
Radius of gears B and D is nr
Diameter of each shaft is 'd'

Considering gears B and C

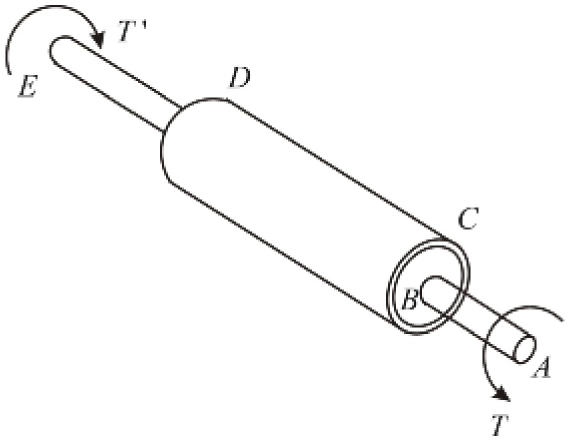
45-

Given data:
The maximum allowable stress $\tau_{max} \le 60$ MPa
Twisting in CD is limited to $\phi_D \le 1.5°$
Rigidity modulus, $G = 77$ GPa
Torque in shaft CD is $T_{CD} = T = 1000$ N-m
Radius of the gear B, $r_B = 100$ mm
Radius of the gear C, $r_C = 40$ mm

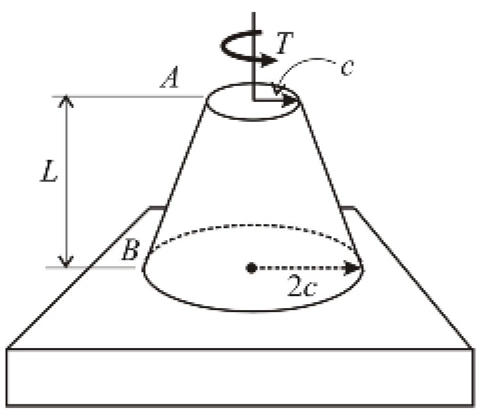
49-

Given data:
Torque applied on pulley A, $T_A = 2$ kip-in
Allowable shear stress, $\tau_{all} = 12$ ksi
Modulus of rigidity, $G = 11.2 \times 10^6$ psi
Radius of gear B, $r_B = 2$ in
Radius of gear C, $r_C = 5$ in
Twisting in D is limited to $\phi = 7.5°$
Total length of the shaft, $L = 30$ in

59-



61-



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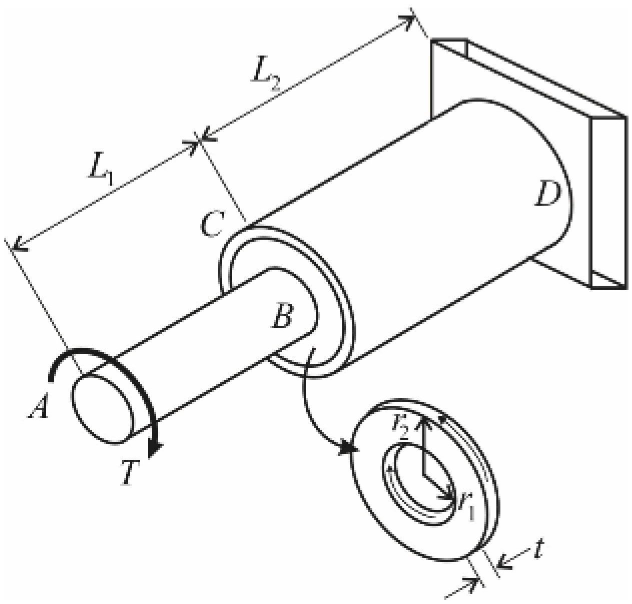


65-

Given data

Diameter of solid shaft $d = 1.5$ in

Radius of the shaft, $c = \dfrac{1.5}{2}$ in

Power $P = 75$ hp

$$= 75 \times 6600 \text{ lb} \cdot \text{in/s}$$

69-

Given data:-

Speed $N = 120$ rpm

Angle of twist $\phi = 2°$

$$= 2 \times \frac{\pi}{180°} \text{ rad}$$

$$\phi = 0.0349 \text{ rad}$$

Length $= 12$ ft

$$= 12 \times 0.3048 \text{ m}$$

$$L = 3.657 \text{ m}$$

Modulus of rigidity, $G = 11.2 \times 10^6$ psi

$$G = 77 \times 10^9 \text{ Pa}$$

Outer diameter $d_2 = 3$ in

Outer radius $C_2 = 1.5$ in

$$C_2 = 0.0381 \text{m}$$

Inner diameter $d_2 = 1.2$ in

Inner radius $C_1 = 0.6$ in

$$C_1 = 0.015 \text{ m}$$

71-

(a) Power transmitted by the shaft $P = \dfrac{2\pi NT}{60}$

$$P = \frac{2\pi \times 180 \times 997.6}{60}$$

$$P = 18.804 \text{kW}$$

Power transmitted, $\boxed{P = 18.804 \text{kW}}$

75-

Given data:

Diameter of the shaft = 1 in

Power, $P = 16$ hp

$= 16 \times 6600$ lb·in/s

Speed of rotation, $N = 1260$ rpm

Torque $T = \dfrac{60P}{2\pi N}$

$= \dfrac{60 \times 16 \times 6600}{2\pi \times 1260}$

$T = 800.32$ lb-in

79-

Given data:

Length of the shaft, $L = 2.5$ m

Diameter of the shaft, $d = 30$ mm

Frequency $f = 30$ Hz

Modulus of the rigidity, $G = 77.2$ GPa

Allowable shearing stress, $\tau_{max} = 50$ MPa

Angle of twist, $\phi = 7.5°$

81-

Given data:

Allowable shearing stress, $\tau = 9500$ psi

Diameter of shaft AB, $d_{AB} = 0 \cdot 75$ in

Radius, $c_{AB} = 0 \cdot 375$in

Diameter of shaft CD, $d_{CD} = 0 \cdot 625$in

Radius, $c_{CD} = 0 \cdot 3125$in

Power, $P = 3$hp

$= 3 \times 6600$

$= 19800$ lb·in/s

87-

Given data:

Power transmitted, $P = 45$ kW

$= 45\times10^3$ W

Radius of fillet, $r = 6$ mm

Allowable shearing stress, $\tau = 40$ MPa

From the diagram

$D = 60$ mm

$d = 30$ mm

Ratio $\dfrac{D}{d} = \dfrac{60}{30}$

$\dfrac{D}{d} = 2$

Ratio $\dfrac{r}{d} = \dfrac{6}{30}$

$\dfrac{r}{d} = 0.2$

From the graph stress concentration factor $K = 1.26$

89-

Given data:

Speed of the shaft $N = 2400$ rpm

Allowable shearing stress, $\tau = 7500$ psi

Larger diameter of the shaft, $D = 1.25$ in

Smallest diameter of the shaft, $d = 1$ in

Radius of the fillet, $r = \dfrac{1}{2}(D-d)$

$= \dfrac{1}{2}(1.25-1)$

$= 0.125$ in

Ratio $\dfrac{D}{d} = \dfrac{1.25}{1}$

$\dfrac{D}{d} = 1.25$

Ratio $\dfrac{r}{d} = \dfrac{0.125}{1}$

$\dfrac{r}{d} = 0.125$

From the graph, the stress concentration factor K = 1.35

91-

Given data:
Largest diameter of the shaft, $D = 30$ mm
Allowable shearing stress, $\tau = 80$ MPa
$$\tau = 80 \times 10^6 \text{ Pa}$$

97-

Given data:
Modulus of rigidity, $G = 77.2$ GPa
Shear stress, $\tau_y = 145$ MPa
Applied torque $T = 1.1\mathrm{T}_y$
Diameter of the shaft, $d = 30$ mm
Length of the shaft, $L = 1.2$ m

103-

Given data:
Diameter of the shaft $= 1.25$ in
Radius $c = 0.625$ in
Elastic shearing stress, $\tau_y = 18$ ksi
Modulus of rigidity, $G = 11.2 \times 10^6$ psi
Length of the shaft, $L = 8$ ft
$$L = 96 \text{ in}$$
Torque, $T = 7.5$ kip-in

105-

Given that:
τ_{Y}, ϕ_Y are the torque and angle of twist at the onset of yield
We have
$$T = \frac{4}{3} T_y \left(1 - \frac{1}{4} \frac{\phi_y{}^3}{\phi^3}\right)$$
$$\frac{T}{T_Y} = \frac{4}{3} \left(1 - \frac{1}{4} \frac{\phi_Y{}^3}{\phi^3}\right)$$

107-

Given data:

Elastic shearing stress, $\tau_y = 145$ MPa

Length of the shaft, $L = 5$ m

Modulus of rigidity, $G = 77.2$ GPa

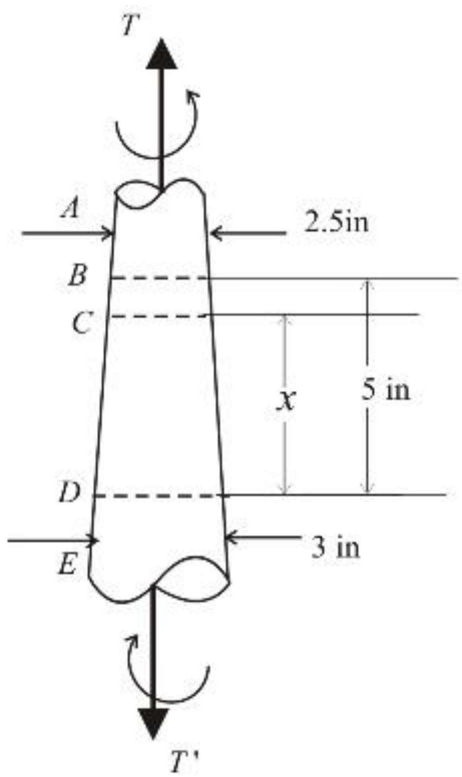
Outer radius of the shaft, $c_2 = \dfrac{60}{2}$ mm

$$c_2 = 30 \text{ mm}$$

Inner radius of the shaft, $c_1 = \dfrac{25}{2}$ mm

$$c_1 = 12.5 \text{ mm}$$

109-



111-

Given data:

a) Maximum shear stress, $\tau = 15$ ksi

Diameter of solid rod, $d = 0.8$in

Radius of solid rod, $c = 0.4$in

b) Length of the rod, $L = 20$in

115-

Given data:

Elastic shear stress, $\tau_y = 22$ ksi

Modulus of rigidity, $G = 11.2\times10^6$ psi

Torque, $T = 75$ kip-in

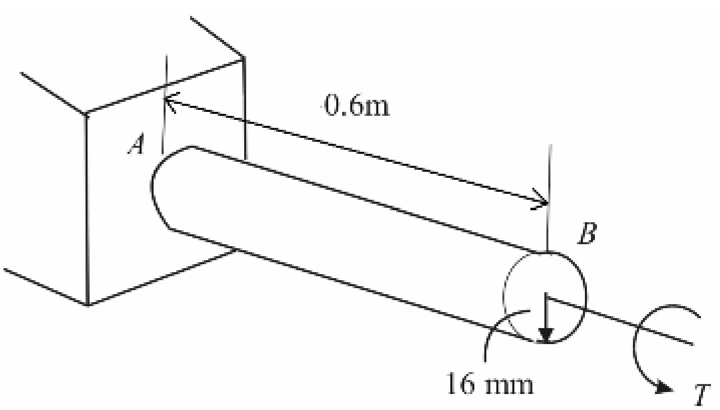
This torque is applied to the rod and then removed.

Radius, $c = 1.2$ in

Length $L = 35$ ft

$L = 420$ in

117-



119-

Given data:
Yield shear stress, $\tau_y = 145\text{MPa}$
Modulus of rigidity, $G = 77.2\,\text{GPa}$
Length of the shaft, $L = 5\text{m}$
Outer diameter of shaft, $d_o = 60\,\text{mm}$
Outer radius of shaft, $c_o = 30\text{mm}$
Inner diameter of shaft, $d_i = 25\text{mm}$
Inner radius of shaft, $c_i = 12.5\,\text{mm}$

125-

Given data:
Allowable maximum shear stress, $\tau_{\max} = 10$ ksi
Modulus of rigidity, $G = 11.2 \times 10^6$ psi
Length of the steel shaft, $L = 20$ ft
$L = 240$ in
Angle of twist, $\phi = 2\pi$ rad

129-

Given data,
Side of square cross section b
Diameter of the circle cross section is b
The both shafts are subjected to the same torque i.e., $T_A = T_B$

131-

Let the diameter of the shaft A is d
Let the side of the square cross section of bar B is b
Given that, A and B have the same cross sectional area

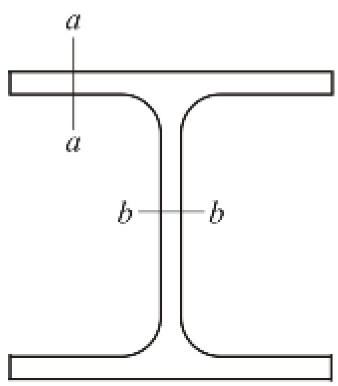
$$\text{i.e., } \frac{\pi}{4}d^2 = b^2$$

$$b = d \times \frac{\sqrt{\pi}}{2} \quad \ldots\ldots \ (1)$$

133-

Given data,
Angle of twist $\phi = 2°$
$b = 30$ mm,
Allowable shearing stress, $\tau_{all} = 50$ MPa
Modulus of rigidity, $G = 27$ GPa

137-



W 8×31

139-

Given that:
Applied torque, $T = 750$ kN-m
Wall thickness, $t = 8$mm

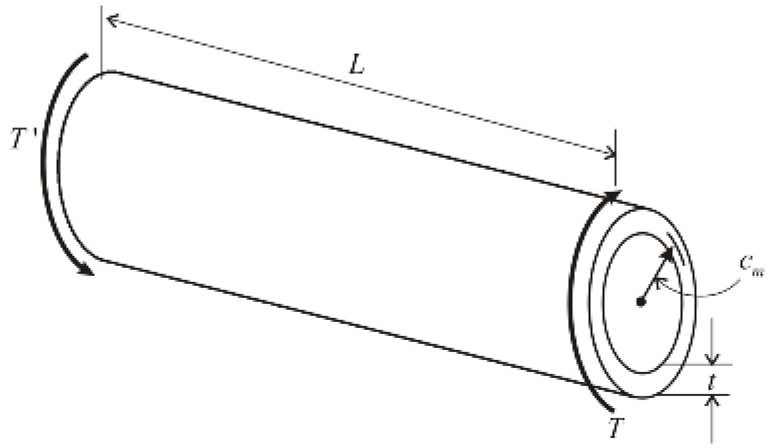
141-

Given data:
Torque applied on the shaft $T = 90$ N-m
At point a thickness, $t = 4$ mm
At point b thickness, $t = 2$ mm

145-

Given that,
Shearing stress, $\tau = 750$ psi
Thickness of the sheet, $t = 0.06$ in
Torque, $T = 1250$ lb-in

149-



151-

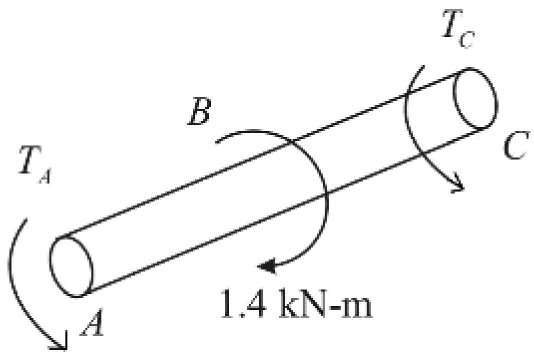
Given data:
Diameter of drill $d = 8$ in
Radius of the drill $c = 4$ in
Modulus of rigidity, $G = 11.2 \times 10^6$ psi
Length of drill bit $l = 5000$ ft

153-

Given data:
Given outer diameter of pipe, $d_0 = 12$ in
$\therefore$ Outer radians, $c_0 = 6$ in
Thickness of the pipe, $t = \dfrac{1}{4}$ in
Helix angle, $\varphi = 45°$
Maximum allowable tensile stress in the weld is $\sigma_{45°} = 12$ ksi

155-

Given that,
Modulus of rigidity, $G = 77.2$ GPa



159-

Given that,
Speed of rotation, $N = 450$ rpm
Fillet radius, $r = 0.5$ in
Allowable shearing stress, $\tau = 7500$ psi
From the diagram

Ratio $\frac{D}{d} = \frac{6}{5}$

$\frac{D}{d} = 1.2$

Ratio $\frac{r}{d} = \frac{0.5}{5}$

$\frac{r}{d} = 0.1$

From the graph the stress concentration factor
$K = 1.33$

161-

Given data:
Maximum shear stress in the steel shell $\tau_{steel} = 150$ MPa
Modulus of rigidity steel, $G_1 = G_{steel} = 77.25$ GPa
Modulus of rigidity of aluminum, $G_2 = G_{Al} = 27$ GPa
Length of the shaft, $L = 2\,\text{m}$
Outer radius, $c_o = 40\,\text{mm}$
Inner radius, $c_i = 30\,\text{mm}$

CHAPTER 4:

5-

Given:

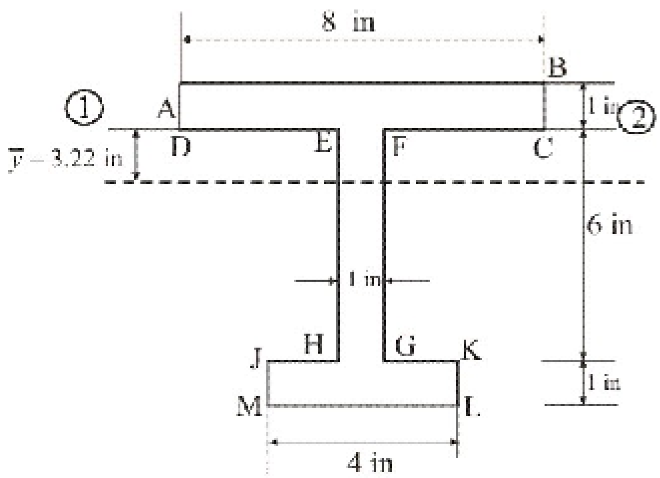
$\sigma_Y = 250\,\text{MPa}$

$\sigma_U = 450\,\text{MPa}$

Factor of Safety = 3

$$\sigma_{all} = \frac{\sigma_U}{3} = \frac{450}{3} = 150\,\text{MPa}$$

11-



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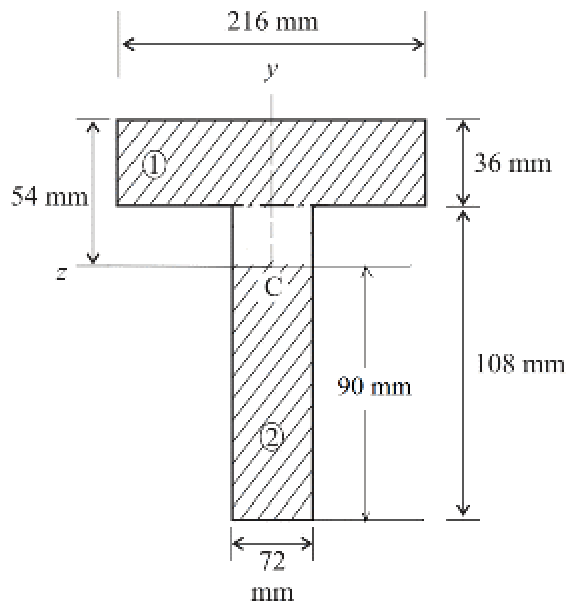

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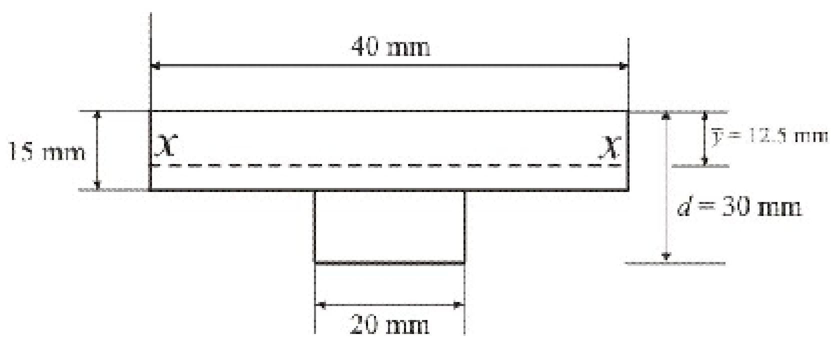
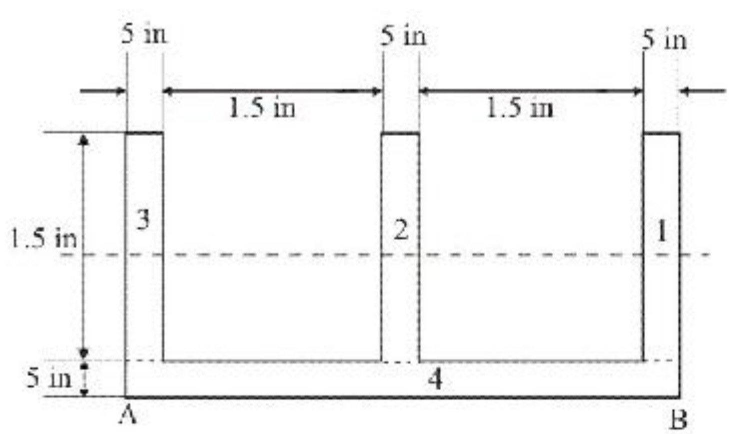


17-



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19-

Given data:

Allowable stress in tension $(\sigma_{\text{all}})_T = 120$ MPa

Allowable stress in compression $(\sigma_{\text{all}})_C = 150$ MPa

21-

Given data:

Young's modulus $E = 29 \times 10^6$ psi

Thickness $t = 0.018$ in

Width, $w = 0.625$ in

Diameter of pulley $d = 8$ in

25-

We know the Bending equation is

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

Where M = Bending moment or couple

I = Moment of inertia about neutral axis

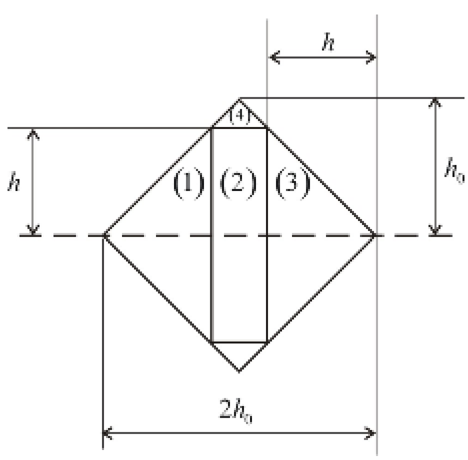
σ = Bending stress at distance 'C'

C = Distance from Neutral axis

E = Modulus of Elasticity

R = Radius of curvature

27-



29-

Given, $E = 10.6\times10^6$ psi ,
$\nu = 0.33$
Moment M = 103.8kip · in
$= 103.8\times10^3$ lb · in

Centroidal moment of inertia, $I = \dfrac{3.25\times5^3}{12} - \dfrac{2.75\times4.5^3}{12}$
$= 12.97\text{in}^4$

31-

Rolled steel beam: $W200\times31.3$
Moment $M = 45$ kN-m
$= 45\times10^3$ N-m
Young's modulus $E = 200$ GPa
$= 200\times10^9$ Pa
Poisson's ratio $\upsilon = 0.29$

33-

The transformed section corresponding to an equivalent bar made entirely of Aluminium as shown in the figure

Since $n = \dfrac{E_B}{E_{AL}}$
$= \dfrac{105\,\text{GPa}}{70\,\text{GPa}}$
$= 1.5$

The width of the central portion of aluminium which replaces the original brass portion, is obtained by multiplying the original width by 1.5, we have $32\times1.5 = 48$

35-

The transformed section corresponding to an equivalent bar made of entirely aluminium is shown in the figure

Since, $n = \dfrac{E_B}{E_A}$
$= \dfrac{105\,\text{GPa}}{70\,\text{GPa}}$
$= 1.5$

41-

Given

Modulus of elasticity for Steel, $E_S = 29\times10^6$ psi

Modulus of elasticity for Wood, $E_W = 1.8\times10^6$ psi

Moment, $M = 450\,\text{kip}\cdot\text{in}$

45-

Given for Steel, $E_S = 29\times10^6$ psi

For word, $E_W = 1.8\times10^6$ psi

$M = 450\,\text{kip}\cdot\text{in}$

47-

Given data:

Modulus of elasticity of concrete, $E_c = 25$ GPa

Modulus of elasticity of steel, $E_s = 200$ GPa

Bending moment, $M = 175\,\text{kN}\cdot\text{m}$

51-

Given data:

Modulus of elasticity of steel rod, $E_s = 30\times10^6$psi

Modulus of elasticity of concrete, $E_c = 3\times10^6$psi

Allowable stress in concrete is $\sigma_c = 1350$ psi

Allowable stress in steel is $\sigma_s = 20$ ksi

53-

Given, allowable stress in steel $= \sigma_s$

Allowable stress in concrete $= \sigma_c$

Modulus of elasticity of steel $= E_s$

Modulus of elasticity of concrete $= E_c$

Distance from top of beam to reinforcing steel – d

59-

$n_1=1$

Ratio, $n_2 = \frac{E_t}{E_c}$

$= \frac{1}{2}$

let x be the distance from top to the neutral axis.
The neutral axis of the beam passes through the centroid of the transformed section.
Summing moments of the transformed area about the neutral axis, we have:

$$\left(n_1 \times 50 \times x \times \frac{x}{2}\right) - n_2 \times 50 \times (100-x)\left(\frac{100-x}{2}\right) = 0$$

$$25x^2 - 12.5(100-x)^2 = 0$$

$$2x^2 - (100^2 + x^2 - 200x) = 0$$

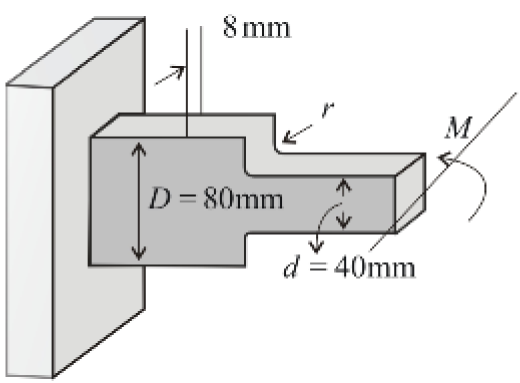
$$x^2 - 400x + 20000 = 0$$

x=41.42mm

61-

Given data:
Allowable stress, $\sigma_{max} = 60$ MPa
(a) Fillet radius, $r = 9$ mm
(b) Fillet Radius, $r = 18$ mm

63-



67-

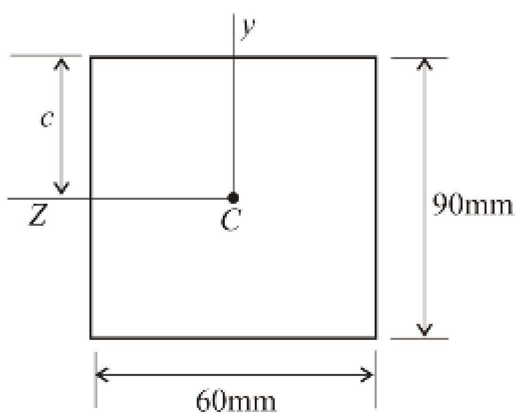
Solution:
Given data
Yield stress
$\sigma_Y = 300\text{MPa}$
$= 300 \times 10^6 \text{ Pa}$

69-

Given data:
Modulus of elasticity, $E = 29 \times 10^6$ psi
Face width of the block, $b = \frac{1}{2}\text{in}$
Yield stress of the prismatic bar, $\sigma_Y = 36$ ksi
Side width $= \frac{5}{8}\text{in}$
Moment of couple applied, $M = 1350 \text{ lb} \cdot \text{in}$

73-

Solution:



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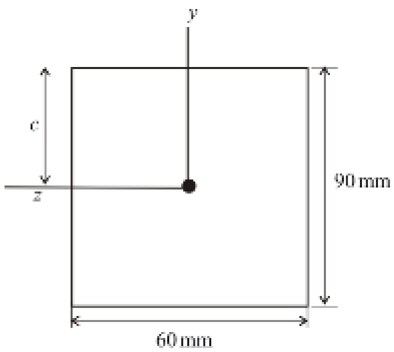

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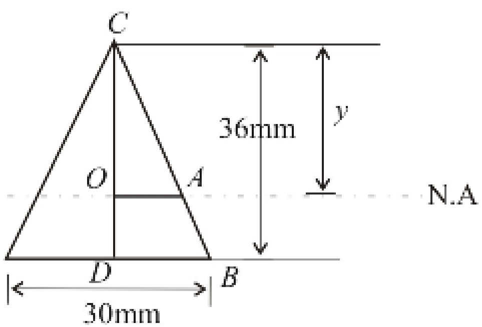
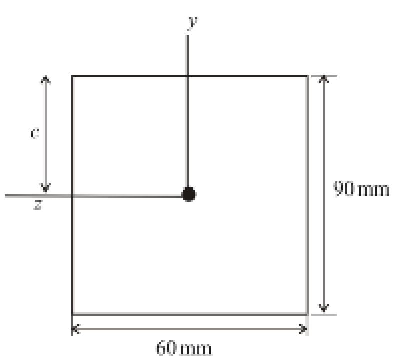
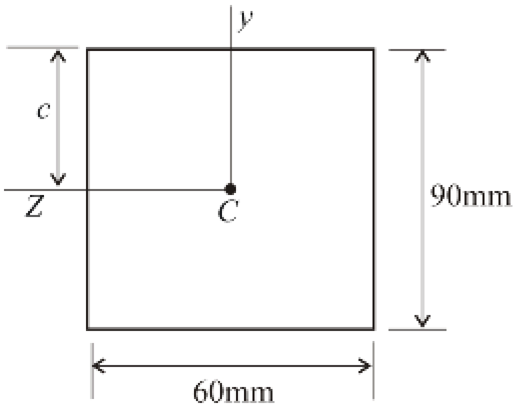


87-



91-



93-

Radius of the circle formed after the rectangular bar is bent $= \rho$

The couple applied is M.

When the couple is removed, radius of curvature $= \rho_R$

Radius of curvature at the on set of yield $= \rho_y$

95-

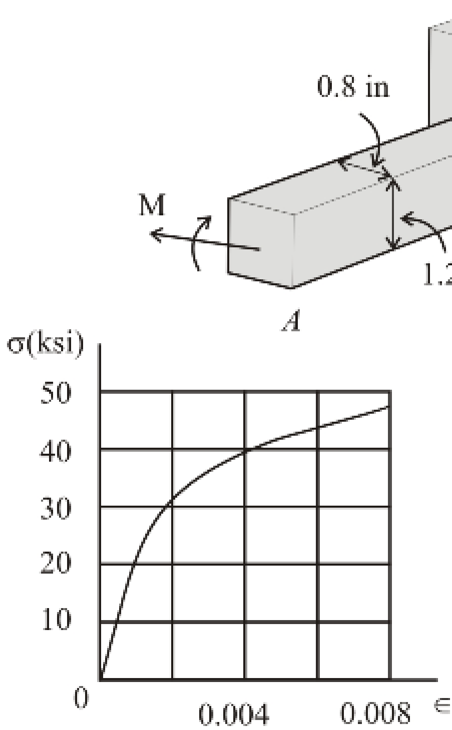
Young's Modulus $E = 200$ GPa

$= 200 \times 10^9$ Pa

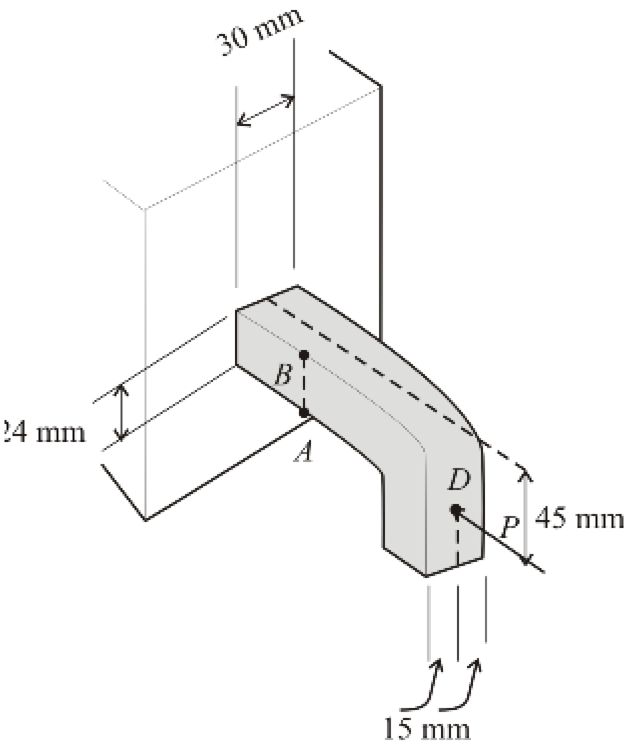
Radius of curvature of bar $\rho = 2.4$ m

Bending moment $M = 350$ N $\cdot$ m

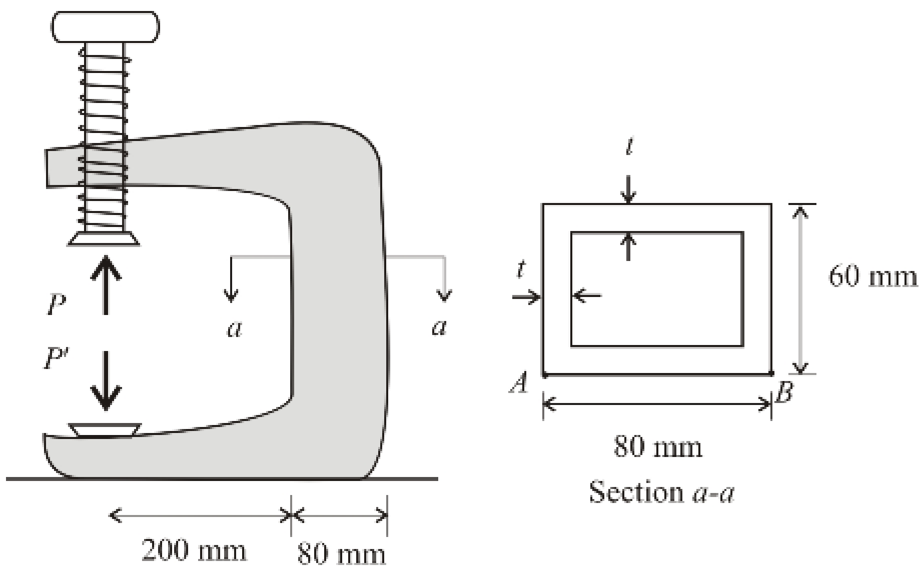
97-



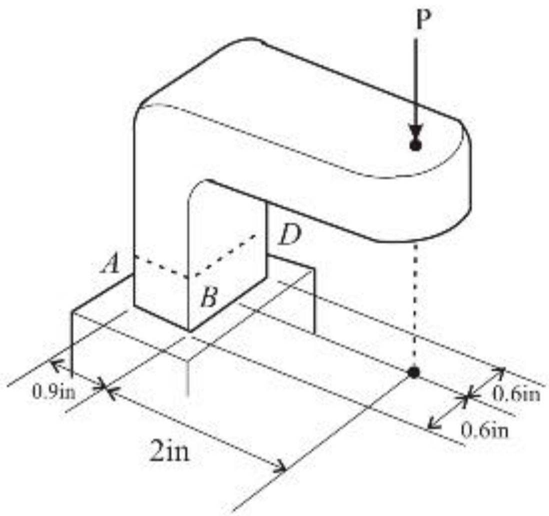
101-


30 mm
B
24 mm
A
D
P
45 mm
15 mm

103-


P
P'
a
a
t
t
60 mm
A
B
80 mm
Section a-a
200 mm
80 mm

105-



107-

Given

Load $P = 100\text{ kN}$

$= 100 \times 10^3\text{ N}$

Radius $a = 40\text{ mm}$

$= 0.04\text{ m}$

109-

Given

Magnitude of force $P = 18\text{ kN}$

$a = 30\text{ mm}$

$= 0.03\text{m}$

Allowable stress $\sigma_{all} = 135\text{ MPa}$

$= 135 \times 10^6\text{ Pa}$

Cross sectional area of the bar

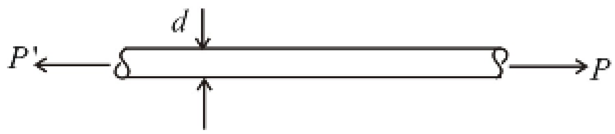
$A = a \times d$

$A = ad$

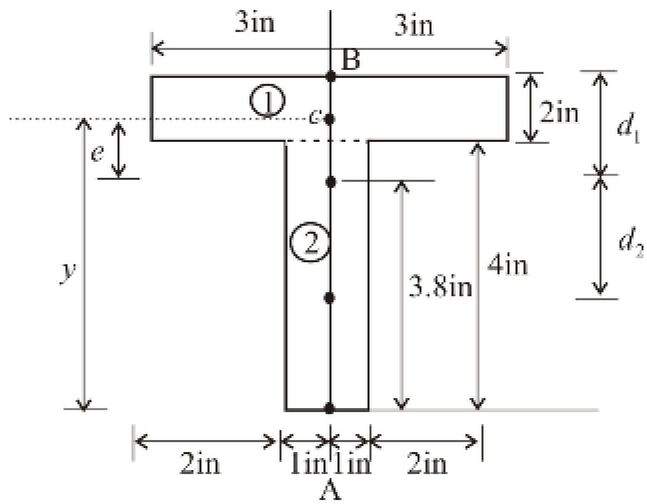
e – Eccentricity

$e = \frac{a}{2} - \frac{d}{2}$

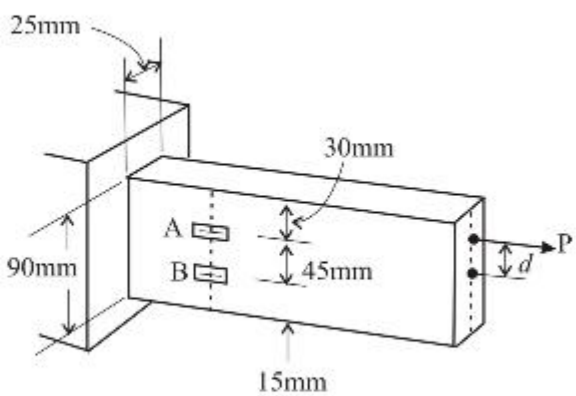
111-



117-



123-



127-

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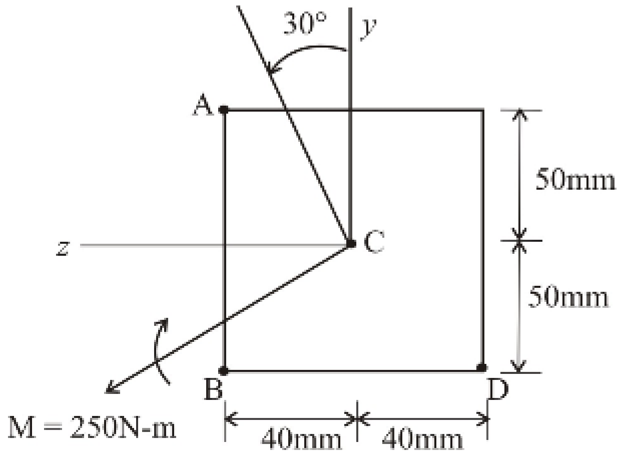
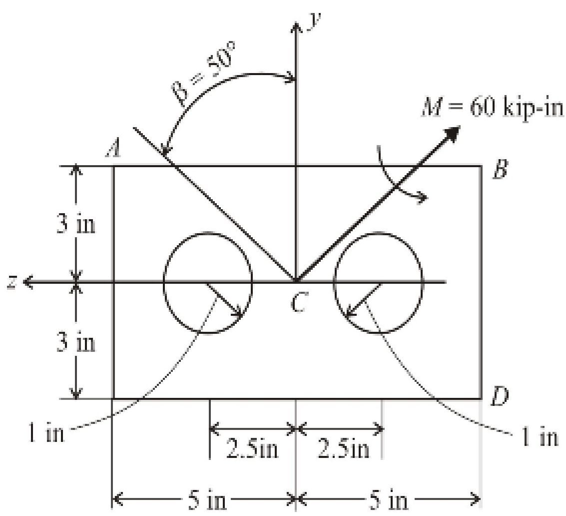


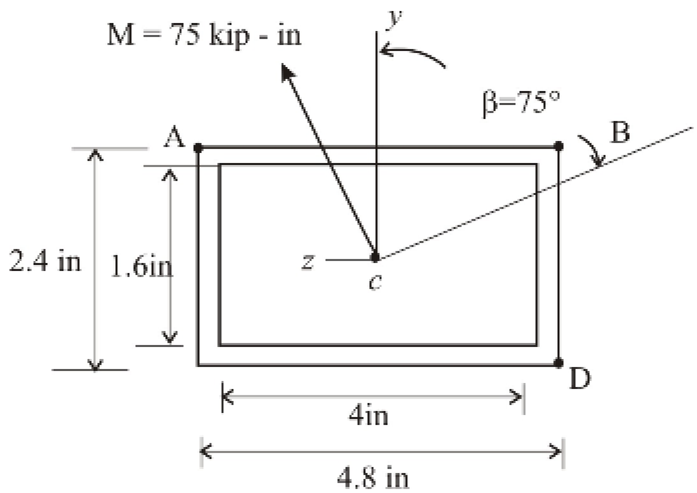
30°
y
A
50mm
z
C
50mm
M = 250N-m
B
D
40mm
40mm

129-

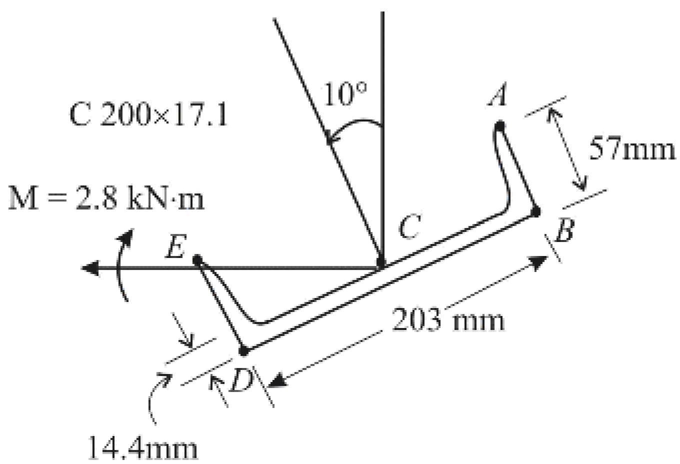


y
β = 50°
M = 60 kip-in
A
B
3 in
z
C
3 in
D
1 in
1 in
2.5in
2.5in
5 in
5 in

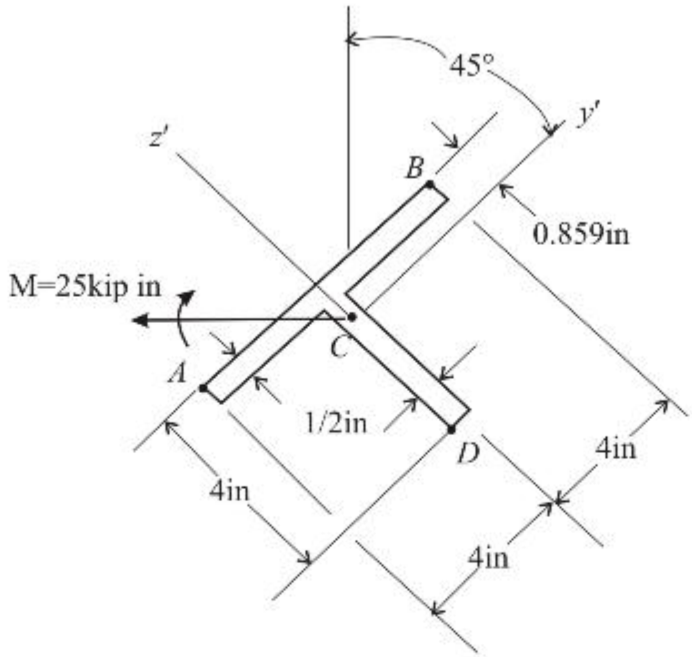
133-


M = 75 kip - in
y
β=75°
A
B
2.4 in
1.6in
z
c
D
4in
4.8 in

135-

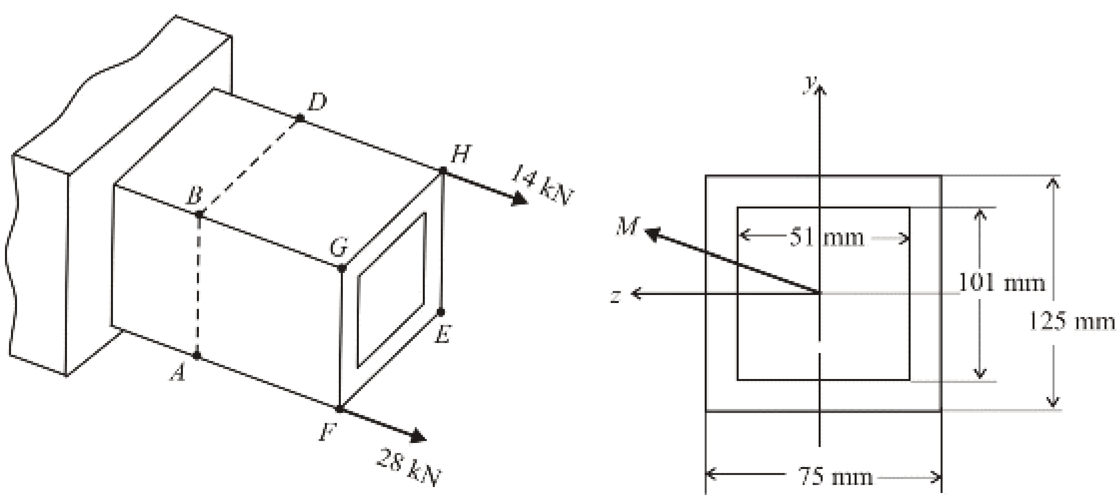

C 200×17.1
10°
A
57mm
M = 2.8 kN·m
C
B
E
203 mm
D
14.4mm

137-



45°
y′
z′
B
0.859in
M=25kip in
C
A
1/2in
D
4in
4in
4in
4in

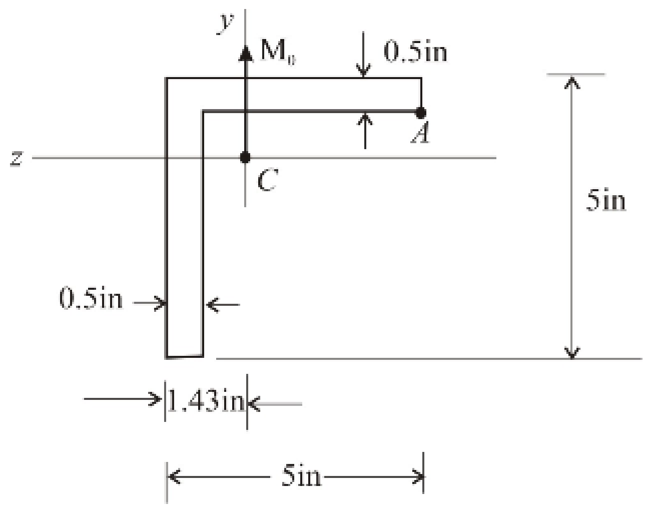
145-



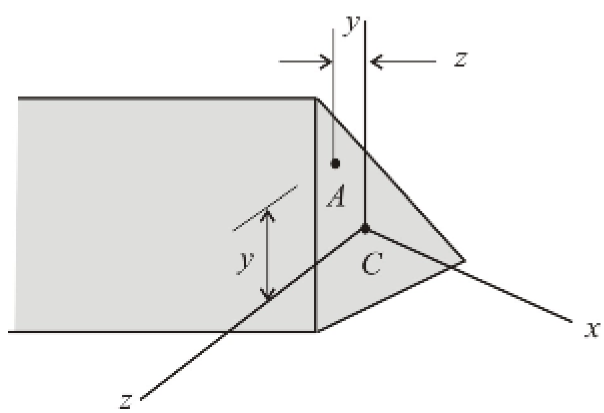
D
H
14 kN
B
G
E
A
F
28 kN
y
M
51 mm
z
101 mm
125 mm
75 mm

153-

The couple M_0 acts in a horizontal plane.



157-



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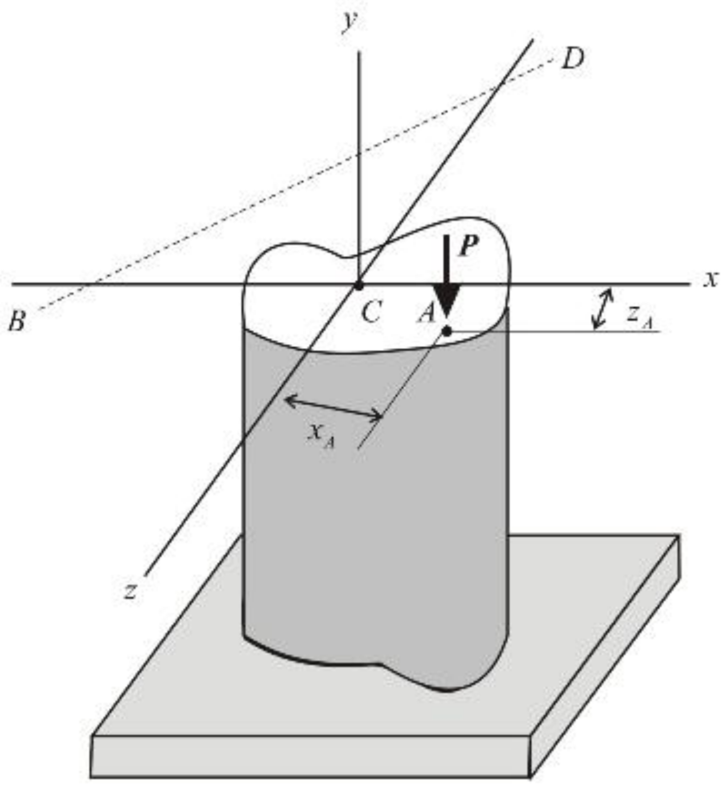
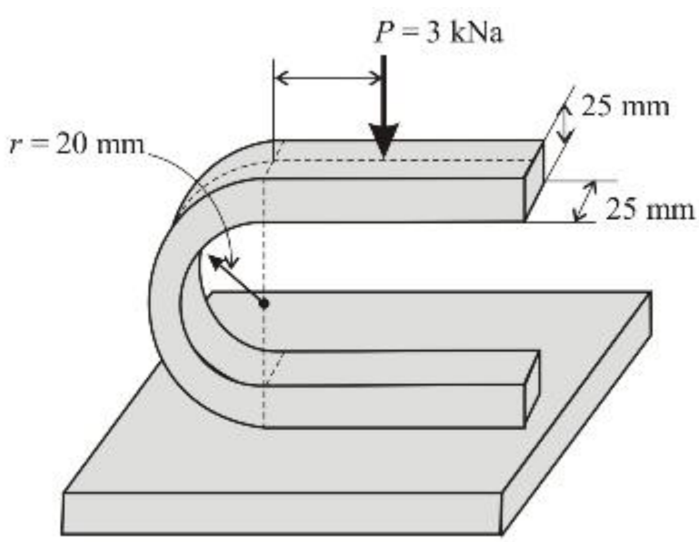
159-



163-



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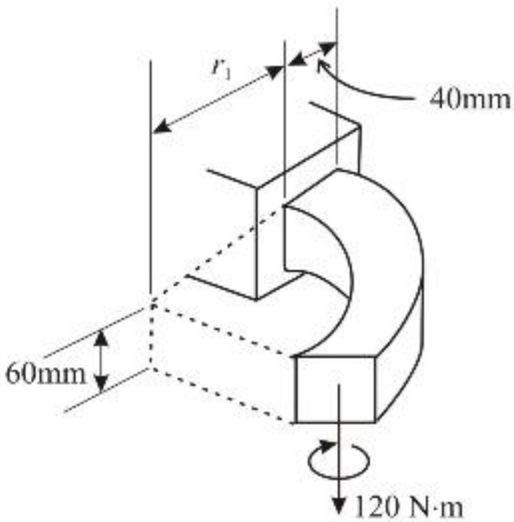
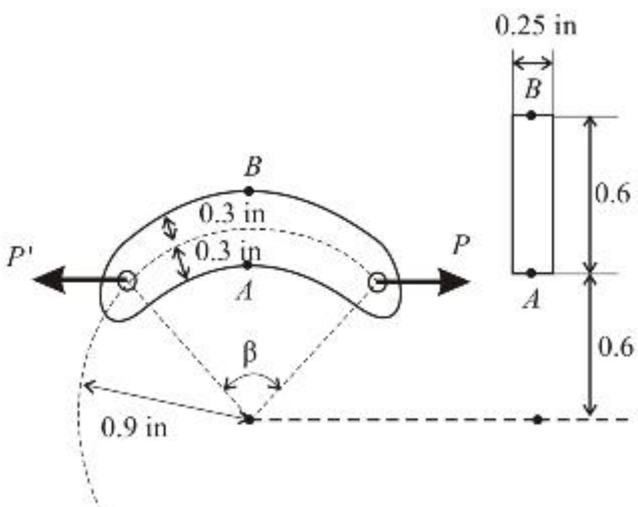
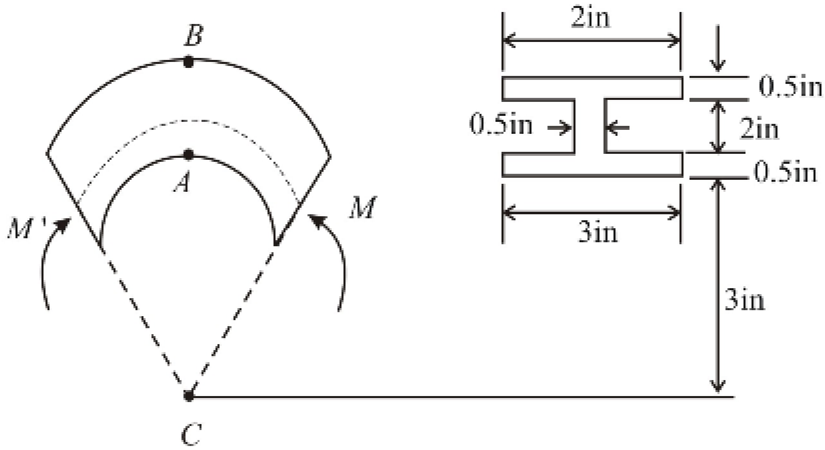
165-



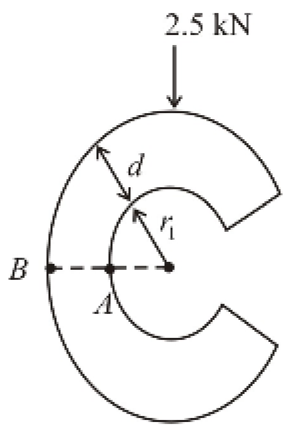
169-



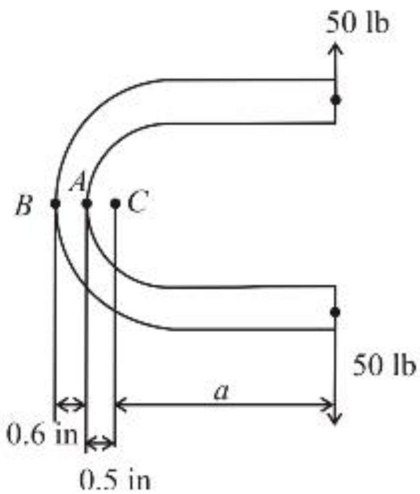
173-



175-

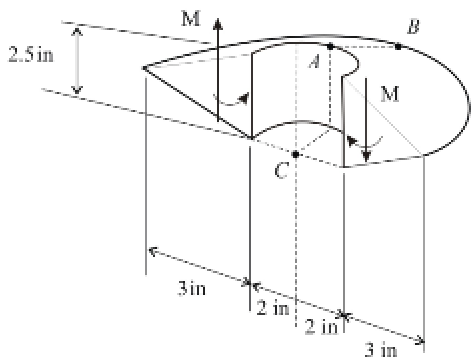


179-



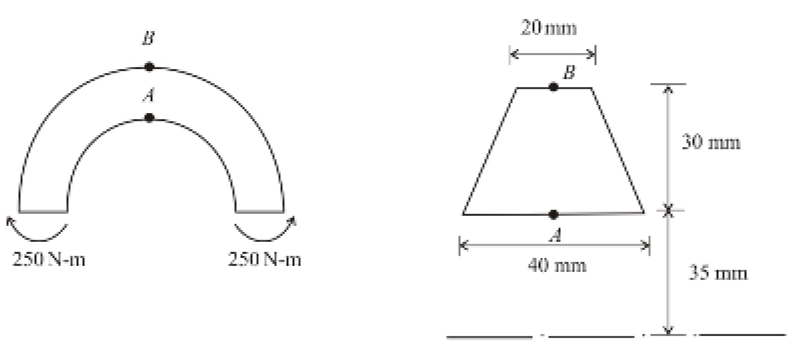
50 lb
A
B
C
50 lb
a
0.6 in
0.5 in

181-



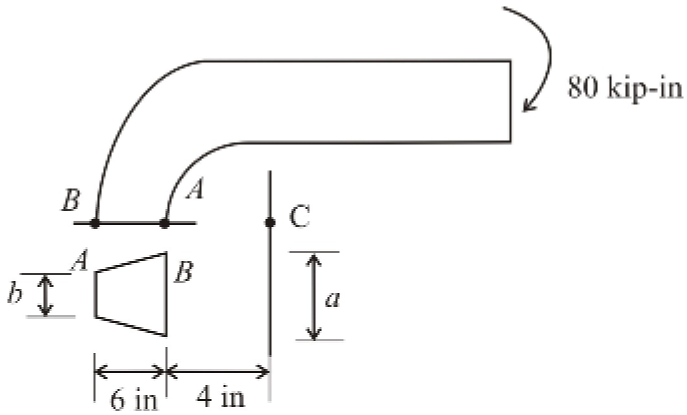
M
B
2.5 in
A
M
C
3 in
2 in
2 in
3 in

183-

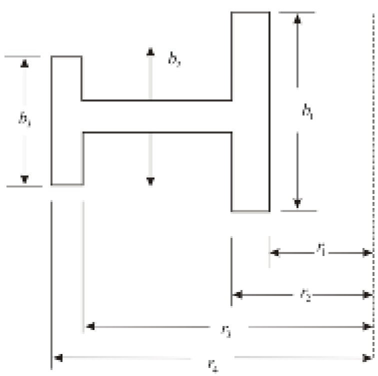


B
A
250 N-m
250 N-m
20 mm
B
30 mm
A
40 mm
35 mm

185-



187-



189-

Solution:-

We have radius R of the neutral surface

$$R = \frac{A}{\int \frac{dA}{r}}$$

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193-

We know in the relation for pure bending

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

Where, $I =$ Moment of Inertia about neutral axis

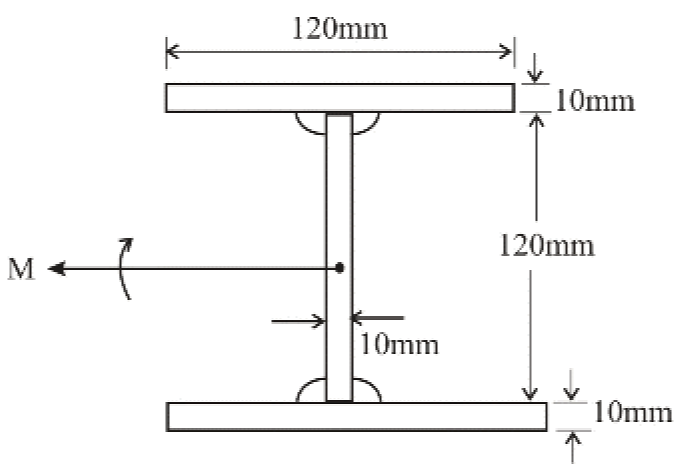
$M =$ Bending stress induced at a distance of 'C'

$C =$ Distance from Neutral Axis

$E =$ Modulus of Elasticity

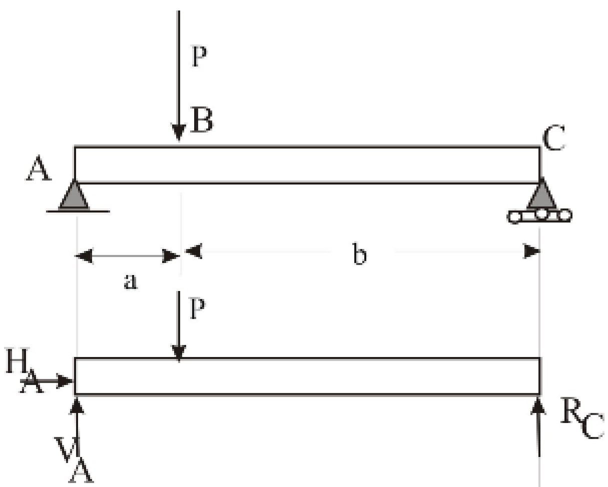
$R =$ Radius of curvature

201-

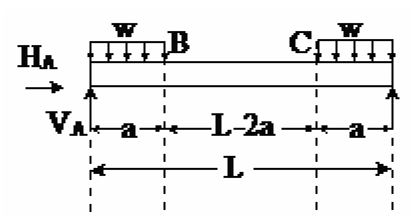


CHAPTER 5:

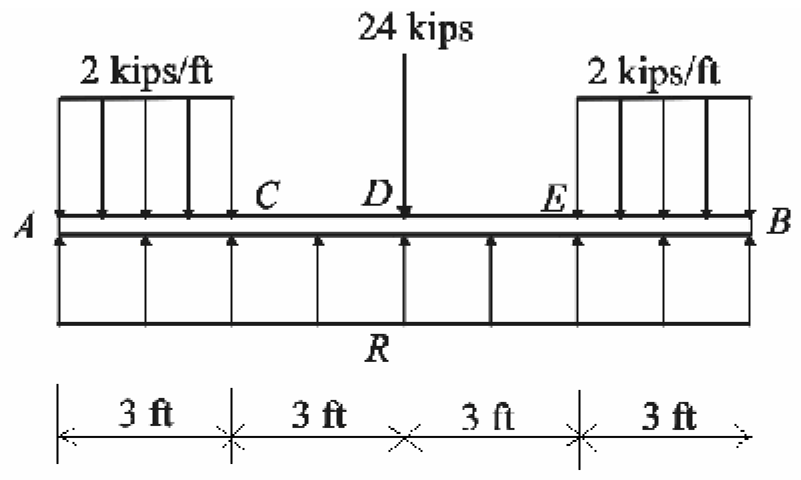
1-



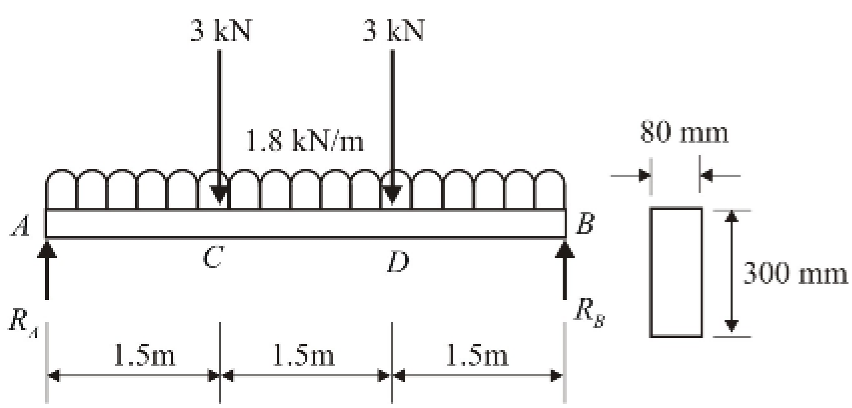
5-



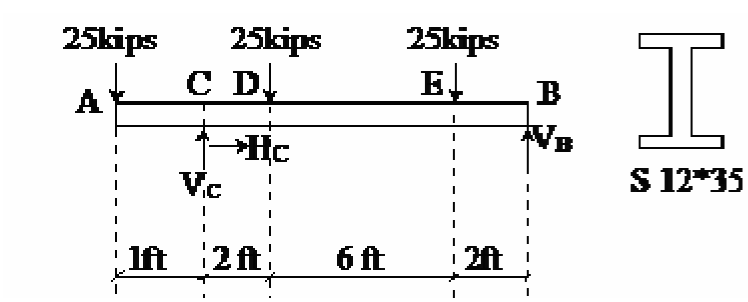
13-



15-



21-



25-

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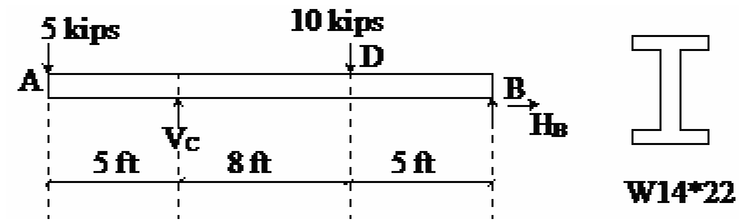
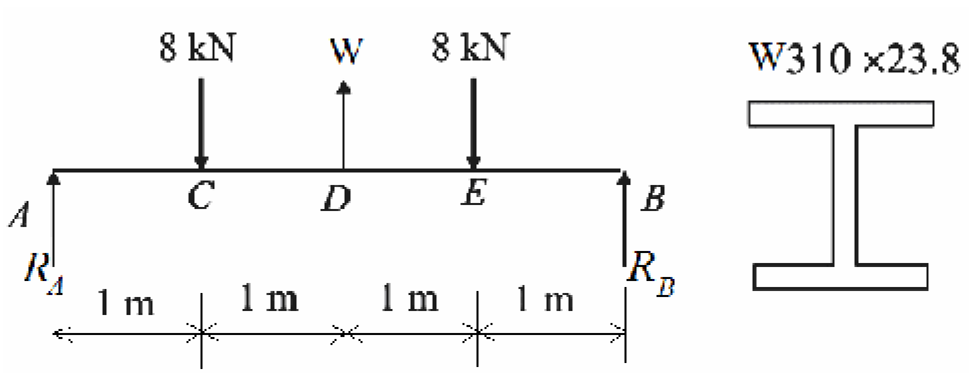
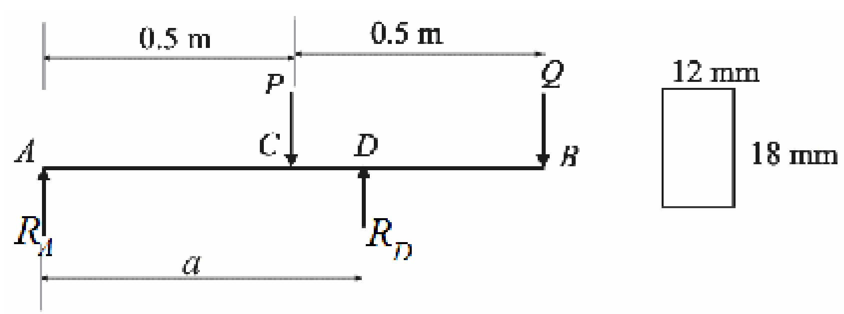


27-



31-



33-

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Given

Specific weight, $\gamma = 490\,\text{lb/ft}^3$

$$= \frac{490}{(12)^3}$$

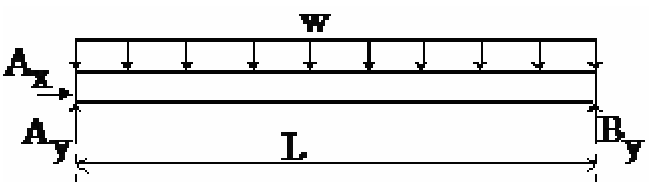
$$= 0.2835\,\text{lb/in}^3$$

Normal bending stress, $\sigma = 4\,\text{ksi}$

$$= 4\,\text{kips/in}^2$$

$$= 4\times10^3\,\text{lb/in}^2$$

35-



37-

We first compute the ratio

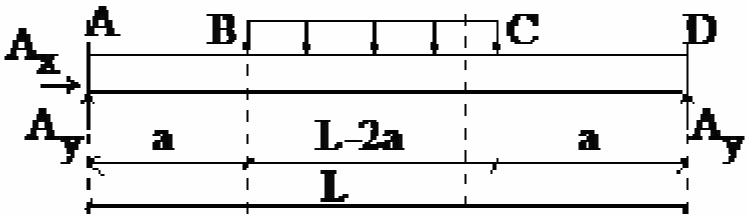
$$n = \frac{E_S}{E_W}$$

$$= \frac{30\times10^6}{2\times10^6}$$

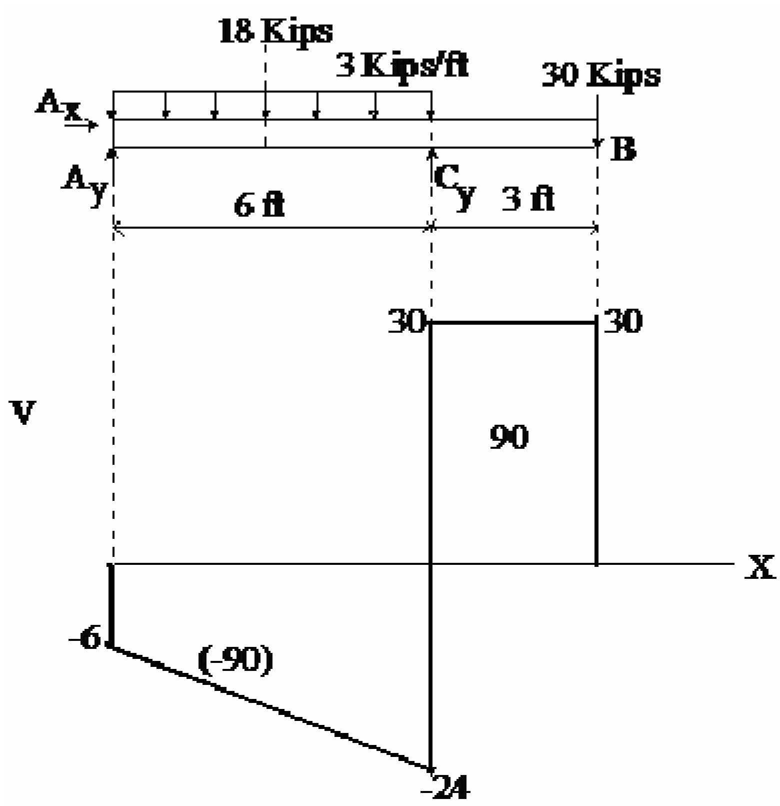
$$= 15$$

Multiplying the horizontal dimension of the steel portion of the section by $n = 15$, we obtain a transformed section made entirely of word.

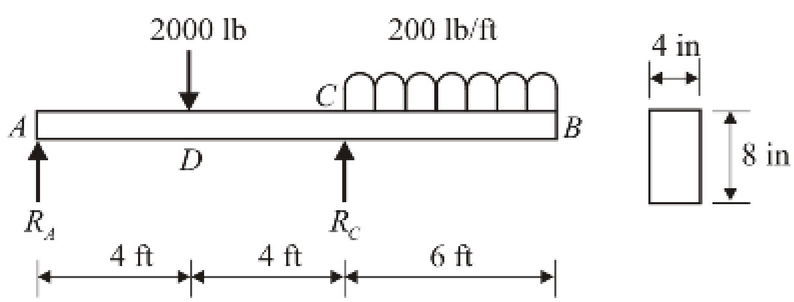
39-



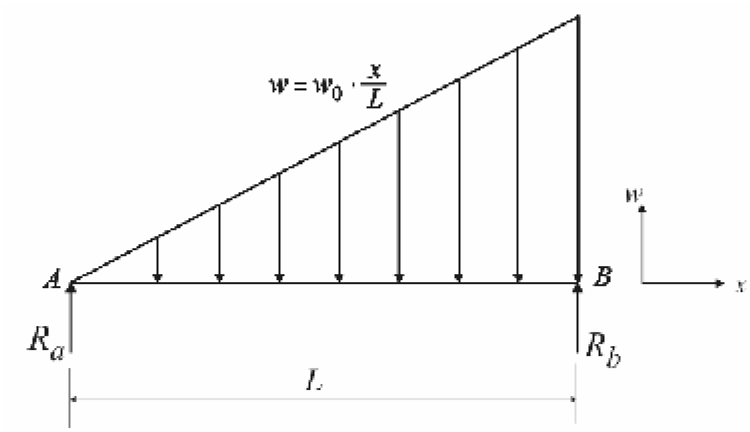
43-


18 Kips
3 Kips/ft
30 Kips
A_x
A_y
C_y
B
6 ft
3 ft
30
30
V
90
X
-6
(-90)
-24

47-

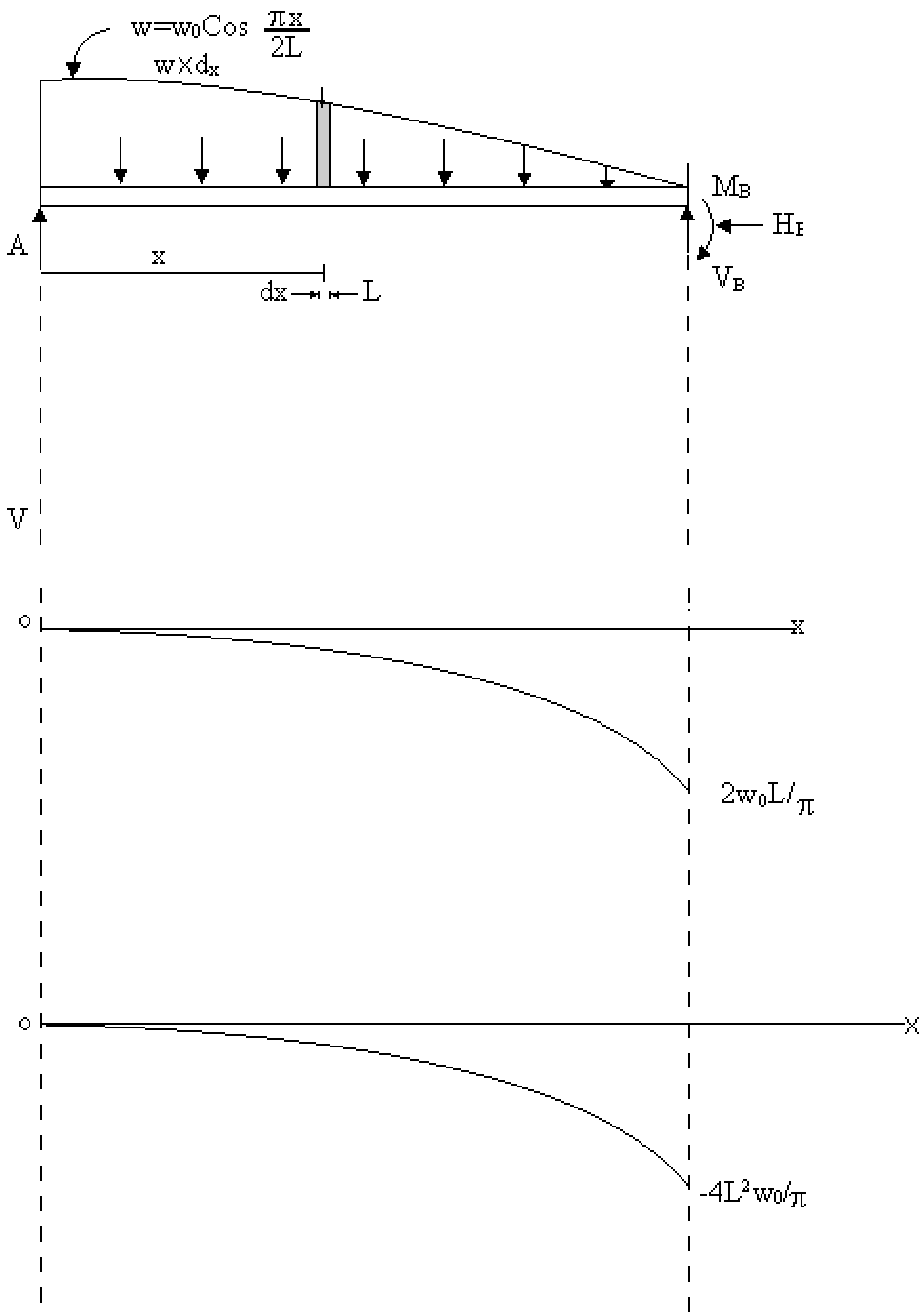

2000 lb
200 lb/ft
4 in
C
A
B
D
8 in
R_A
R_C
4 ft
4 ft
6 ft

51-



$w = w_0 \cdot \frac{x}{L}$
A
B
R_a
R_b
L
w
x

53-



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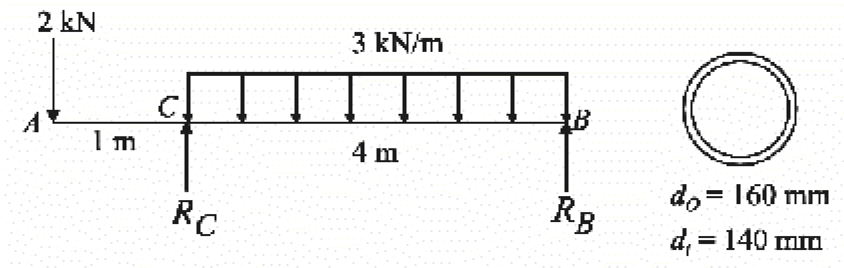
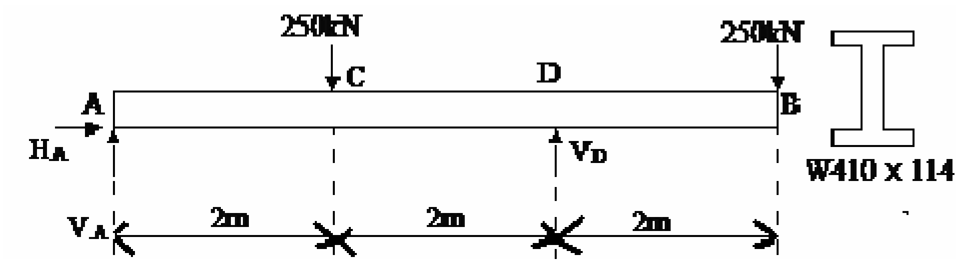
55-



57-



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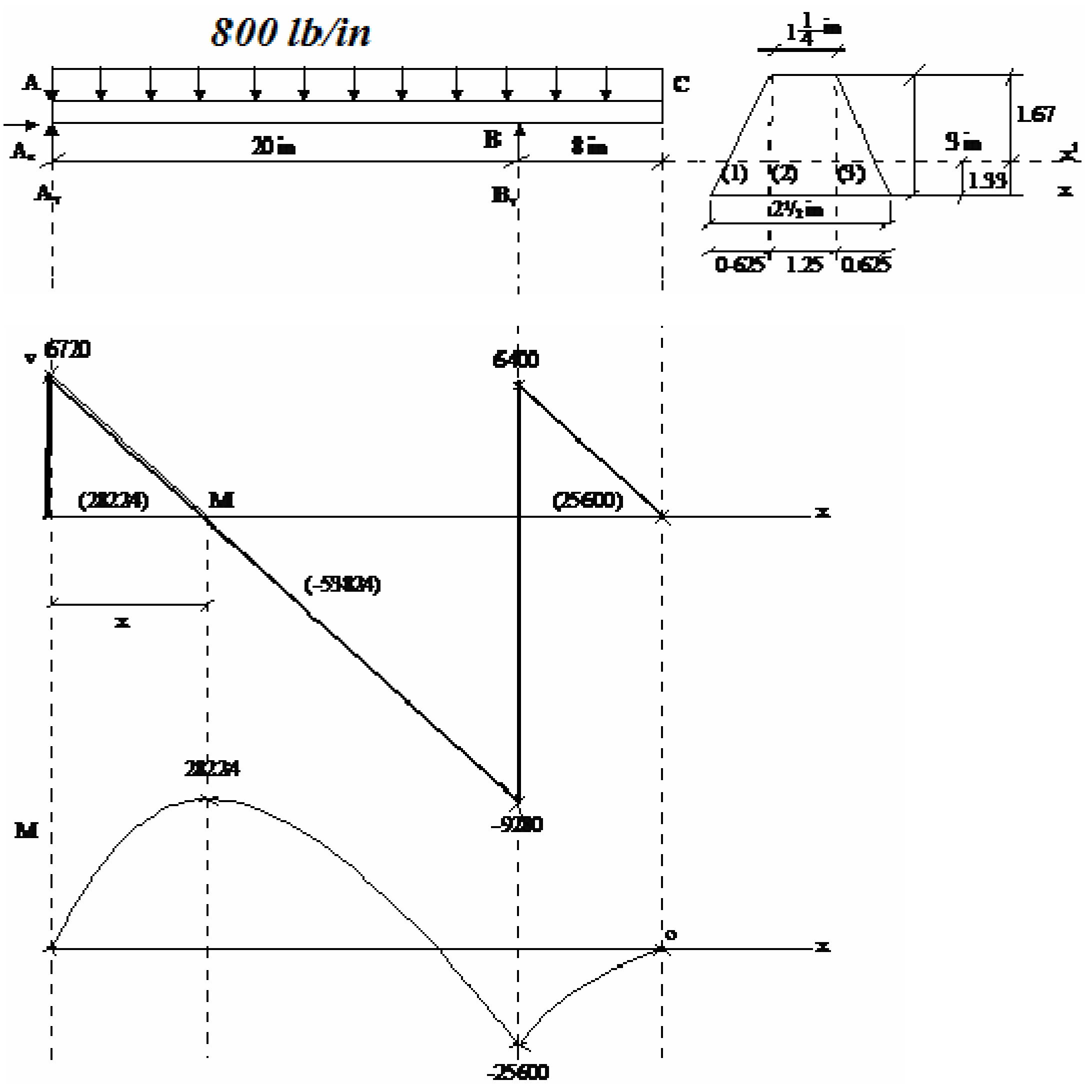
59-



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61-

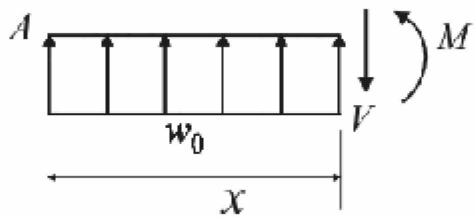
From equilibrium equations

$\sum F_y = 0$

$(w_0 \times 1) - (400 \times 0.4) = 0$

$w_0 = 160 \text{ kN/m}$

From A to C:–



From equilibrium equations

$\sum F_y = 0$

$V = w_0 x$

$V = 160x$

Taking moments about A

$\Sigma M_A = 0$

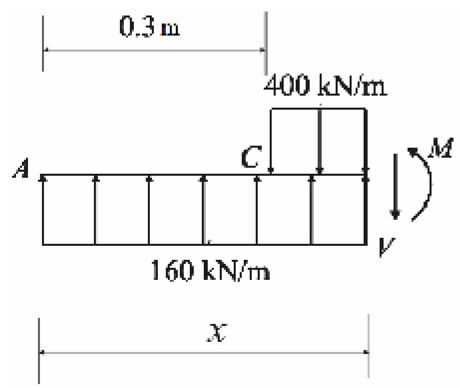
$$\left(w_0 \times x \times \frac{x}{2}\right) - (V \times x) + M = 0$$

$$160\frac{x^2}{2} - 160x^2 + M = 0$$

$$M = 80x^2$$

These expressions are valid for $0 < x < 0.3$

From C to D:–



From equilibrium equations

$$\sum F_y = 0$$

$$160x - 400(x - 0.3) - V = 0$$

$$V = -240x + 120$$

Taking moments about A

$$\Sigma M_A = 0$$

$$\left(160x \cdot \frac{x}{2}\right) - 400(x - 0.3)\left(0.3 + \frac{x - 0.3}{2}\right) - Vx + M = 0$$

$$80x^2 - 400(x - 0.3)\left(\frac{x}{2} + 0.15\right) - (-240x + 120)x + M = 0$$

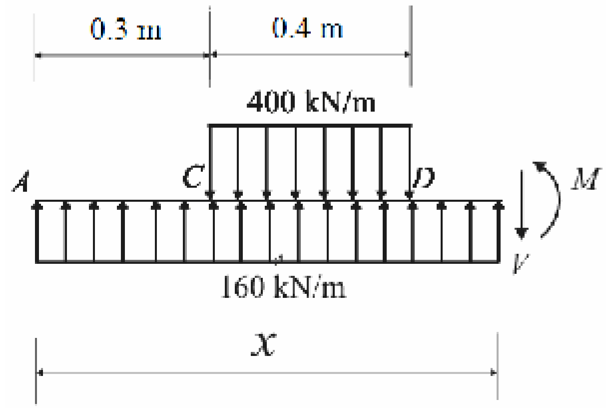
$$80x^2 - 200x^2 + 18 + 240x^2 - 120x + M = 0$$

$$120x^2 - 120x + 18 + M = 0$$

$$M = -120x^2 + 120x - 18$$

These expressions are valid for $0.3 < x < 0.7\,\mathrm{m}$

From D to B:–



From equilibrium equations

$\sum F_y = 0$

$$160x - (400 \times 0.4) - V = 0$$

$$V = 160x - 160$$

Taking moments about A

$$\Sigma M_A = 0$$

$$\left(160x \times \frac{x}{2}\right) - (400 \times 0.4 \times (0.3 + 0.2)) - Vx + M = 0$$

$$80x^2 - 80 - (160x - 160)x + M = 0$$

$$80x^2 - 80 - 160x^2 + 160x + M = 0$$

$$M = 80x^2 - 160x + 80$$

These expressions are valid for $0.7 < x < 1\text{m}$

63-

Given data

Normal stress at A, $\sigma_A = -56.9$ MPa

$$= \frac{-56.9 \times 10^6}{10^3}$$

$$= -56.9 \times 10^3 \text{ kN/m}^2$$

Normal stress at C, $\sigma_C = -29.9$ MPa

$$= -29.9 \times 10^3 \text{ kN/m}^2$$

65-

Given

Allowable normal stress,

$$\sigma_{all} = 12 \text{ MPa } \ (\text{N/mm}^2)$$

$$= \frac{12\times10^6}{10^3}$$

$$\sigma_{all} = 12\times10^3 \text{ kN/m}^2$$

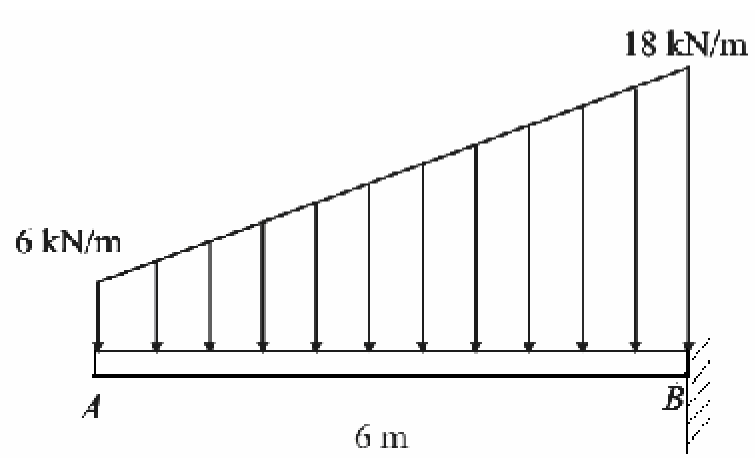
69-

Give data

Allowable normal stress, $\sigma_{all} = 12$ MPa $\quad (\text{N/mm}^2)$

$$= 12\times10^3 \text{ kN/m}^2$$

73-



77-

Given

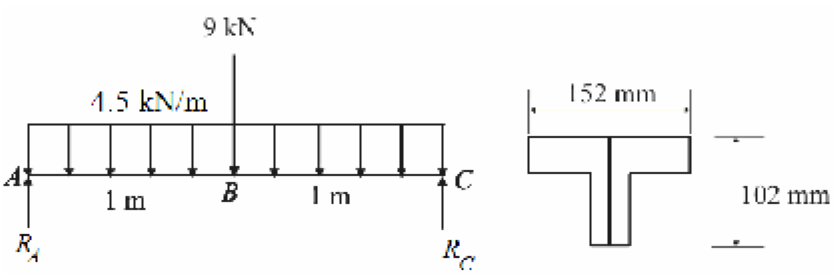
Allowable normal stress,

$\sigma_{all} = 24 \text{ ksi} \ \ (\text{kips/in}^2)$

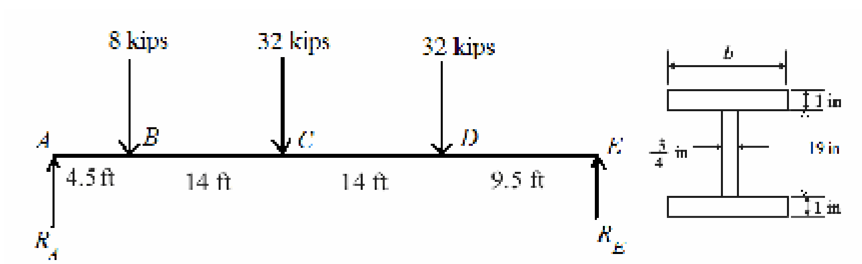
$= 24 \times 12^2$

$= 3456 \text{ kips/ft}^2$

79-



81-



83-

Given

Allowable normal stress, $\sigma_{all} = 24 \text{ ksi}$

$= 24 \times 12^2$

$= 3456 \text{ kips/ft}^2$

87-

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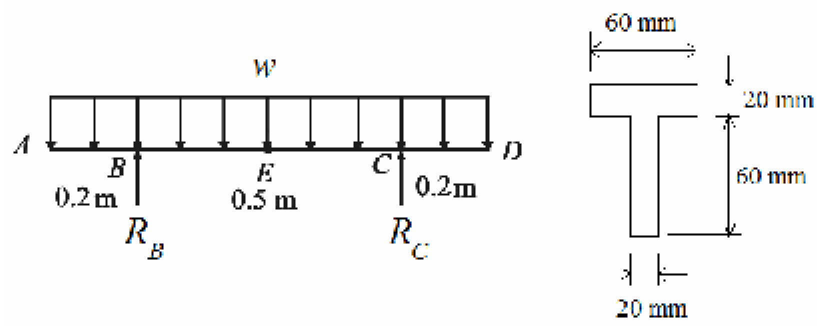


93-

Allowable normal stress in tension $\sigma_{all} = 110$ MPa

Allowable normal stress in compression $\sigma_{all} = -150$ MPa

95-

Solution

Given

$L = 48$ ft

$\sigma_u = 60$ ksi

$w = 0.75$ kips/ft

$a = 14$ ft

$P_1 = 24$ kips

$P_2 = 6$ kips

$\gamma_D = 1.25$

$\gamma_L = 1.75$

$\phi = 0.9$

97-

<u>Data</u>

$L = 16 \text{ m}$

$W_D = 350 \text{ N/m}$

$W_L = 600 \text{ N/m}$

$P = 6 \text{ kN} = 6 \times 10^3 \text{ N}$

$\sigma_u = 50 \text{ MPa} \left(\text{N/mm}^2\right) = 50 \times 10^6 \text{ N/m}^2$

$b = 75 \text{ mm}$

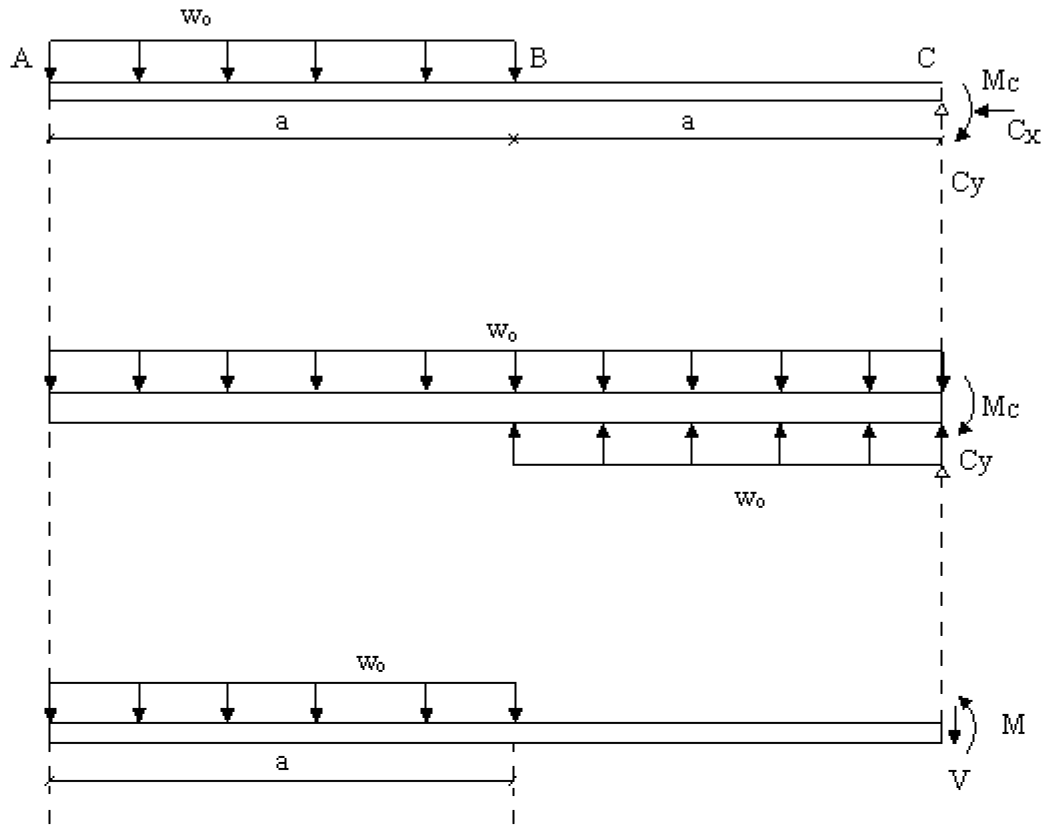
$h = ?$

$r_D = 1.2$

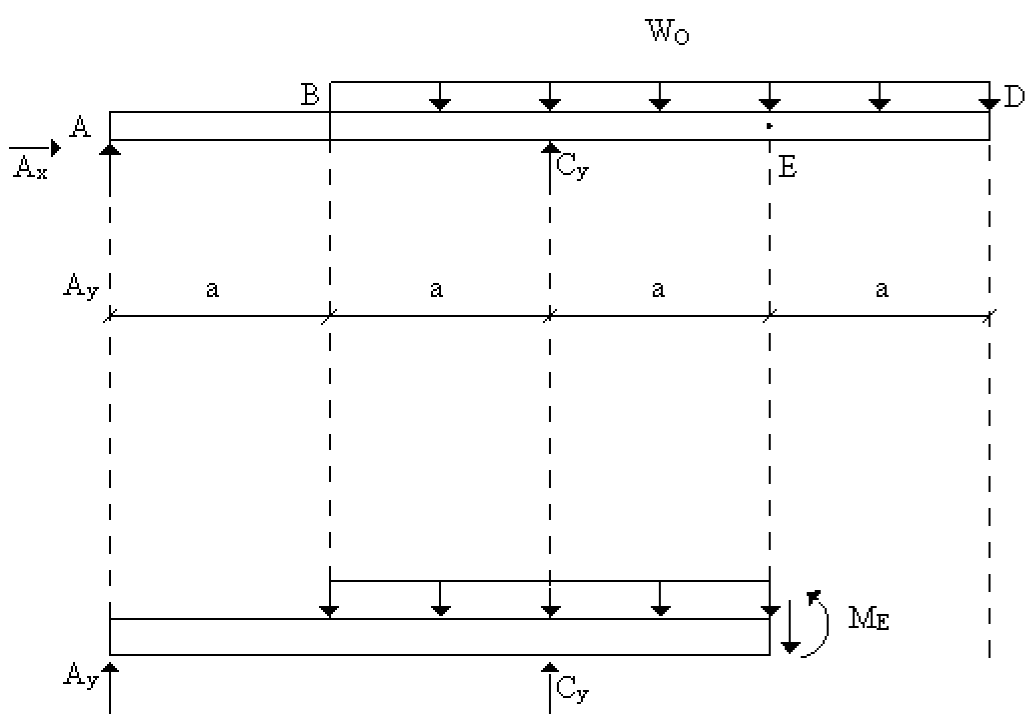
$r_L = 1.6$

$\theta = 0.9$

99-



101-



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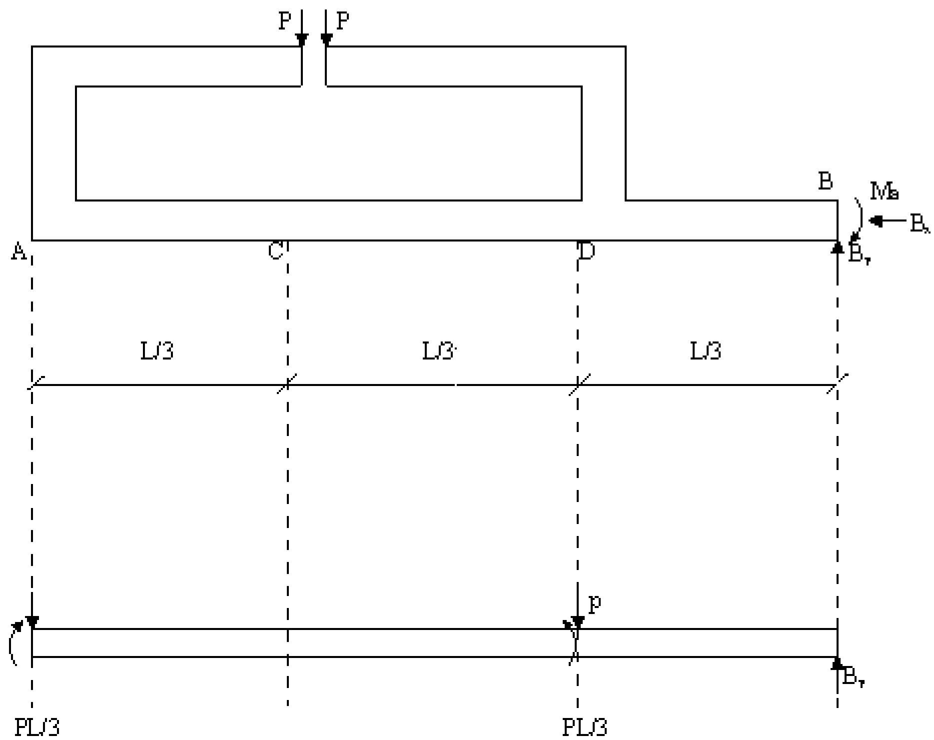
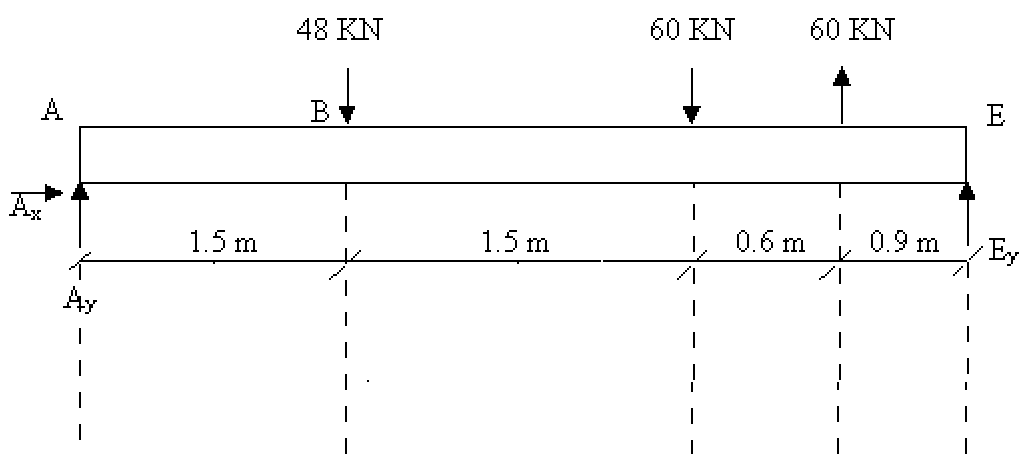
105-



107-



109-

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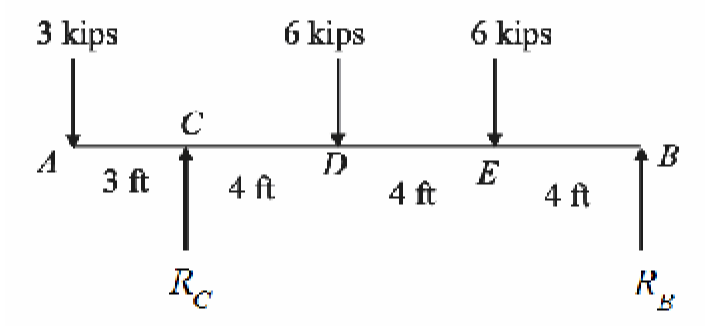
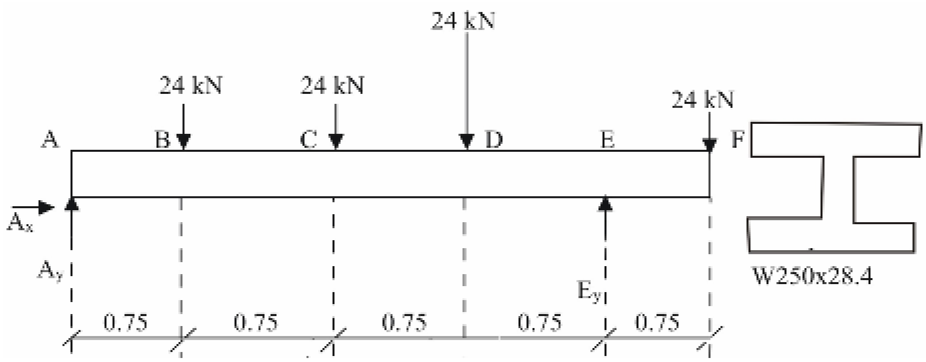
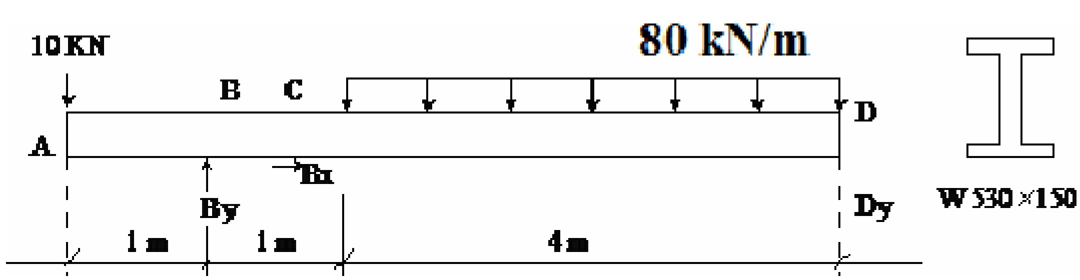


111-



113-



115-

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Allowable normal stress, $\sigma_{all} = 24$ ksi (kips/in^2)

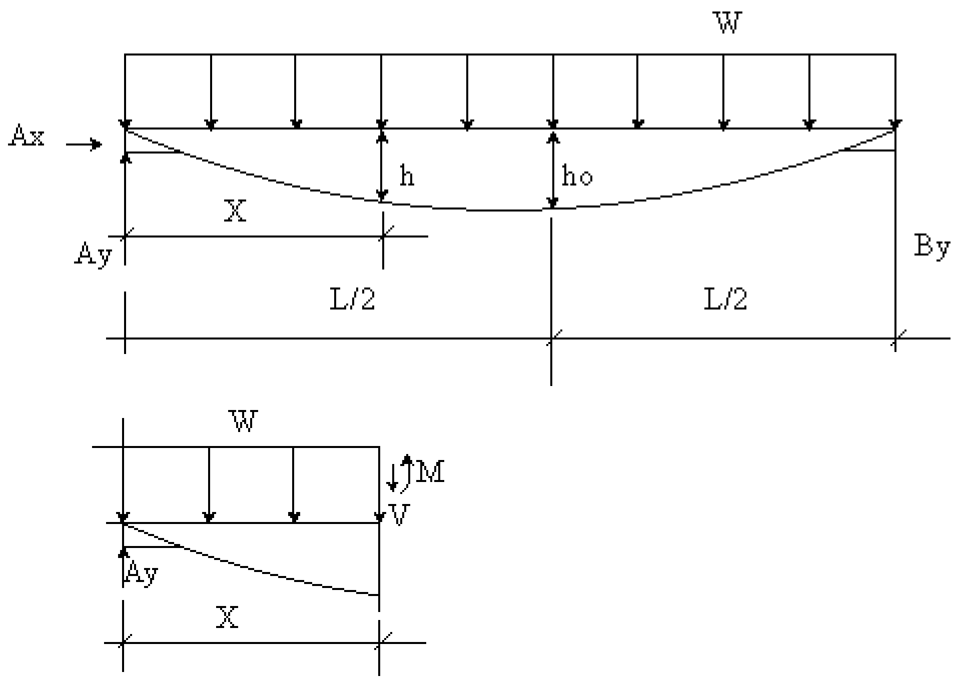
$= 24 \times 12^2$

$= 3456$ kips/ft^2

117-

Allowable normal stress, $\sigma_{all} = 12$ MPa

129-



131-

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Solution

We have

Load, $w = w_0 \sin \dfrac{\pi x}{2L}$

Relation between load & shear

$$\frac{dV}{dx} = -w$$

$$= -w_0 \sin\left(\frac{\pi x}{2L}\right)$$

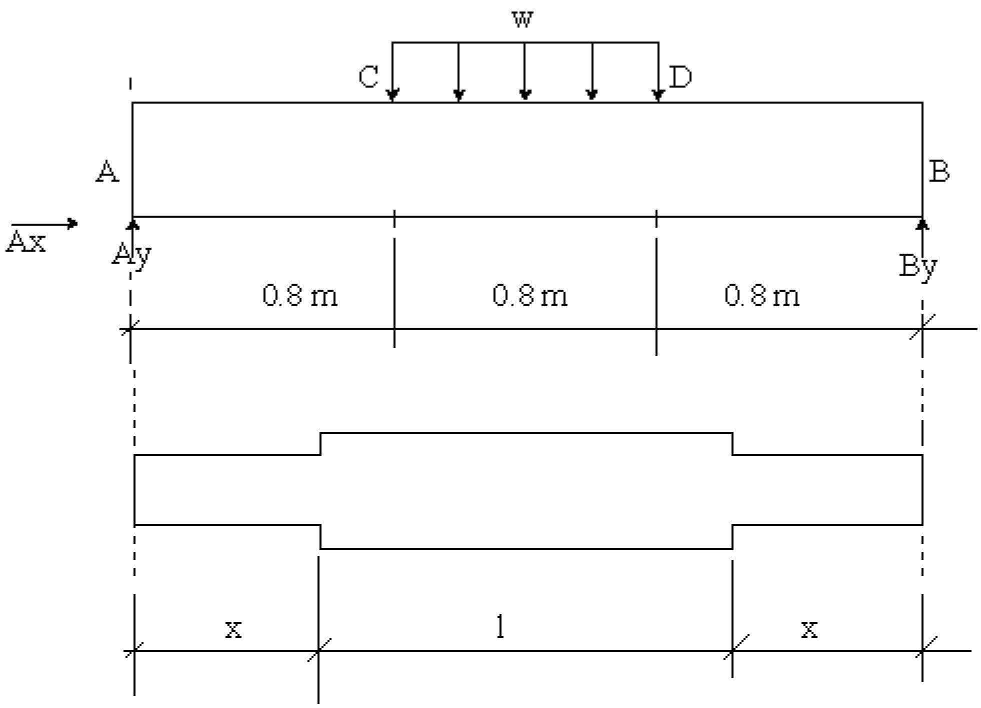
$$V = \frac{-2w_0 L}{\pi}\left(-\cos \frac{\pi x}{2L}\right) + C_1$$

$$V = \frac{2w_0 L}{\pi} \cos\left(\frac{\pi x}{2L}\right) + C_1$$

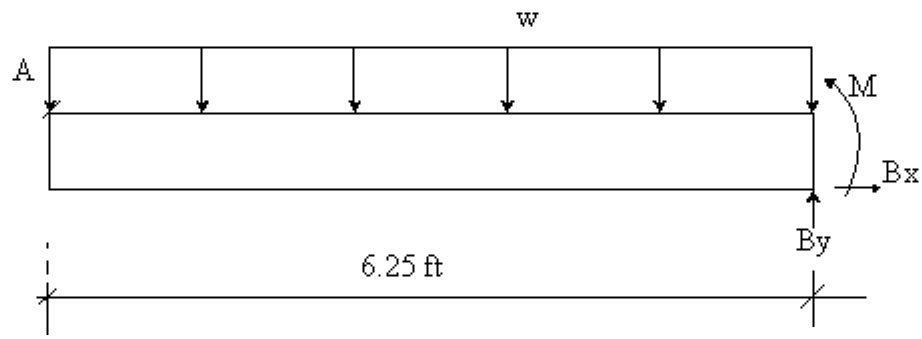
$V = 0$

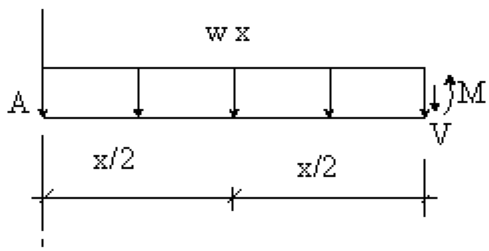
$@\, x = 0$

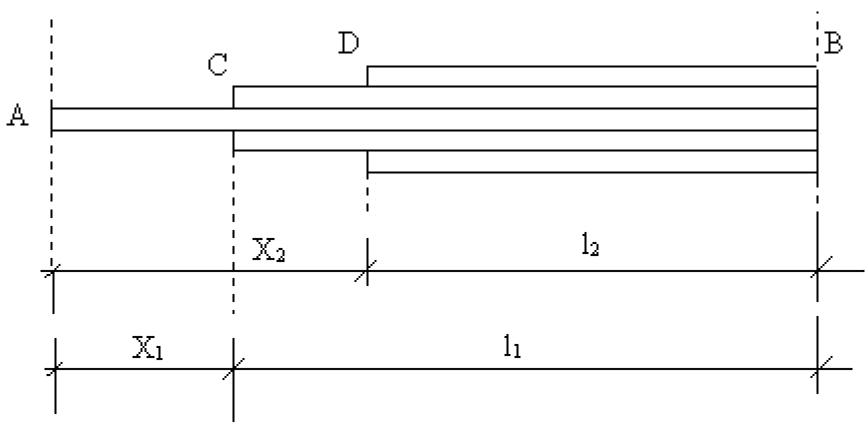
$$\therefore \quad C_1 = \frac{-2w_0 L}{\pi}$$


w
C
D
A
B
Ax
Ay
By
0.8 m
0.8 m
0.8 m
x
l
x

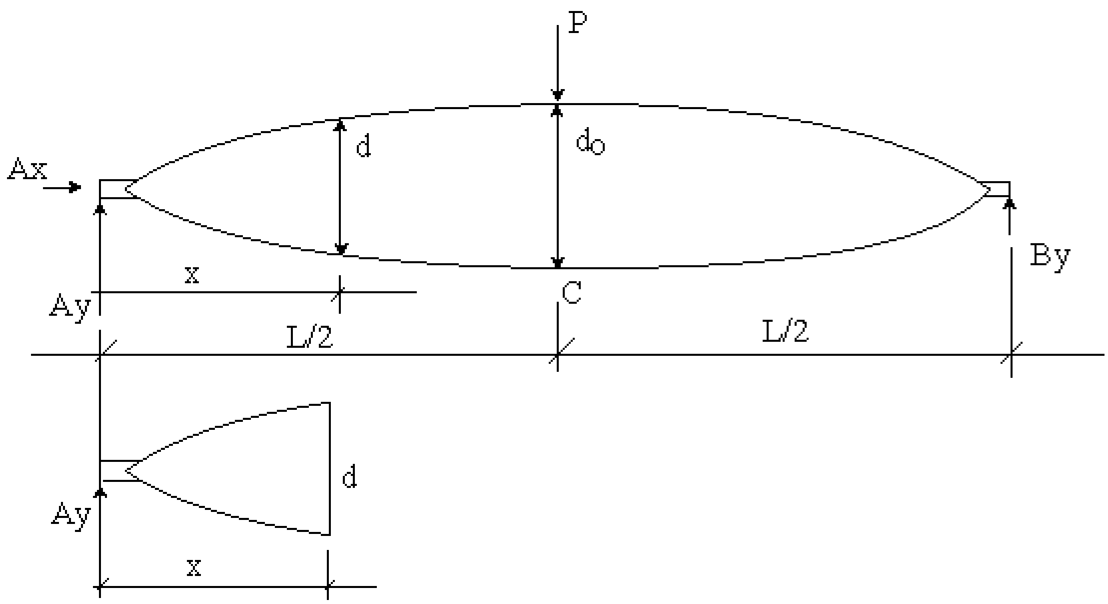
135-



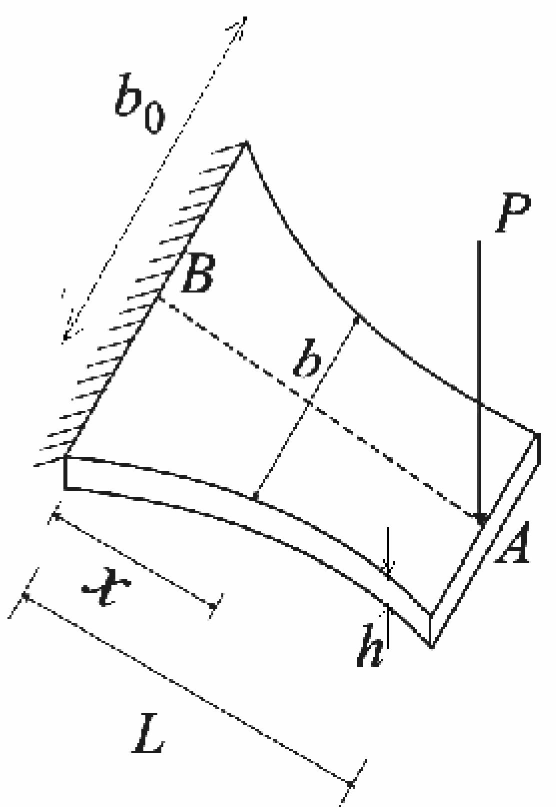




137-



139-



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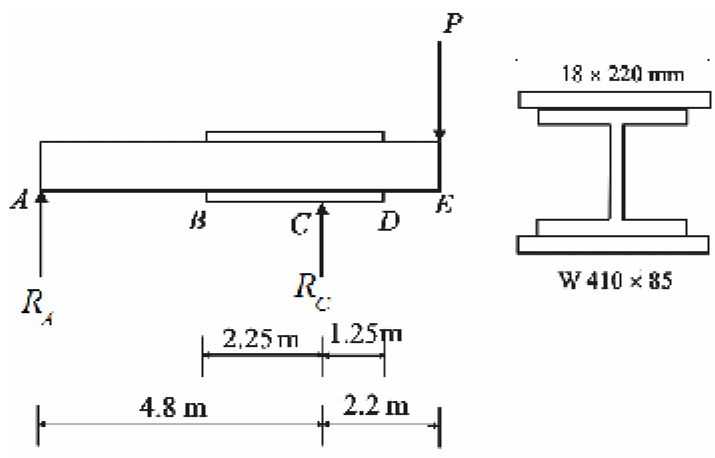
141-



143-

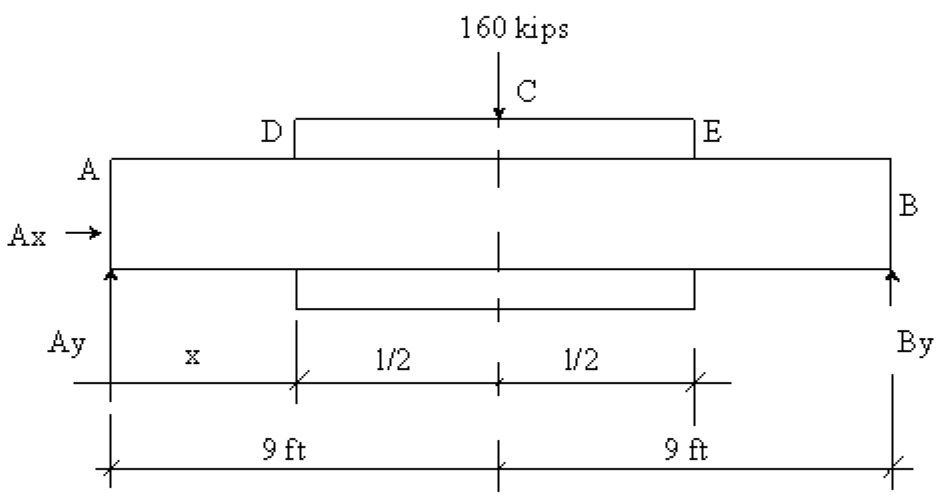
$\sigma_{all} = 22$ ksi

145-

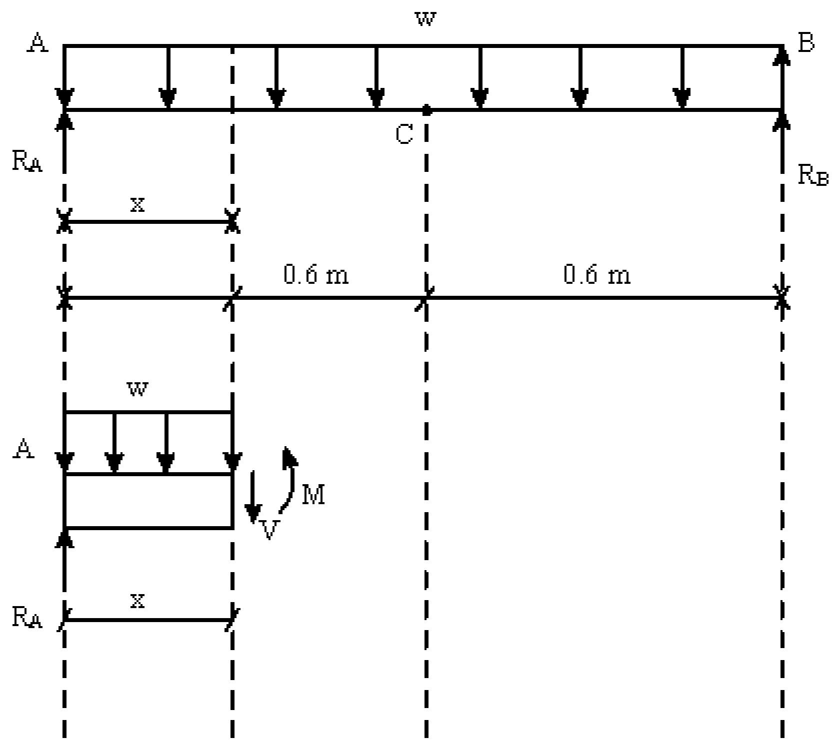
Allowable normal stress,

$\sigma_{all} = 150$ MPa

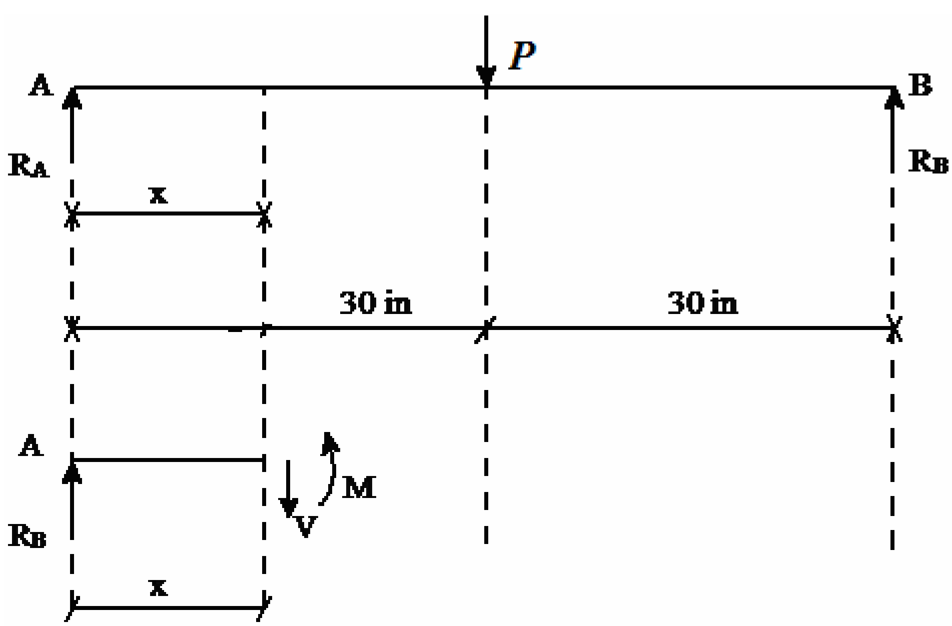
147-



149-



151-



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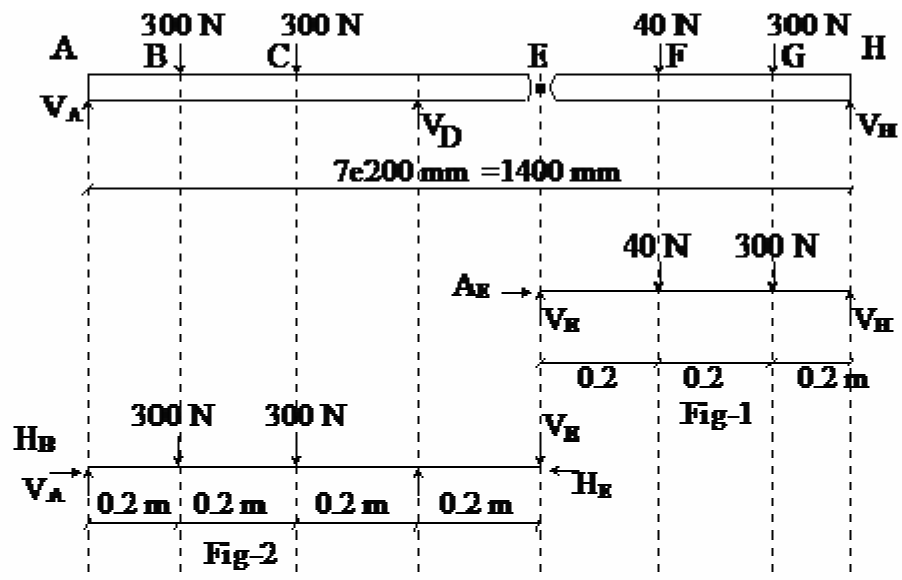
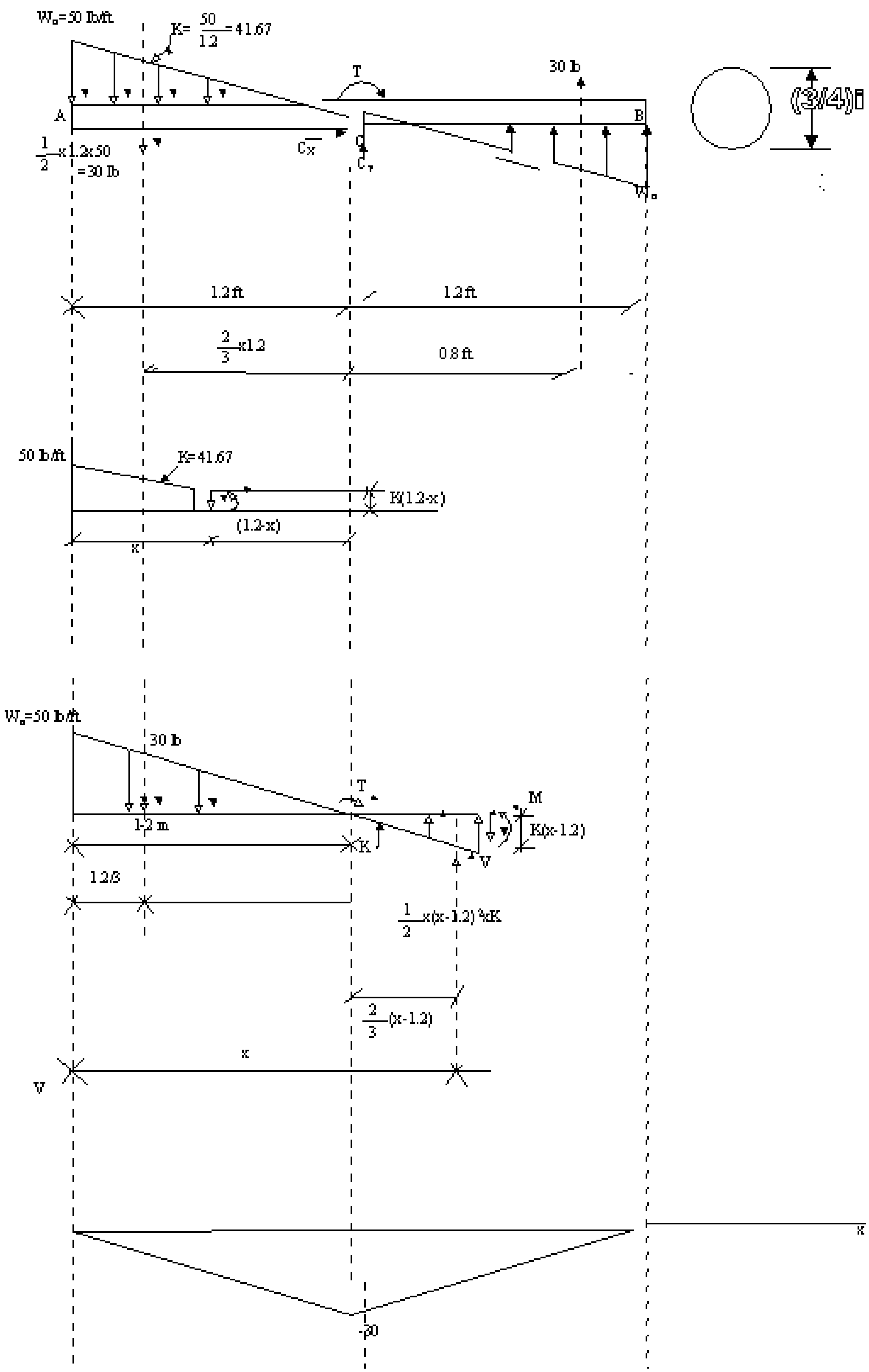
153-

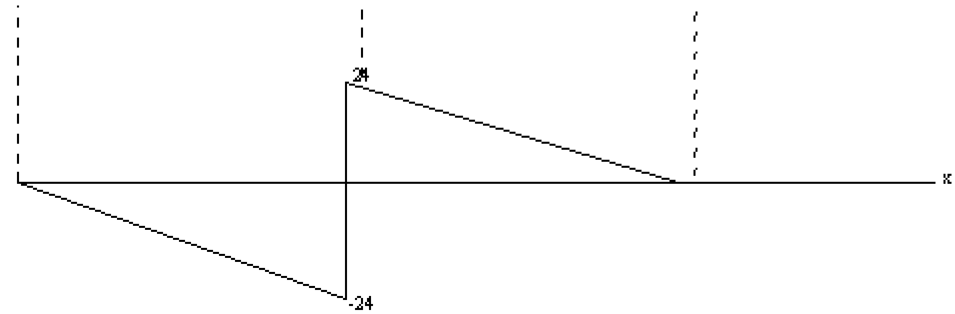


300 N
300 N
40 N
300 N
A
B
C
E
F
G
H
V_A
V_D
V_H
7e200 mm =1400 mm
40 N
300 N
A_E
V_E
V_H
0.2
0.2
0.2 m
Fig-1
300 N
300 N
H_B
V_A
V_E
H_E
0.2 m
0.2 m
0.2 m
0.2 m
Fig-2

157-



http://mmzzhh.com



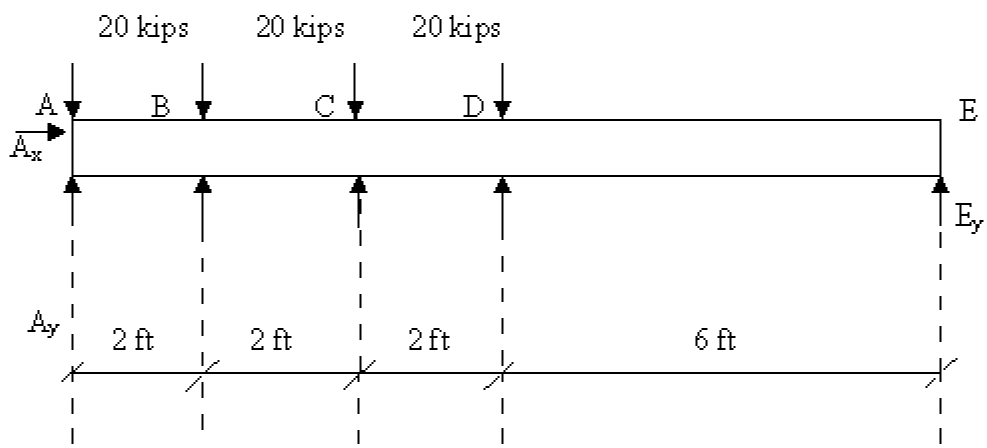
159-

Given data

Allowable normal stress, $\sigma_{all} = 160$ MPa (N/mm^2)

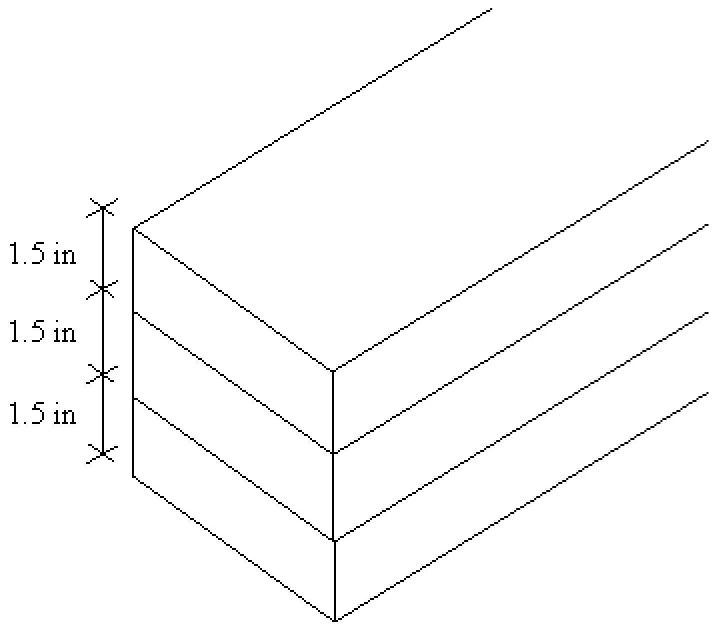
$$= 160 \times 10^3 \text{ kN/m}^2$$

161-



CHAPTER 6:

1-



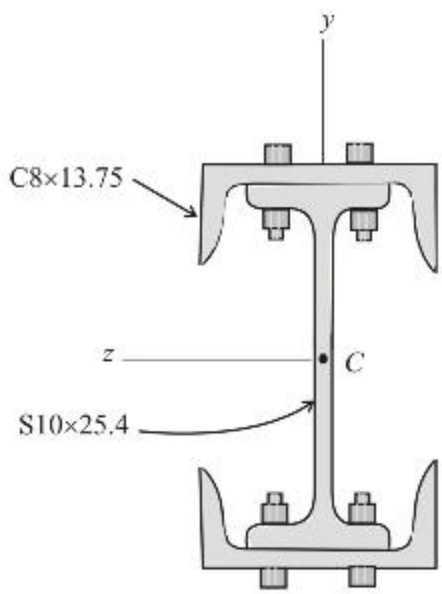
3-

Given that,
The spacing between the nails, $s = 75\,\text{mm}$
Allowable sharing force in each nail, $V = 400\,\text{N}$

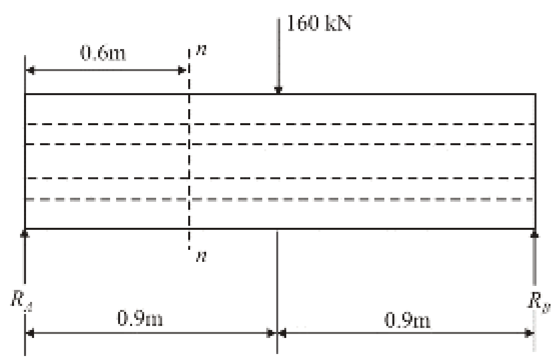
5-

Given data:
The spacing between the bolts $s = 120\text{ mm}$
Allowable shearing stress, $\tau_{av} = 90\text{MPa}$

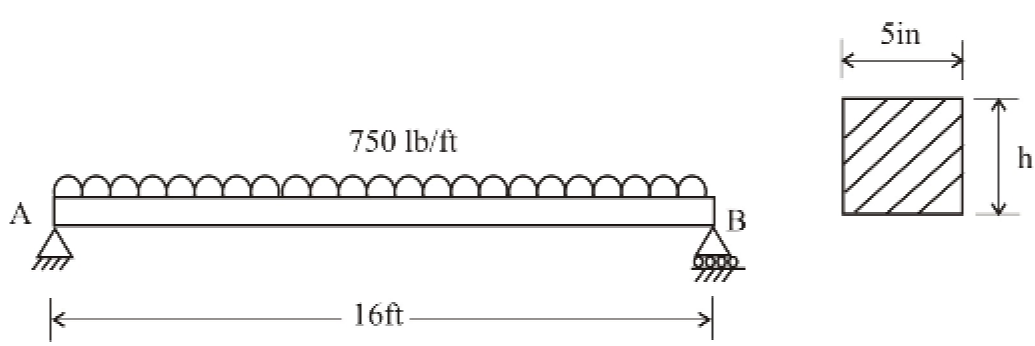
7-


y
C8×13.75
z
C
S10×25.4

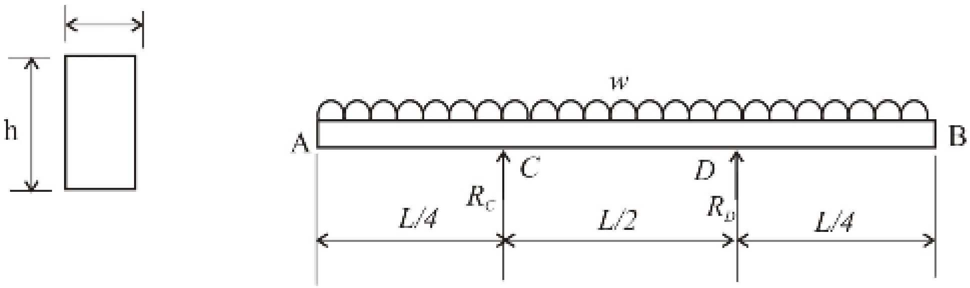
11-


160 kN
0.6m
n
n
R_A
R_B
0.9m
0.9m

15-

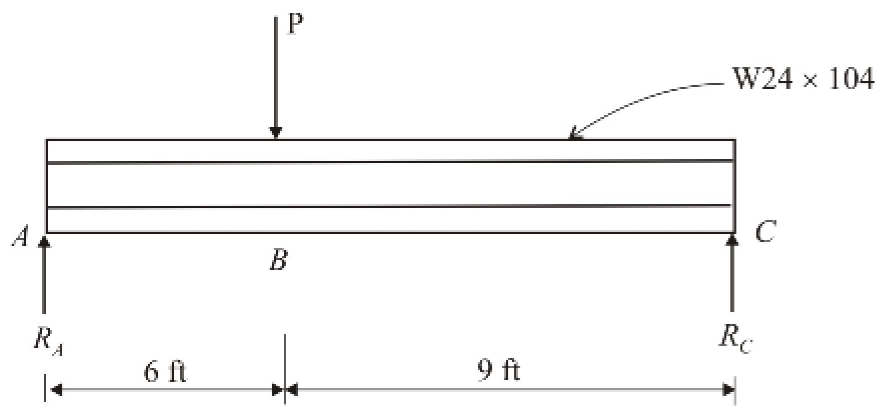

750 lb/ft
A
B
16ft
5in
h

17-



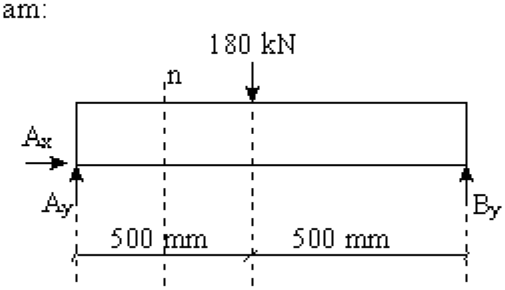
19-

Solution:

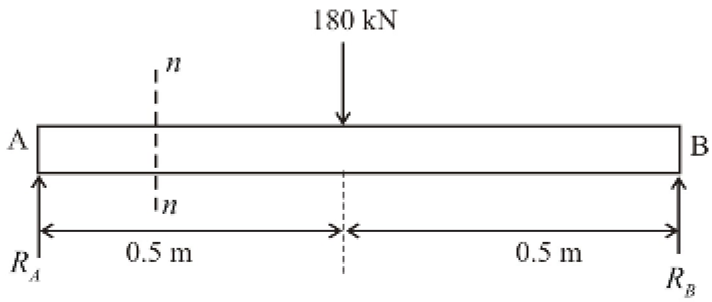


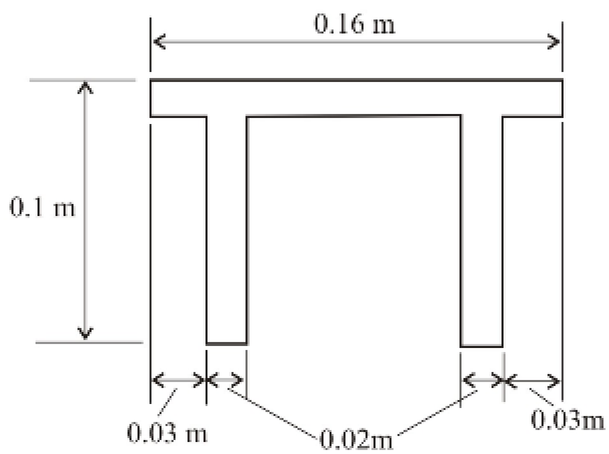
21-

Free body diagram of the beam:

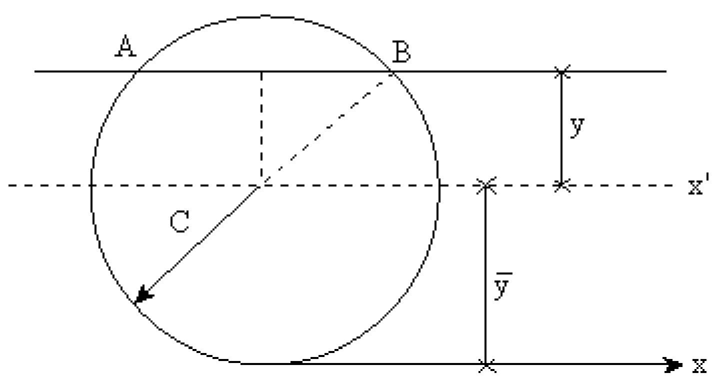


23-





25-



Solution

$$\overline{y} = C$$

$$I_{x1} = \frac{\pi C^4}{4}$$

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Consider a section AB at a distance y from x_1 width of section $AB = 2\sqrt{C^2 - y^2}$

Moment of the area AB about the N.A , $a\bar{y}\,{}_{y}^{r}\int = 2y\sqrt{C^2 - y^2}\,dy$

Let $2\sqrt{C^2 - y^2} = U$

$4(C^2 - y^2) = U^2$

$-8ydy = 2Udu$

$\therefore \quad ydy = -\frac{1}{4}Udu$

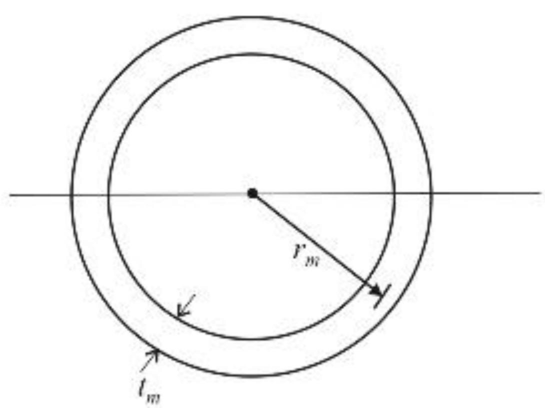
$\therefore \quad a\bar{y} = {}_{u}^{0}\int \; -\frac{1}{4}U^2du$

$= \frac{1}{4}\,{}_{u}^{0}\int U^2du$

$= \frac{U^3}{12}$

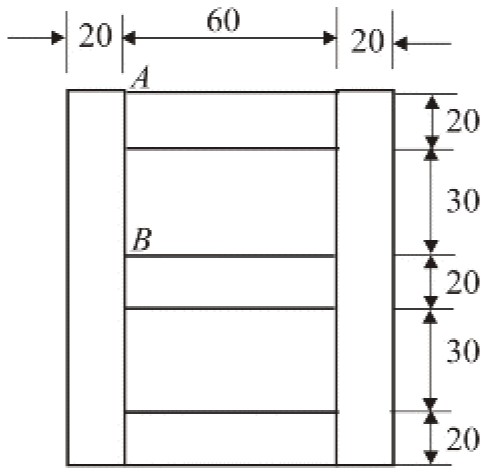
27-

Solution:



31-

Solution:

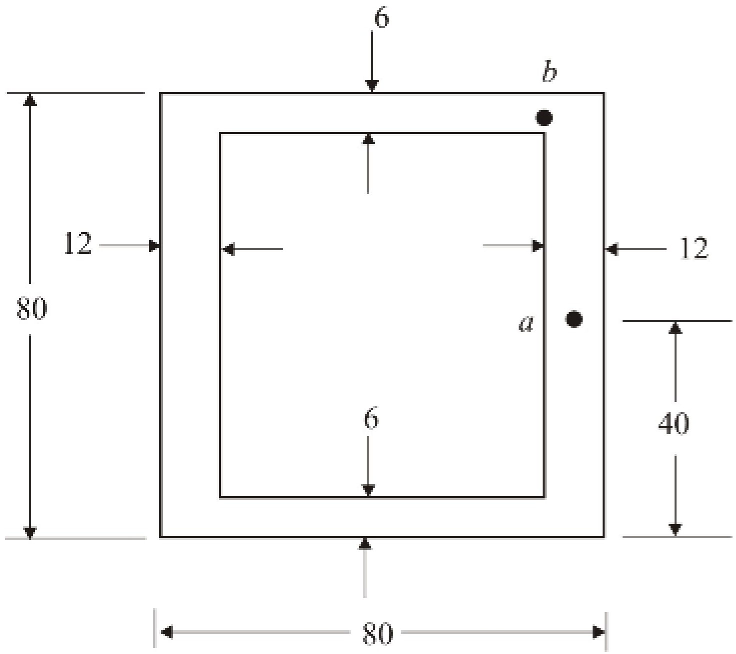


33-

$V = 8\text{kN}$
$S_A = 60\ \mathbf{mm}$
$S_B = 25\ \mathbf{mm}$
$I_x = 1.504 \times 10^9\ \mathbf{mm^4}$

35-

Solution:



41-

Shear force $(V) = 2$ kips

43-

Given:

Diameter of bolt, $d = \frac{7}{8}$in

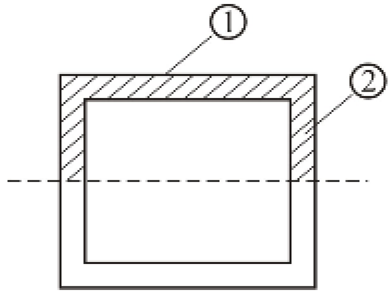
Longitudinal space, $s = 5$in

Allowable average shearing stress, $\tau_{all} = 12$ksi

Moment of inertia, $I_x = 6123\text{in}^4$

53-

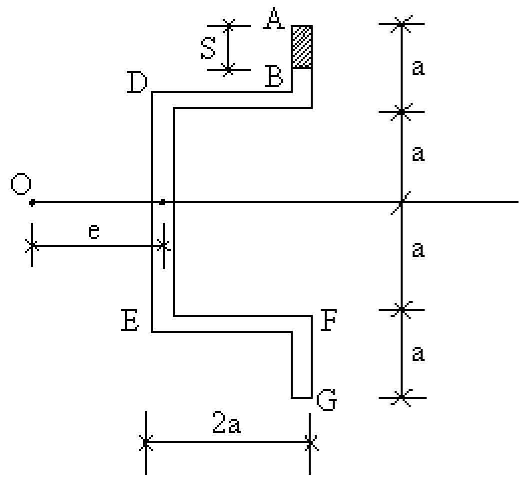
(a)



55-

Consider a beam made up of two different materials of Young's modulus E_1 and E_2 as shown in Figure 1.

61-



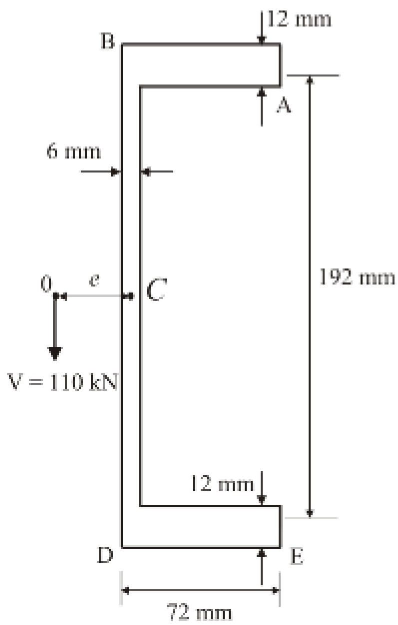
Shear in AB

The first moment with respect to the neutral axis of the area above the section

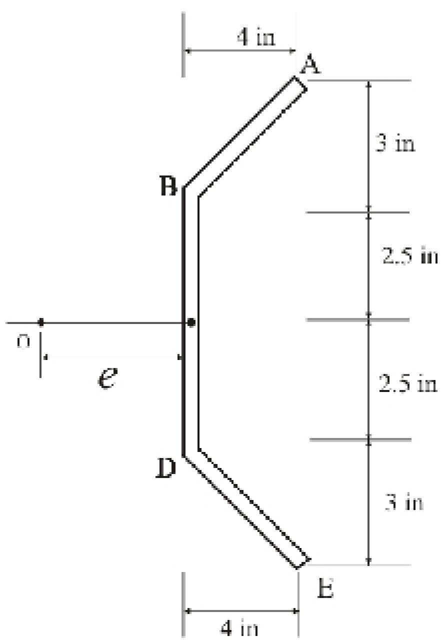
$$Q_1 = A_1\bar{y}_1$$
$$= (t)(s)\left(2a - \frac{s}{2}\right)$$

$$q_1 = \frac{VQ_1}{Ib}$$
$$= \frac{Vts\left(2a - \frac{S}{2}\right)}{It}$$
$$F_1 \int_0^a = q_1 da$$
$$= \int_0^a \frac{Vts}{It}\left(2a - \frac{S}{2}\right)tds \qquad [\because da = tds]$$
$$= \frac{Vt^2}{It}\int_0^a \left(2as - \frac{S^2}{2}\right)ds$$
$$= \frac{Vt^2}{It}\left[2as^2 - \frac{S^3}{6}\right]_0^a$$
$$F_1 = \frac{Vt^2}{It}\left[\frac{2a^3}{2} - \frac{a^3}{6}\right]$$
$$= \frac{Vt^2}{It}\left[\frac{6a^3 - a^3}{6}\right]$$
$$= \frac{5a^3Vt^2}{6It}$$
$$I = 2\left[\frac{(t)(a)^3}{12} + (t)(a)\left(a + \frac{a}{2}\right)^2\right] + 2\left[\frac{(2a)(t)^3}{12} + (2a)(t)(a)^2\right] + \frac{(t)(a)^3}{12}$$

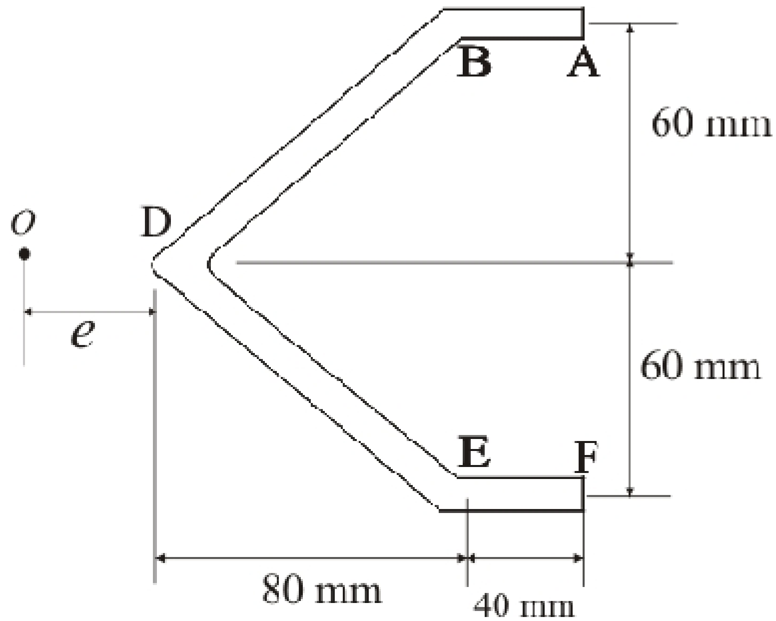
63-


12 mm
B
A
6 mm
0
e
C
192 mm
V = 110 kN
12 mm
D
E
72 mm

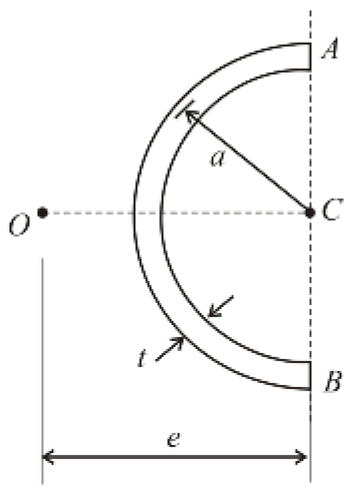
69-


4 in
A
3 in
B
2.5 in
0
e
2.5 in
D
3 in
E
4 in

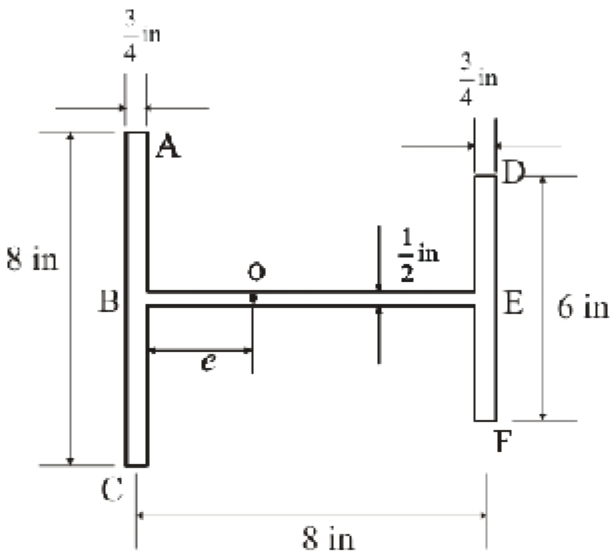
71-



73-

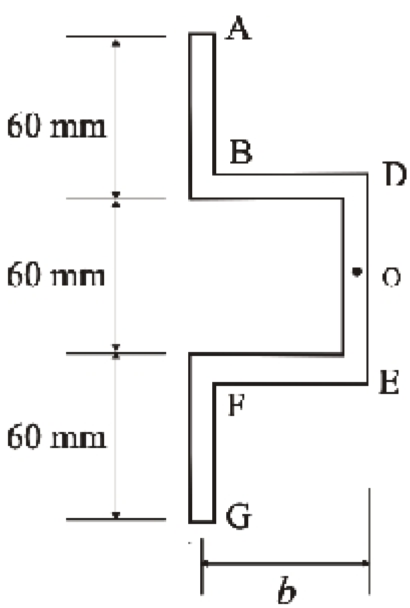


75-



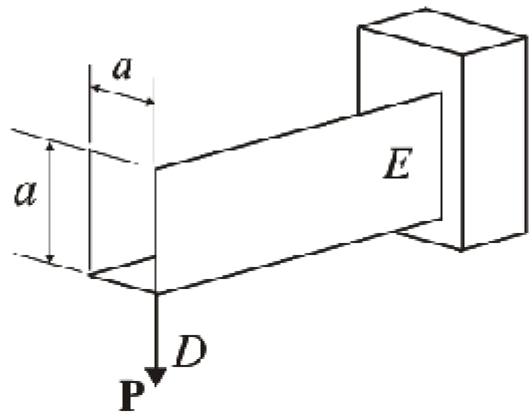
$\frac{3}{4}$ in
$\frac{3}{4}$ in
A
D
8 in
$\frac{1}{2}$ in
o
B
E
6 in
e
F
C
8 in

77-

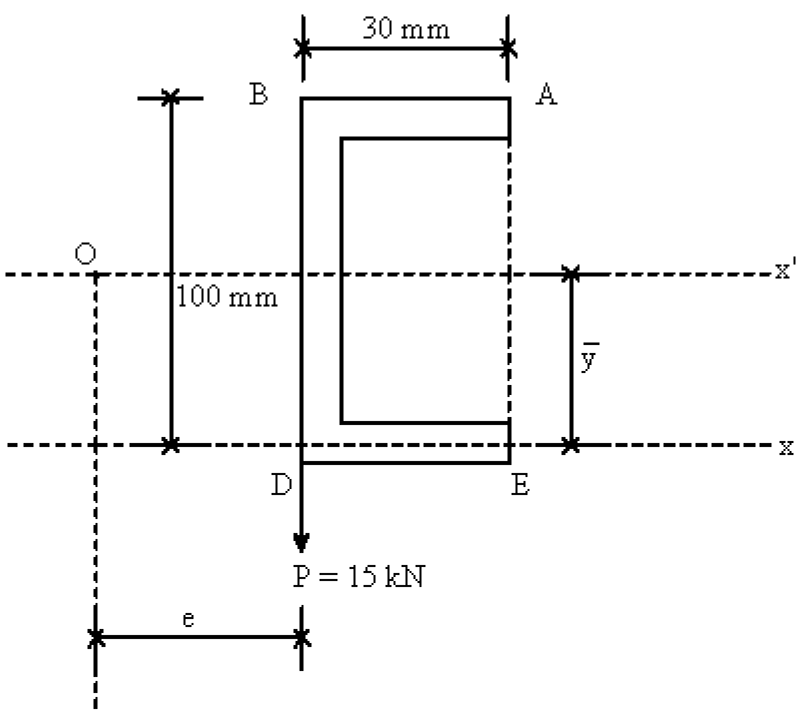


A
60 mm
B
D
60 mm
O
E
F
60 mm
G
b

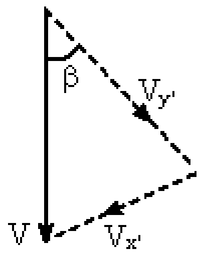
79-

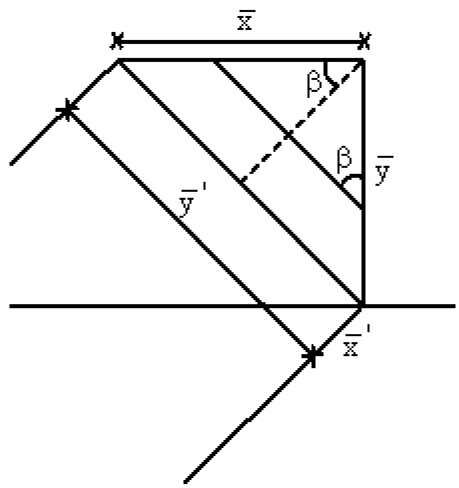


81-



85-





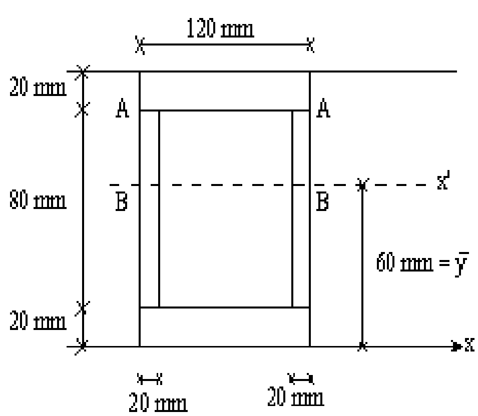
89-

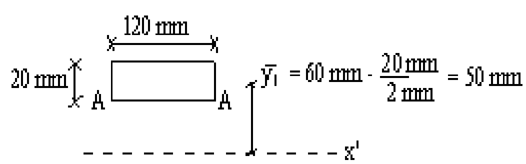
551-6-4P

SA CODE: MN
SR CODE: 4584

Given

Spacing between nail(s) =30mm
The vertical shear in the beam (V)=1200N





Centriod of y-axis $\bar{y} = \dfrac{20+80+20}{2}$

$= 60\,\text{mm}$

The centriodal Moment of inertia about x-axis $I_{x'} = \sum\left(I + Ad^2\right)$

$$= \left[\frac{b_1 d_1^3}{12} + a_1 h_1^2\right] \times 2 + \frac{b_2 d_2^3}{12}$$

$$= \left[\frac{120\times 20^3}{12} + 120\times 20\times 50^2\right]\times 2 + \frac{2\times 80^3}{12}\times 2$$

$$= \left[80\times 10^3 + 6\times 10^6\right]\times 2 + 853.33\times 10^3\times 2$$

$$= 13.87\times 10^6\,\text{mm}^4$$

(A)

Allowable shear stress,

$$\tau_{AA} = \frac{VQ_1}{Ib}$$

$$Q_1 = A_1\bar{y}_1$$

$$= (20)\times(120)\times(50)$$

$$= 120\times 10^3\,\text{mm}^3$$

$$\tau_{AA} = \frac{1200\times 120\times 10^3}{13.87\times 10^6\times 120}$$

$$= 86.52\times 10^{-3}\,\text{N/mm}^2$$

Allowable shear stress

$$\tau_{all} = \frac{V_{all}}{A}$$

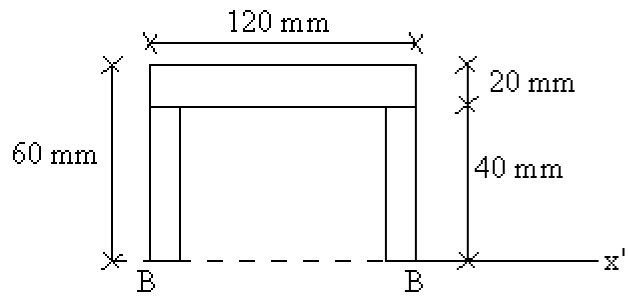
$$V_{all} = \tau_{AA}\times A$$

$$= 86.52\times 10^{-3}\times 30\times 120$$

$$\boxed{V_{all} = 311.472\,\text{N}}$$

The shearing force in each nail

$$V = \frac{311.472}{2}$$
$$= 155.736 \text{ N}$$
$$\boxed{V = 155.8\,\text{N}}$$



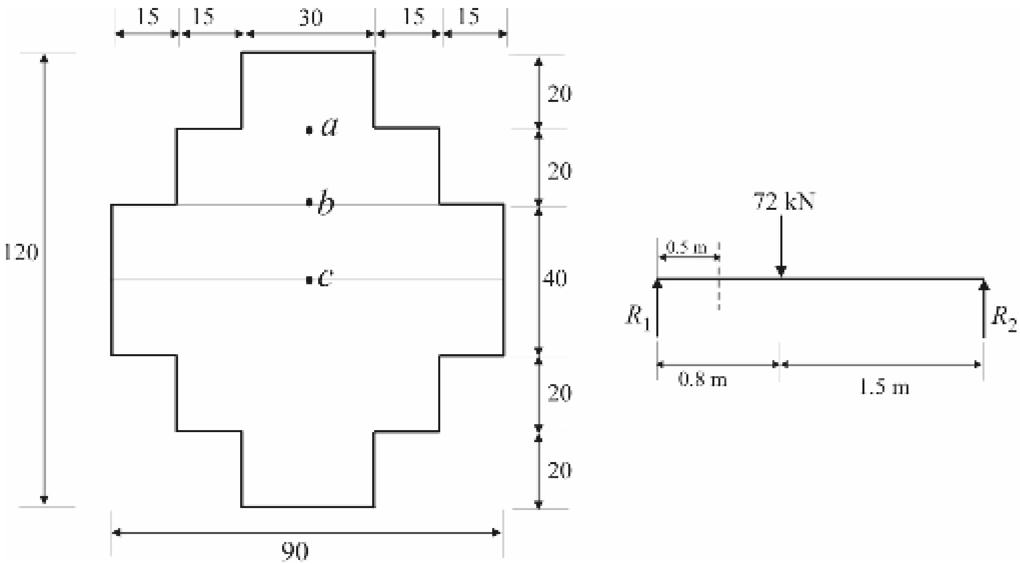
Centriod of y-axis $\bar{y}_2 = \dfrac{120\times20\times50+(40)\times20\times20\times2}{120\times20+40\times20\times2}$

$= 38\,\text{mm}$

The first moment with respect to the neutral axis of the area above the section B-

$$Q_2 = A_2\bar{y}_2$$
$$= \left[(120)(20)+2(20)(40)\right]\times(38)$$
$$= 152000\,\text{mm}^3$$

91-

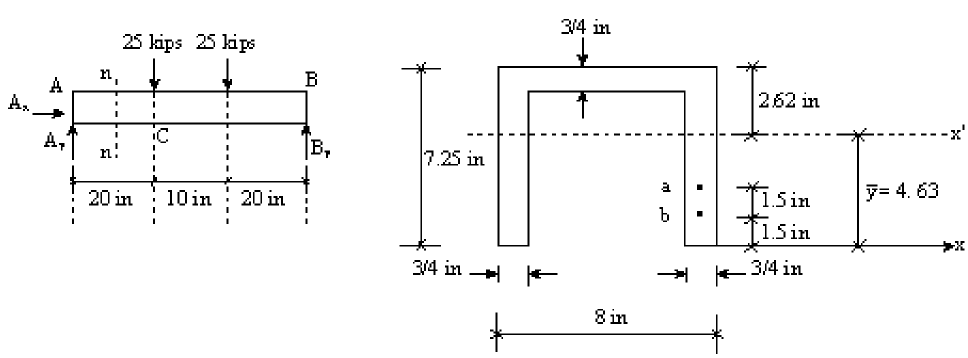


93-

551-6-92P

SA CODE: MN

SR CODE: 4584



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Solution

$$+\rightarrow \sum F = 0$$

$$A_x = 0$$

$$+\circlearrowleft \sum M_B = 0$$

$$-A_y \times 50 + 25 \times 30 + 25 \times 20 = 0$$

$$A_y = \frac{1250}{50}$$
$$= 25 \text{ kips}$$

Shear between A and C

$$A_y - V = 0$$
$$V = A_y$$
$$= 25 \text{ kips}$$

$\therefore$ Shear at n-n = 25 kips

$$\bar{y} = \frac{\Sigma A\bar{y}}{\Sigma A}$$

$$= \frac{\left[(8)\left(\frac{3}{4}\right)\left(7.25 - \frac{3}{4} \times \frac{1}{2}\right) + 2 \times \left[\left(\frac{3}{4}\right)\left(7.25 - \frac{3}{4}\right)\left[7.25 - \frac{3}{4}\right]\right]\right]}{(8)\left(\frac{3}{4}\right) + 2 \times \left(\frac{3}{4}\right)\left(7.25 - \frac{3}{4}\right)}$$

$$= \frac{(41.25) + 2(15.84)}{6 + 9.75}$$

$$= 4.63 \text{ in}$$

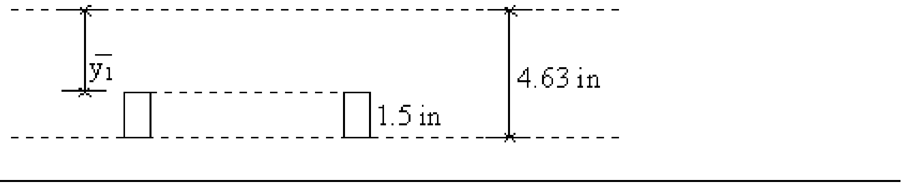
$$I_{x1} = \sum (I + ad^2)$$

$$= \left[\frac{(8)\left(\frac{3}{4}\right)^3}{12} + (8)\left(\frac{3}{4}\right)\left(2.62 - \frac{3}{4} \times \frac{1}{2}\right)^2\right] + 2\left[\frac{\left(\frac{3}{4}\right)\left(7.25 - \frac{3}{4}\right)^3}{12} + \left(\frac{3}{4}\right)\left(7.25 - \frac{3}{4}\right)\left(\frac{7.25 - \frac{3}{4}}{2}\right.\right. -$$

$$= (281.25 \times 10^{-3} + 30.24) + 2(17.16 + 9.28)$$

$$= 83.41 \text{ in}^4$$

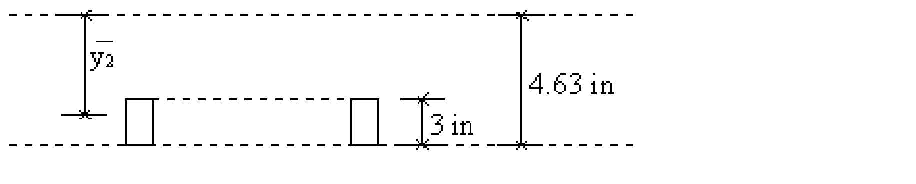
Part a



The first moment with respect to the neutral axis of the area above the section

$$Q_1 = A_1\bar{y}_1$$
$$= \left[\left(\frac{3}{4}\right)(1.5)\left(4.63 - \frac{1.5}{2}\right)\right] \times 2$$
$$= 8.73 \text{ in}^3$$
$$\tau_a = \frac{VQ_1}{I_{x1}b}$$
$$= \frac{25 \times 10^3 \times 8.73}{83.41 \times 2 \times \left(\frac{3}{4}\right)}$$
$$= 1744.39 \frac{\text{lb}}{\text{in}^2}$$
$$\boxed{\tau_a = 1.745 \text{ ksi}}$$

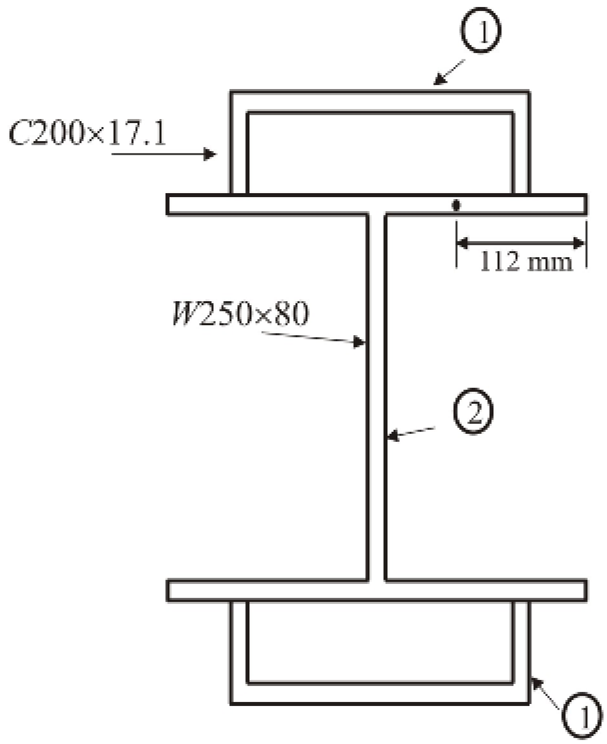
Part b



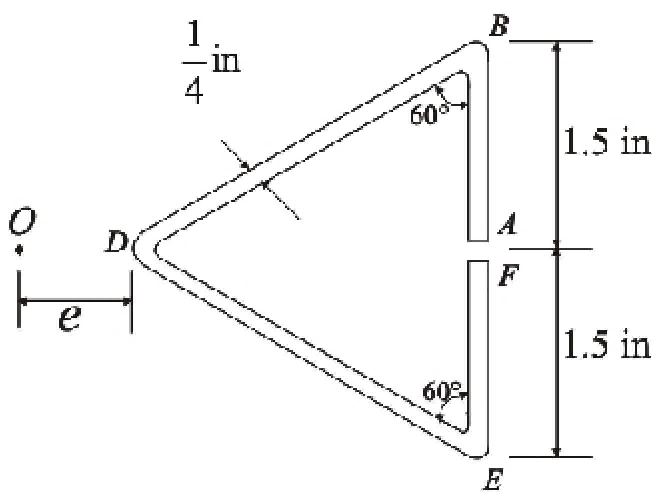
The first moment with respect to the neutral axis of the area above the section

$$Q_2 = A_2\bar{y}_2$$

95-



99-



CHAPTER 7:

1-

Given,

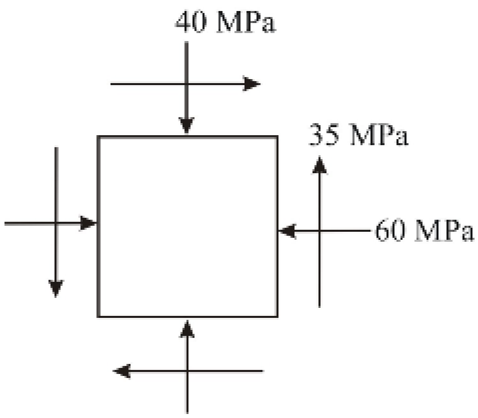
Tensile stress in x-direction $(\sigma_x) = 0$

Compressive stress in y-direction $(\sigma_y) = -10\,\text{ksi}$

Shear stress $(\tau_{xy}) = 15\,\text{ksi}$

Angle $\theta = 60°$

5-



7-

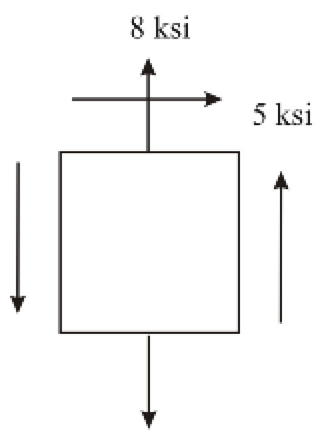
Given:

Tensile stress in x-direction $(\sigma_x) = 4$ ksi

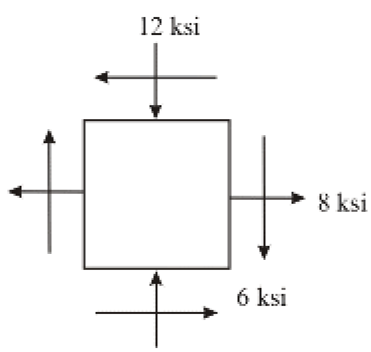
Compressive stress in y-direction $(\sigma_y) = -12$ ksi

Shear stress $(\tau_{xy}) = -15$ ksi

13-



15-



21-

Area of the weld $(A) = 10 \times 80$ mm

Force $(F) = 100$ kN

Angle $(\beta) = 25°$

23-

Vertical force $(F) = 400$ lb

Radius of the wheel $(r) = 2$ in

Distance from A to H $(l) = 6$ in

Section at H

The forces and couple

Vertical force (F) 400 lb

$$\text{Moment } (M) = F \times l$$
$$= 400 \times 6$$
$$= 2400 \text{ lb - in}$$

$$\text{Torque } (T) = F \times r$$
$$= 400 \times 2$$
$$= 800 \text{ lb -in}$$

25-

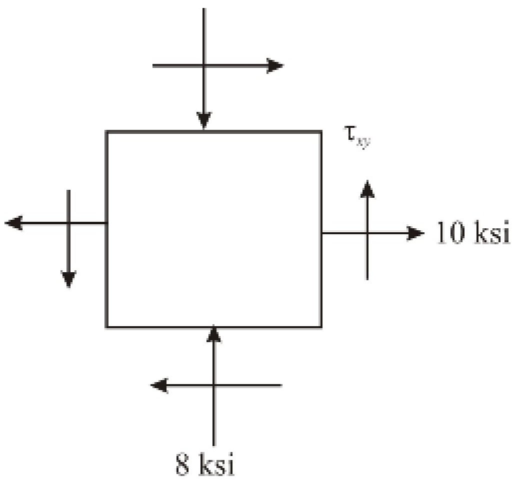
The outer diameter of steel pipe $(D_0) = 102$ mm

$$\text{Outer radius of steel pipe } (r_0) = \frac{102}{2} = 51 \text{ mm}$$

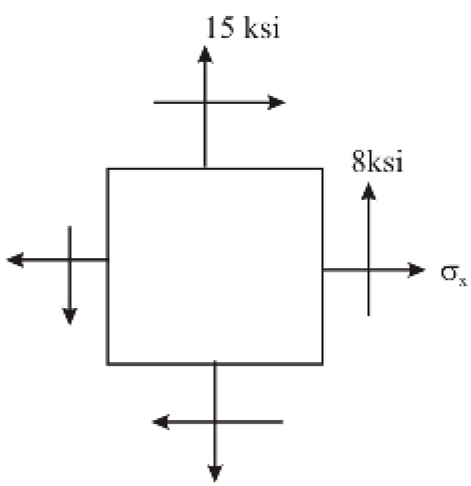
Thickness of the steel pipe wall $(t) = 6$ mm

$$\text{Inner radius of steel pipe } (r_i) = r_0 - t$$
$$= 51 - 6$$
$$= 45 \text{ mm}$$

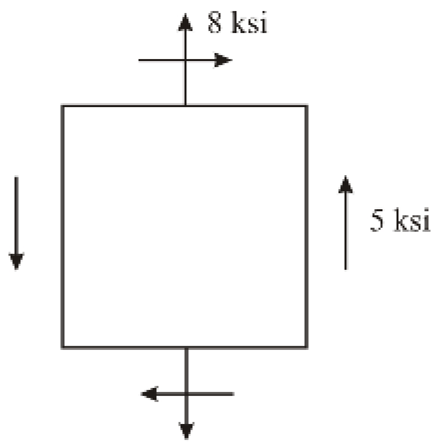
27-



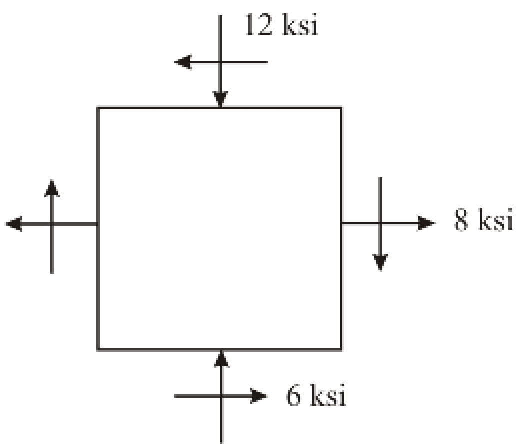
29-



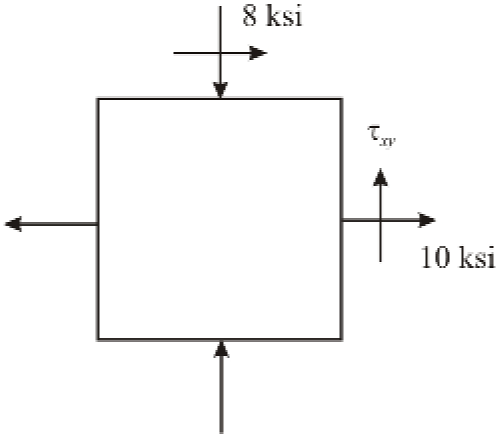
35-



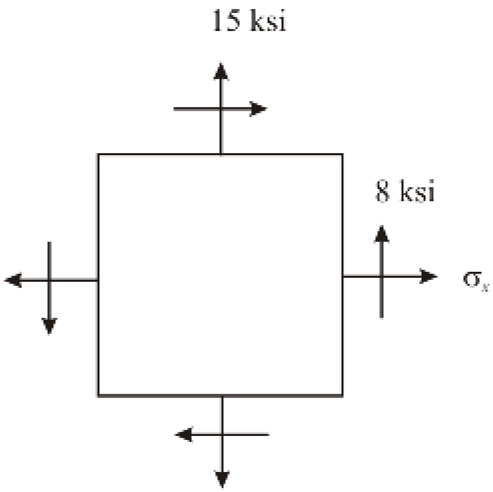
37-



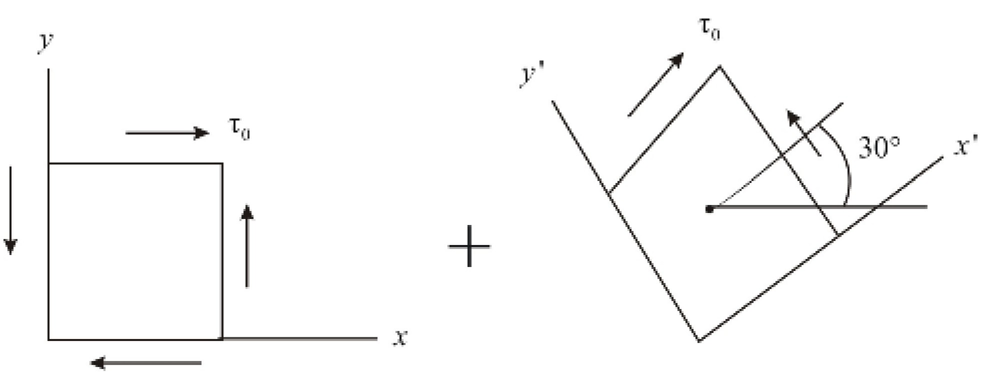
49-



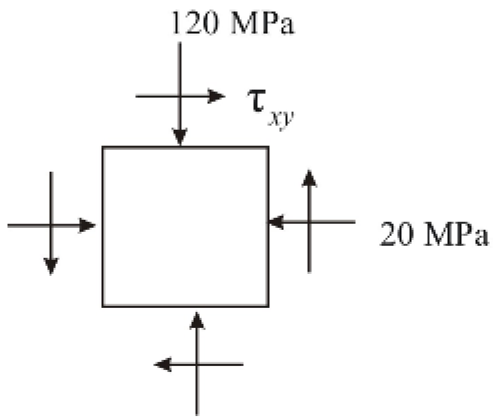
51-



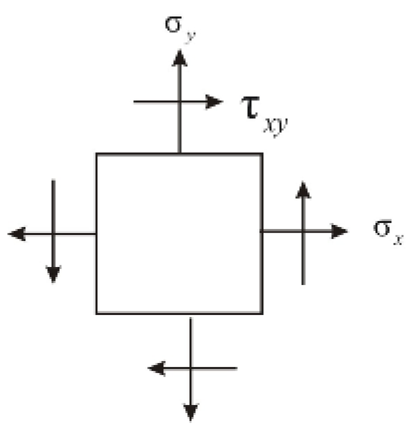
57-



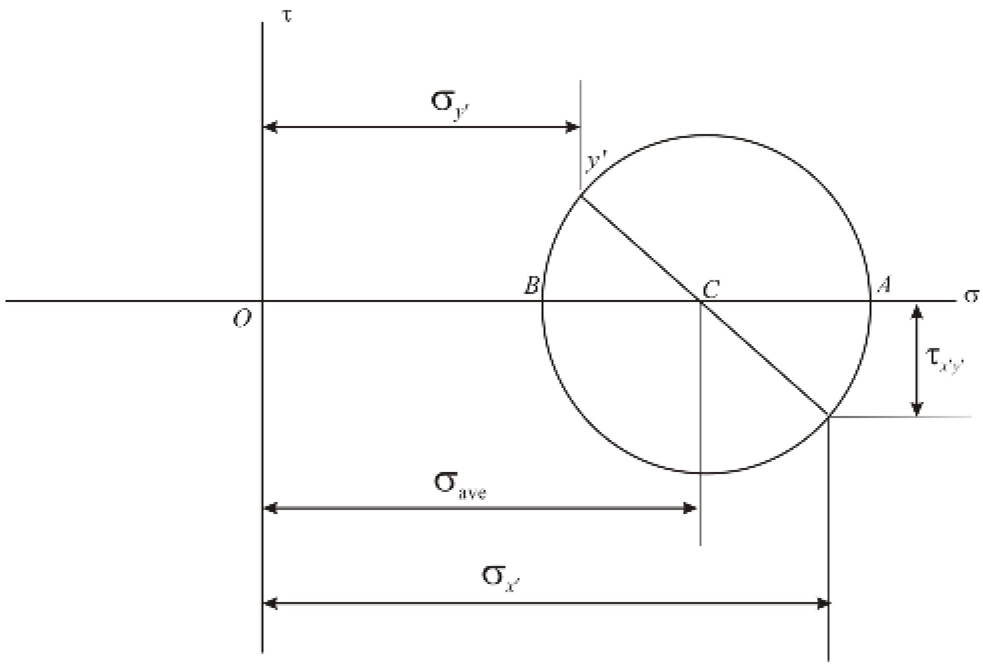
61-



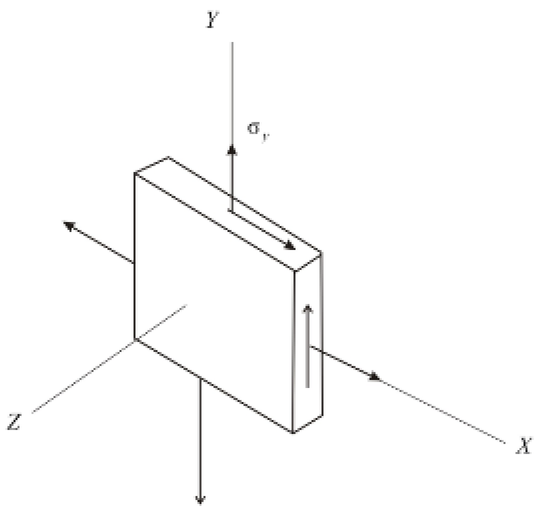
63-



65-



69-



71-

Tensile stress in $x-$direction $(\sigma_x) = 5$ ksi

Tensile stress in y − direction $(\sigma_y) = 10$ ksi

Shear stress $(\tau_{xy}) = -6$ ksi

Average stress $\sigma_{ave} = \dfrac{\sigma_x + \sigma_y}{2}$

$$\sigma_{ave} = \frac{5+10}{2} = \frac{15}{2} = 7.5 \text{ ksi}$$

Maximum shear stress $(\tau_{x'y'}) = \sqrt{\left(\dfrac{\sigma_x - \sigma_y}{2}\right)^2 + (\tau_{xy})^2}$

$$= \sqrt{\left(\frac{5-10}{2}\right)^2 + (-6)^2}$$

$$= \sqrt{(-2.5)^2 + (-6)^2}$$

$$= 6.5 \text{ ksi}$$

From Mohr's circle

73-

Stress in x – direction $(\sigma_x) = 150$ MPa

Stress in y – direction $(\sigma_y) = 70$ MPa

Shear stress $(\tau_{xy}) = 75$ MPa

77-

Given

Tensile stress in x – direction $\sigma_x = 100$ MPa

Tensile stress in y – direction $\sigma_y = 40$ MPa

81-

Compressive stress in x – direction $(\sigma_x) = -\sigma_0$

Compressive stress in y – direction $(\sigma_y) = -\sigma_0$

Shear stress $(\tau_{xy}) = 100$ MPa

$$\text{Average stress } (\sigma_{ave}) = \frac{\sigma_x + \sigma_y}{2}$$

$$= \frac{(-\sigma_0) + (-\sigma_0)}{2}$$

$$= \frac{-2\sigma_0}{2}$$

$$= -\sigma_0$$

$$\text{Maximum shear stress } (\tau_{max}) = \sqrt{U^2 + (\tau_{xy})^2}$$

$$U = \frac{\sigma_x - \sigma_y}{2}$$

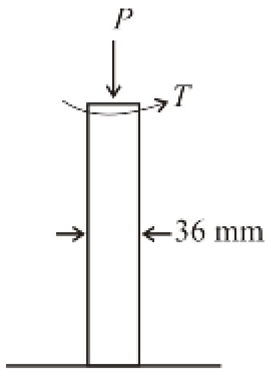
$$= \frac{-\sigma_0 - (-\sigma_0)}{2}$$

$$= 0$$

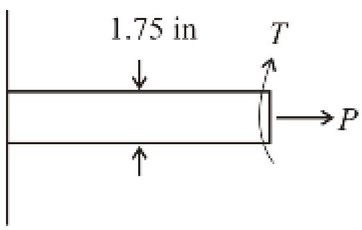
$$\tau_{max} = \sqrt{(100)^2}$$

$$\tau_{max} = 100 \text{ MPa}$$

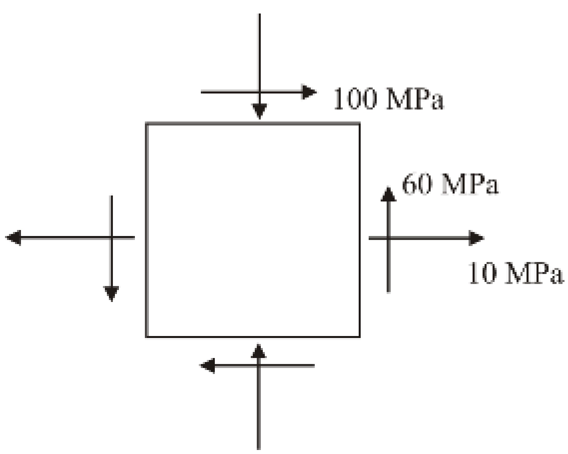
85-



87-



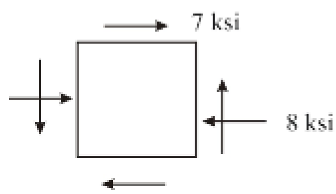
89-



91-

Ultimate tensile strength of Aluminium alloy $\sigma_{UT} = 10$ ksi

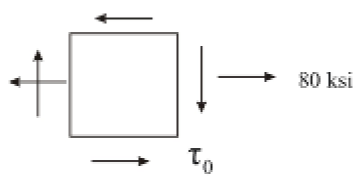
Ultimate compressive strength of a Aluminum alloy $\sigma_{UC} = 30$ ksi



93-

Ultimate tensile strength aluminum along $\sigma_{UT} = 10$ ksi

Ultimate compressive strength in aluminum alloy $\sigma_{UC} = 25$ ksi



95-

Ultimate tensile strength in aluminum alloy $\sigma_{UT} = 60$ MPa

Ultimate compressive strength in a aluminum alloy $\sigma_{UC} = 120$ MPa

Load $(P) = 26$ kN

$= 26 \times 10^3$ N

Diameter of rod $(d) = 32$ mm

Are of the rod (A), $= \frac{\Pi}{4}(d)^2$

$= \frac{\Pi}{4}(0.032)^2$

$= 0.000803 \text{ m}^2$

97-

Ultimate tensile strength of a cast iron $(\sigma_{UT}) = 8$ ksi

Ultimate compressive strength of cast iron $(\sigma_{UC}) = 20$ ksi

105-

Given data:

Outside diameter of a steel penstock $d_0 = 750\,\text{mm}$

Density of water $(\rho) = 1000\,\text{kg/m}^3$,

The distance between head race to tail race $h = 300\,\text{m}$

Allowable normal stress in the steel $\sigma_{\text{allow}} = 85\,\text{MPa}$

107-

Outer diameter of cylindrical tank $(d_o) = 5.5\text{ ft} = 66\text{ in}$

Wall thickness of cylindrical tank $(t) = \dfrac{5}{8}\text{ in}$

Ultimate normal stress of the steel $(\sigma_u) = 65\text{ ksi}$

Factor of safety $(F \cdot S) = 5.0$

109-

Wall thickness of cylinder $(t) = \dfrac{3}{16}\text{in} = 0.015625\text{ft}$

Outer diameter of cylinder $(d_o) = 25\text{ft} = 300\text{ in}$

Ultimate strength of a steel $(\sigma_u) = 60\text{ ksi}$

Factor of safety $(F \cdot S) = 4.0$

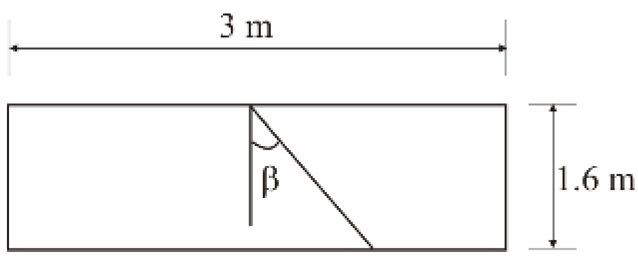
Specific weight of water $(\gamma) = 62.4\text{ lb/ft}^3$

111-

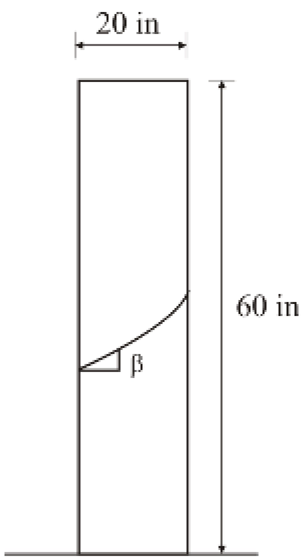
Nominal diameter of steel pipe $d = 12\,\text{in}$,

Pressure in the steel pipe $P = 400\,\text{Psi}$

113-



117-



121-

Inner diameter of a tank $(d) = 450$ mm

Inner radius of a tank $(r_i) = 225$ mm

Wall thickness of a tank $(t) = 6$ mm

Gage pressure in a tank $(P) = 1.2$ MPa

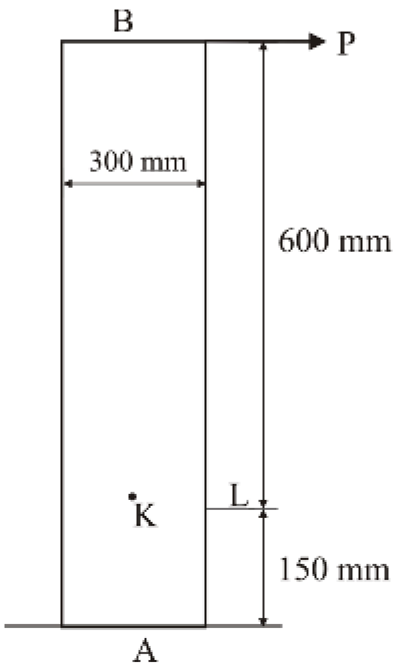
$= 1.2 \text{ N/mm}^2$

Outer radius of a tank $(r_o) = r_i + t$

$= 225 + 6$

$(r_o) = 231$ mm

123-



125-

Inner diameter of pressure vessel $(d_i) = 10$ in

Inner radius of a pressure vessel $(r_i) = \dfrac{10}{2}$ =5 in

Wall thickness of a vessel $(t) = 0.25$ in

Length of the vessel $(l) = 4$ ft

Gage pressure inside vessel $(P) = 300$ psi

Centric axial force P and $P' = 10$ kip

$= 10 \times 0^3$ lb

127-

Outer diameter of a brass ring $(d_{OB}) = 5$ in

Thickness of a brass ring $(t) = 0.125$ in

Outer radius of a brass ring $(r_{OB}) = 2.5$ in

Inner diameter of steel ring $(d_{is}) = 5$ in

Thickness of a steel ring $(t) = 0.25$ in

Inner radius of steel ring $(r_{is}) = 2.5$ in

129-

Strain in x – direction $(\varepsilon_x) = 240\ \mu$

Strain in y – direction $(\varepsilon_y) = 160\ \mu$

Shear strain $(\gamma_{xy}) = 150\mu$

Angle $(\theta) = -60°$

$2\theta = -120°$

131-

Strain in y – direction $(\varepsilon_y) = 320\mu$

Shear stress $(\gamma_{xy}) = -100\mu$

Angle $(\theta) = 30°$

$2\theta = 60°$

133-

Strain in x – direction $(\varepsilon_x) = 240\mu$

Strain in y – direction $(\varepsilon_y) = 160\mu$

Shear stress $(\gamma_{xy}) = 150\mu = \frac{150}{2} = 75\mu$

Angle $(\theta) = 60°$

$2\theta = -120°$

135-

Strain in x – direction $(\varepsilon_x) = 0$

Strain in y – direction $(\varepsilon_y) = 320\mu$

Shear stress $(\gamma_{xy}) = -100\mu$

$$= \frac{-100}{2}$$

$$= -50\mu$$

Angle $(\theta) = 30°$

137-

$$\text{Strain in } x-\text{direction } (\varepsilon_x) = -600\mu$$
$$\text{Strain in } y-\text{direction } (\varepsilon_y) = -400\mu$$
$$\text{Shear strain } (\gamma_{xy}) = 350\,\mu$$

139-

$$\text{Strain in } x-\text{direction } (\varepsilon_x) = 30\mu$$
$$\text{Strain in } y-\text{direction } (\varepsilon_y) = 570\mu$$
$$\text{Shear strain } (\gamma_{xy}) = 720\,\mu$$

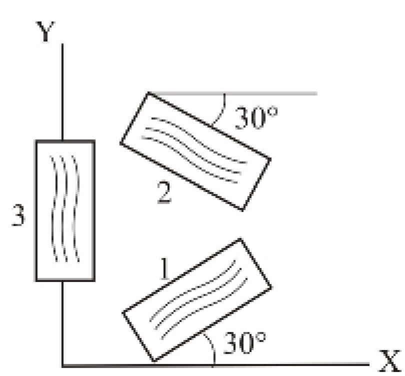
141-

$$\text{Strain in } x-\text{direction } (\varepsilon_x) = 400\mu$$
$$\text{Strain in } y-\text{direction } (\varepsilon_y) = 200\mu$$
$$\text{Shear strain } (\gamma_{xy}) = 375\,\mu$$

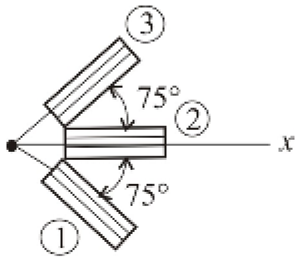
143-

$$\text{Strain in } x-\text{direction } (\varepsilon_x) = 60\mu$$
$$\text{Strain in } y-\text{direction } (\varepsilon_y) = 240\mu$$
$$\text{Shear strain } (\gamma_{xy}) = -50\,\mu$$

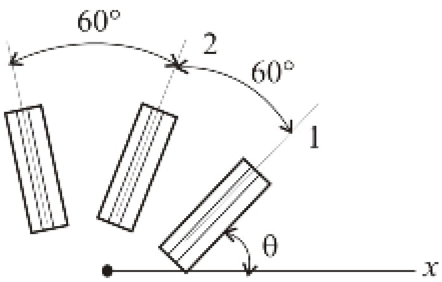
145-



147-



149-



151-

Diameter of steel shaft $(d) = 4$ in

Radius of the steel shaft $(R) = 2$ in

Angle $(\beta) = 35°$

$2\beta = 70°$

Modulus of rigidity $(G) = 11.5\times10^{6}$ psi

Strain of gauge reading $(\varepsilon_g) = 300\times10^{-6}$

153-

Angle $\beta = 35°$

$2\beta = 70°$

Wall thickness of the tank $(t) = 6$ mm

Inside diameter of the tank $(d_i) = 600$ mm $= 0.6$ m

Young's modulus $(E) = 200$ GPa

Passion's ratio $\nu = 0.30$

Strain gauge reading $(\varepsilon_g) = 280\,\mu$

155-

Given:-

The strain in x-direction $\varepsilon_x = -720\ \mu$,

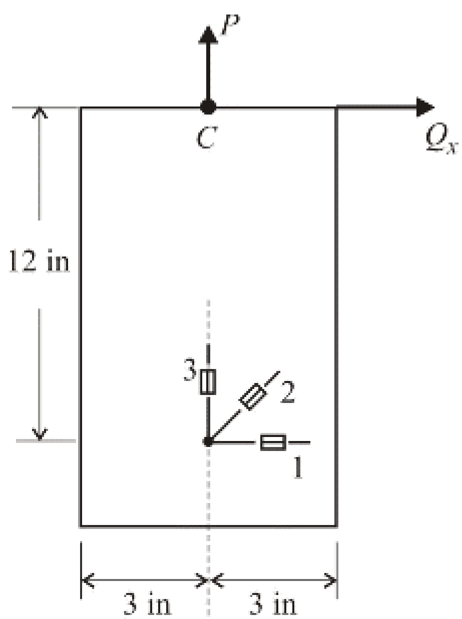
The strain in y-direction $\varepsilon_y = -400\ \mu$,

The shear strain $\gamma_{xy} = 660\ \mu$

The young's modules $E = 69$ GPa ,

The modules of rigidity $G = 28$ GPa

157-

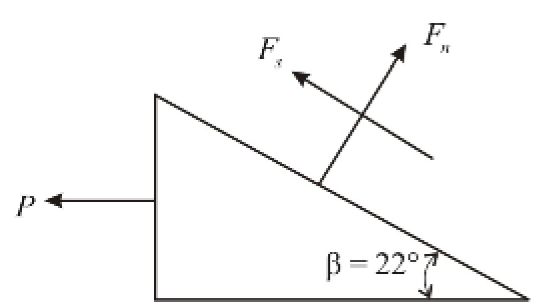


159-

Area of the two wooden members $= 80 \times 120$ mm

Angle of splice $(\beta) = 25°$

The centric load $(P) = 10$



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163-

Given data

Compressive stress in $x-$ direction $\sigma_x = -3$ ksi

Tensile stress in Z $-$ direction $\sigma_z = 12$ ksi

Tensile stress in y $-$ direction $\sigma_y = 0$

165-

Torque applied to the tank $(T) = 12\text{ kN}\cdot\text{m}$

Pressure in a tank $(P) = 8$ MPa

Inner diameter of tank $(d_i) = 180$ mm

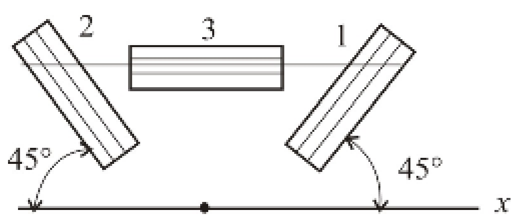
Wall thickness of a tank $(t) = 12$ mm

Inner radius of a tank $(r_i) = 90$ mm

Outer radius of a tank $(r_o) = r_i + t$

$= 90 + 12 = 102$ mm

169-



CHAPTER 8:

1-

Given Data:

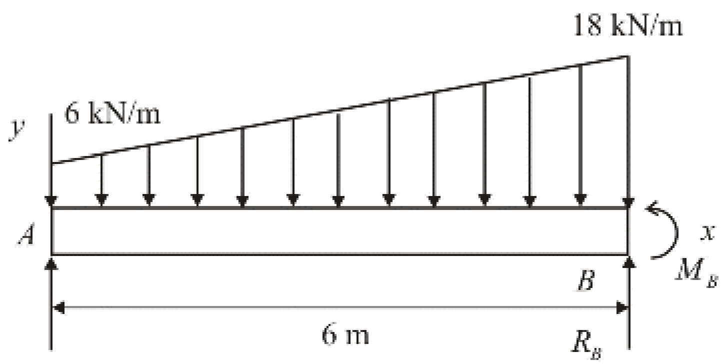
The load $P = 45$ kips

$a = 10$ in

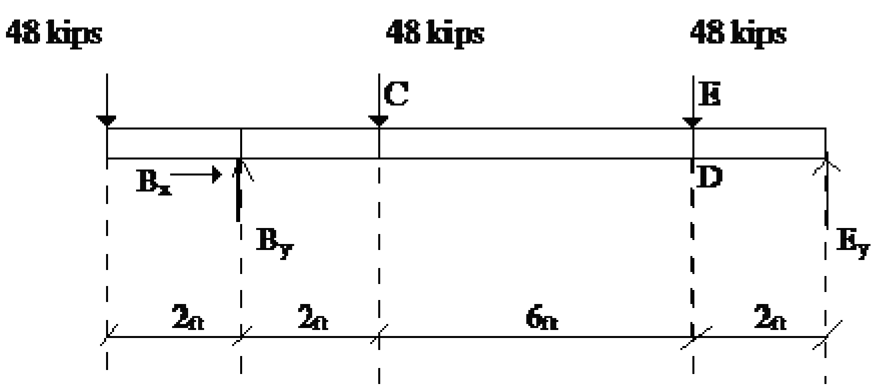
The allowable stress $\sigma_{all} = 18$ ksi

9-

Free body diagram



11-



17-

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Vertical force, $F = 500 \text{ lb}$
Allowable shear stress, $\tau_{all} = 8 \text{ ksi}$

$$r_B = 4 \text{ in}$$
$$r_C = 6 \text{ in}$$
$$r_D = 4 \text{ in}$$

21-

Moment $= M$
Torque $= T$
Force $= V$

23-

Power , $P = 20 \text{ hp}$
$$= (20)(6600)$$
$$= 132 \times 10^3 \text{ lb in/s}$$
Rotation speed, $\omega = 240 \text{ rpm}$
$$\text{Frequency, } f = \frac{240}{60}$$
$$= 4 \text{ Hz}$$
Allowable shear stress, $\tau_{all} = 7.5 \text{ ksi}$

25-

Rotation speed of the shaft $AB, N = 360 \text{ rpm}$
$$\text{So, } f = \frac{N}{60}$$
$$= \frac{360}{60}$$
$$= 6 \text{ Hz}$$

27-

Transmitted power, $P = 10\text{kW}$
$= 10000\text{ W}$

Motor speed, $N = 240$ rpm
$= \frac{240}{60}$
$= 4$ Hz

Allowable shear stress, $\tau_{all} = 60$ Mpa

$r_A = 90$ mm
$= 0.09$ m

$AB = 100$ mm
$= 0.1$ m

29-

Speed of the solid shaft $AE, N = 600$ rpm

Frequency, $f = \frac{N}{60}$
$= \frac{600}{60}$
$= 10$ Hz

Power from motor, $p = 60\text{hp}$
$= 60(6600)$
$= 396000\text{ lb}\cdot\text{in/sec}$

Allowable shear stress, $\tau_{all} = 8$ ksi

Take of power of gear $G, P_G = 40$ hp
$= (40)(6600)$
$= 264000\text{ lb}\cdot\text{in/sec}$

Take of power of gear $H, P_H = 20$ hp
$= (20)(6600)$
$= 132000\text{ lb}\cdot\text{in/sec}$

35-

Area of the rectangular cross section
$A = 10 \times 24\text{mm}$
$= 240\text{mm}^2$
$= 2.4 \times 10^{-4}\text{ m}^2$

37-

Data:

The inside diameter of a pipe $d_i = 1.61$ in

The outside diameter of a pipe $d_0 = 1.9$ in

The inside radius of a pipe $c_i = 0.805$ in

The outside radius of a pipe $c_0 = 0.95$ in

The thickness of pipe $t = c_0 - c_i$

$$t = 0.95 - 0.805$$
$$t = 0.145 \text{ in}$$

39-

Weight of the billboard, $W = 8000\text{lb}$
$$= 8\text{kips}$$

Outer diameter, $d_0 = 15\text{in}$

Wall thickness, $t = 0.5\text{in}$

Wink pressure, $p = 3\text{kips}$

43-

Internal forces in the given section! We first replace the forces y an equivalent system of force and couple applied at the center c of the section centering points H and K.
This system which represents the internal forces in the section consists of the following force and couples

The diameter of a post $d = 65$ mm

The force $V = 10$ kN

The couple $T = 1.4 \text{ kN}\cdot\text{m}$

49-

Vertical force, $P = 120$ kN

Force $F = 50$ kN

$$\theta = 30°$$

51-

$$\text{Cross}-\text{section at area, } A = 1.5\times 2.4$$
$$= 3.6 \text{ in}^2$$
$$\text{Force, } F = 500 \text{ lb}$$

53-

$$\text{Thickness of the each plate, } t = 13\,\text{mm}$$
$$= 0.013\,\text{m}$$

59-

$$\text{Vertical force } = P$$
$$\text{For } W250\times 44.8$$
$$\text{Section modulus about } x-\text{axis , } S_x = 535\times 10^3 \text{ mm}^3$$
$$= 535\times 10^{-6} \text{ m}^3$$
$$S_y = 95\times 10^3 \text{ mm}^3$$
$$= 95\times 10^{-6} \text{ m}^3$$

61-

$$\text{Applied force to a wire } P = 5 \text{ kN}$$
$$d = 40 \text{ mm}$$
$$= 0.04 \text{ m}$$

65-

$$\text{Allowable normal stress}$$
$$\sigma_{\text{all}} = 24\text{ksi}$$
$$\text{Allowable torisional stress}$$
$$\tau_{\text{all}} = 14.5\text{ksi}$$

67-

Torque $= T$
Moment in y- direction $= M_y$

Moment in z- direction $= M_z$

Section modulus $= J$
We know that formula for maximum bending moment

$$\sigma_M = \frac{Mc}{I}$$

Where

$$M = \sqrt{M_y^2 + M_z^2}$$

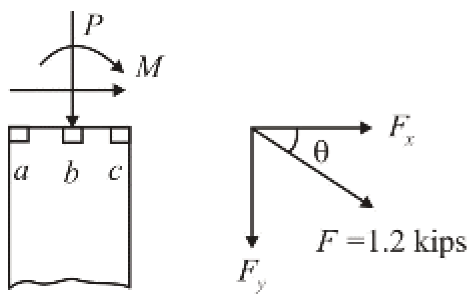
So

$$\sigma_m = \frac{Mc}{I}$$

$$= \frac{\sqrt{M_y^2 + M_z^2}}{I} \times c$$

69-

Internal forces in section a, b and c :



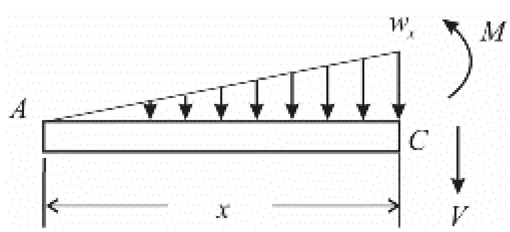
75-

Wall thick ness, $t = 0.25$ in

CHAPTER 9:

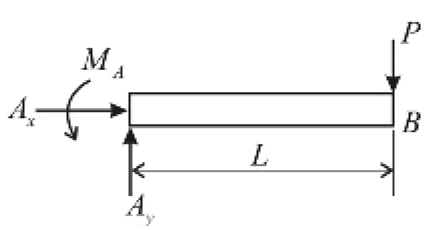
1-

Consider portion AC of length x measured from A



3-

Free body diagram of the given figure is:



5-

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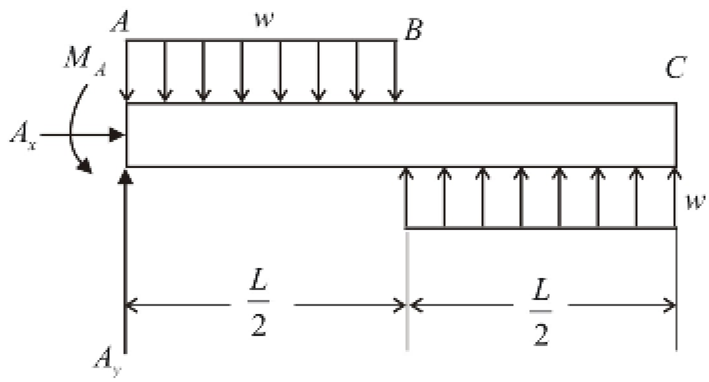
Free body diagram of the given figure is:



13-

Given:

$a = 5$ ft

$= 60$ in

$L = 15$ ft

$= 180$ in

$P = 35$ kips

$= 35\times10^3$ lb

For $W14\times30, I = 291\ \text{in}^4$

$E = 29\times10^6$ psi

17-

Differential equation of the elastic curve:

Recalling equation $\frac{d^4y}{dx^4} = -\frac{w(x)}{EI}$

For prismatic beam supports a distributed load $w(x)$, its elastic curve is governed by the fourth – order linear differential equation. Rearranging terms, we write

$$EI\frac{d^4y}{dx^4} = -w(x)$$

$$= -w_o\left[1 - \frac{x^2}{L^2}\right]$$

$$EI\frac{d^4y}{dx^4} = \frac{w_o}{L^2}\left[x^2 - L^2\right] \qquad \rightarrow (1)$$

Where $y(x)$ is the function which defines the elastic curve for the beam AB. Integrating equation (1) twice:

$$EI\frac{d^3y}{dx^4} = V$$

$$= \frac{w_o}{L^2}\left[\frac{x^3}{3} - L^2x\right] + C_1 \qquad \rightarrow (2)$$

$$EI\frac{d^2y}{dx^2} = M$$

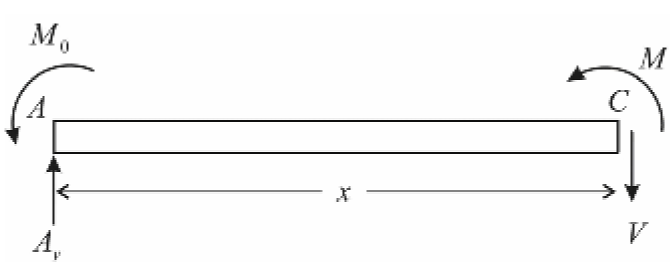
$$= \frac{w_o}{L^2}\left[\frac{x^4}{12} - \frac{L^2x^2}{2}\right] + C_1x + C_2 \qquad \rightarrow (3)$$

Boundary conditions:

The four boundary conditions that must be satisfied are on the sketch

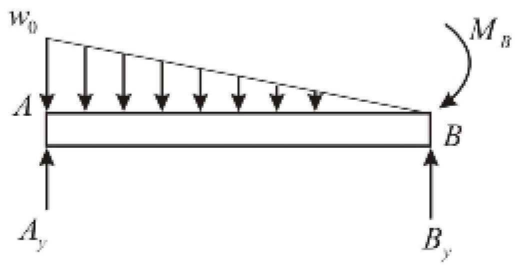
19-

Consider part AC of the beam of length x measured from A:



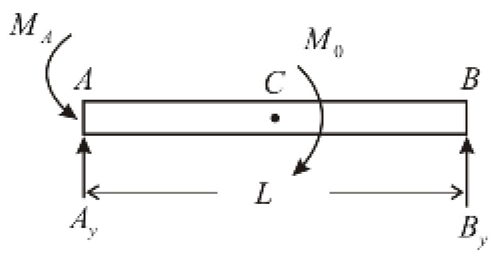
21-

Free body diagram of the given beam:



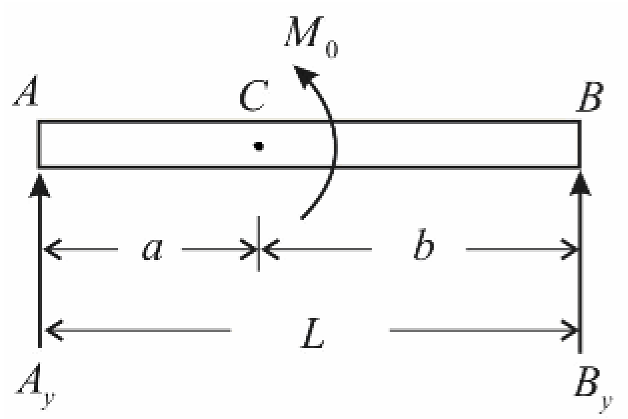
25-

Free body diagram of the given beam is:



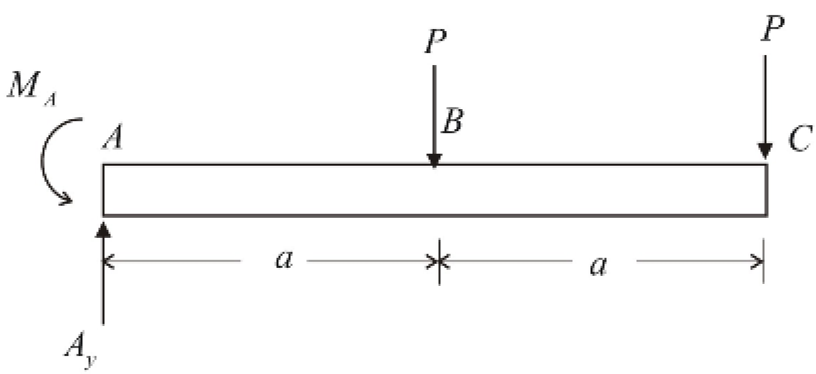
35-

Consider free body diagram of the given beam

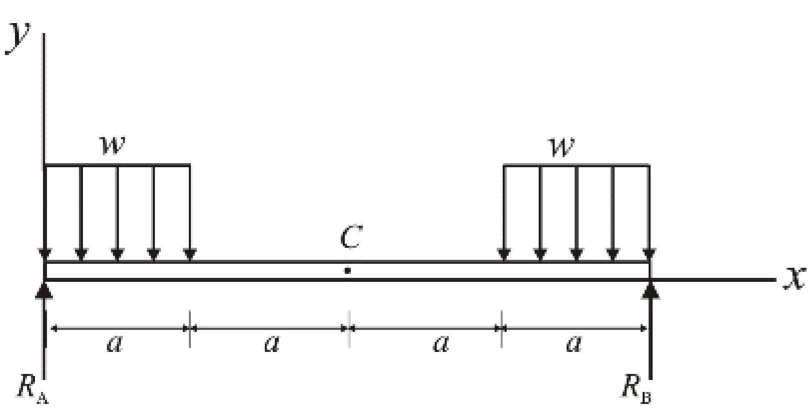


37-

Consider the free – body diagram of the given beam



41-



47-

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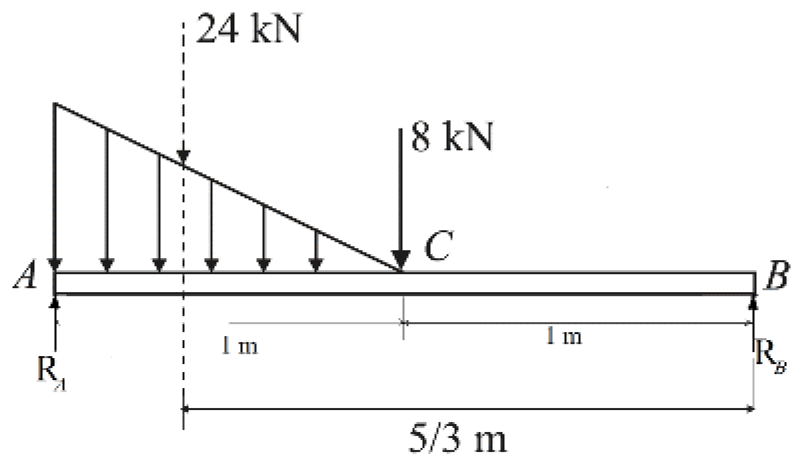
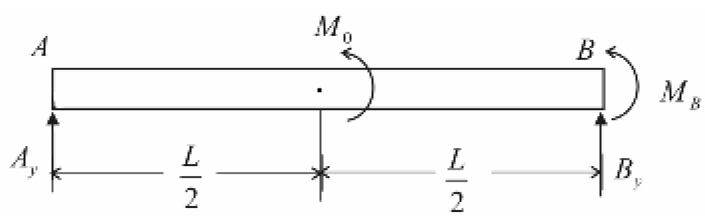
Free body diagram



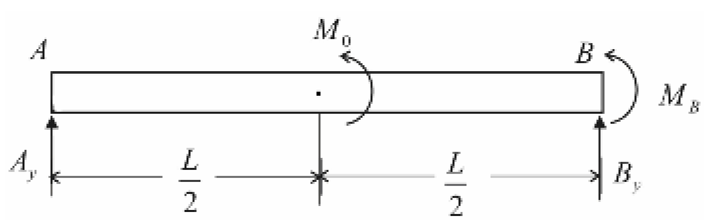
49-

Consider the free body diagram of the given figure:

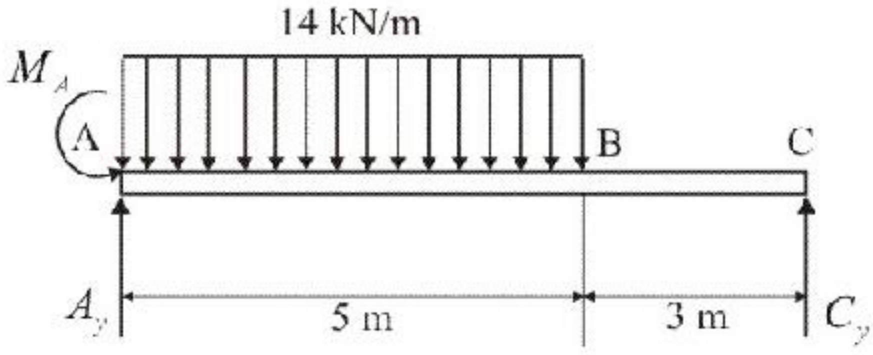


51-

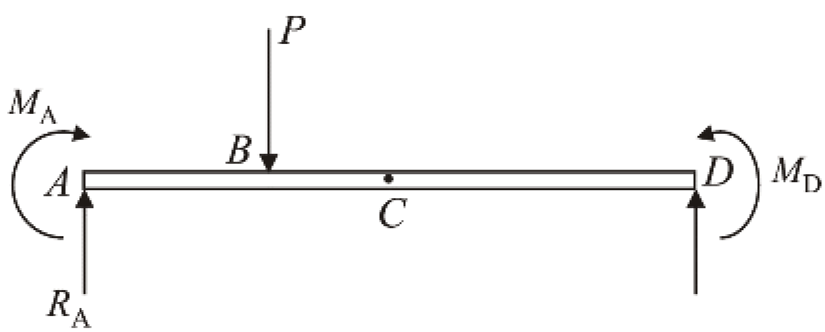
Consider the free body diagram of the given figure:



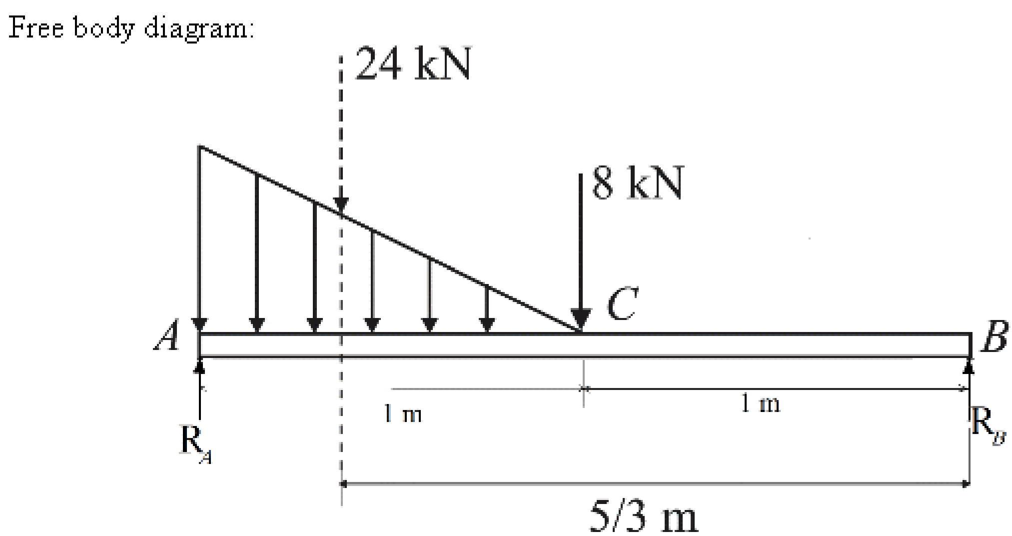
53-



57-



61-



63-

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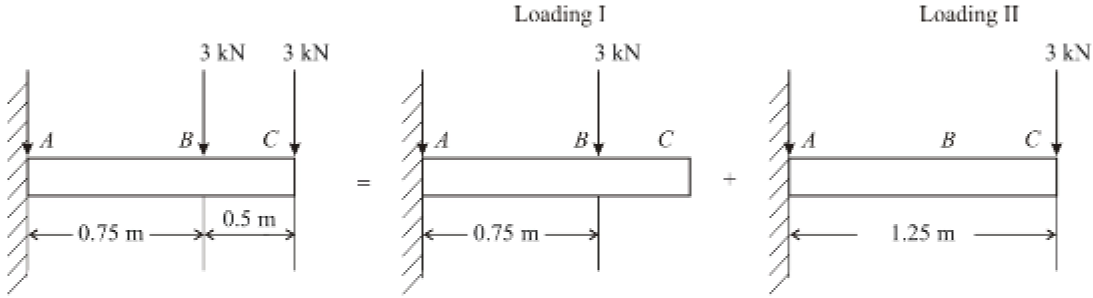
Reactions: For the given vertical wad 100kN the by symmetry $R_A = R_F$

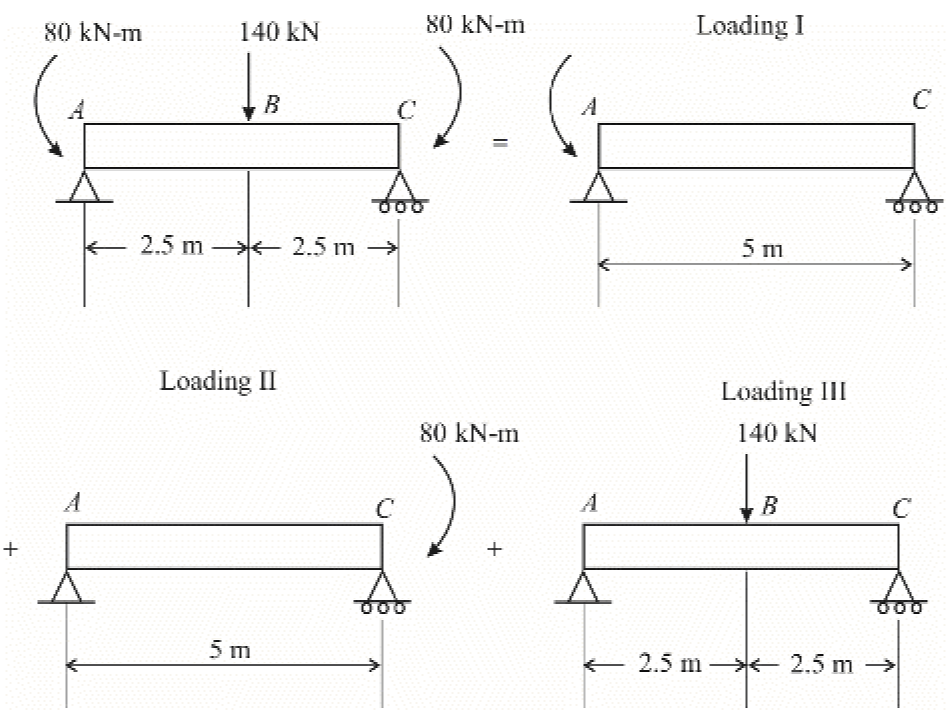
73-

Principle of superposition:
The given loading can be obtained b superposing the loading shown in the following "picture equation"



77-

Principle of super position:
The given loading shown in the following "picture equation"



79-

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Principle of superposition:
Beam is statically in determined to first degree. The reaction R_C is designated as redundant and considered as an unknown load. The given loading can be obtained by superposing the loadings I and II shown in the following "picture equation".

85-

Principle of superposition:
The given loading can be obtained by superposing the loading shown in the following "picture equation ".

87-

Principle of super position: The given loading can be obtained by superposing the loading shown in the following "Picture equation ".

89-

Given
Forces in kips and lengths in ft

$$\delta_0 = 0.8 \text{ in}$$
$$= \frac{1}{15} \text{ ft}$$
$$E = 29 \times 10^6 \text{psi}$$
$$= 29 \times 10^3 \text{ksi}$$

Principle of super position:
Considering R_C , reaction at mid point of beam C as redundant. Replacing the given loading system by the loading I and II
Properties of rolled-steel shapes

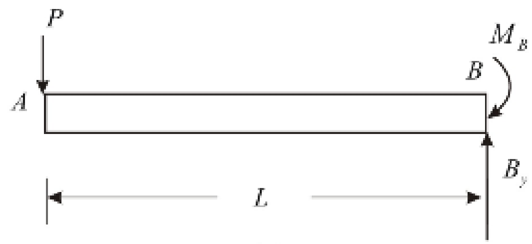
W 16×40 : $I_x = 518 \text{ in}^4$

$$EI = 29 \times 10^3 \times 518$$
$$= 15.022 \times 10^6 \text{ kip} \cdot \text{in}^2$$
$$= 104319.44 \text{ kip-ft}^2$$

95-

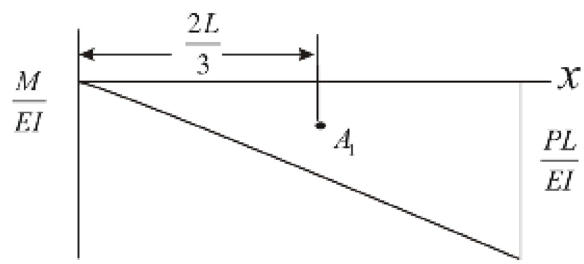
Consider the free body diagram of the beam

Free body diagram



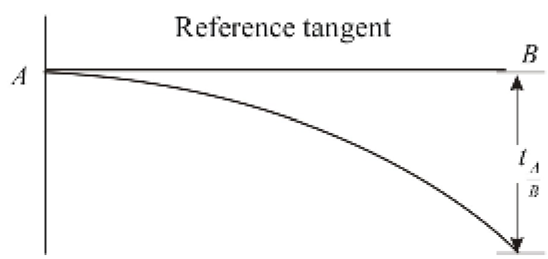
(a)

bending momnet diagram



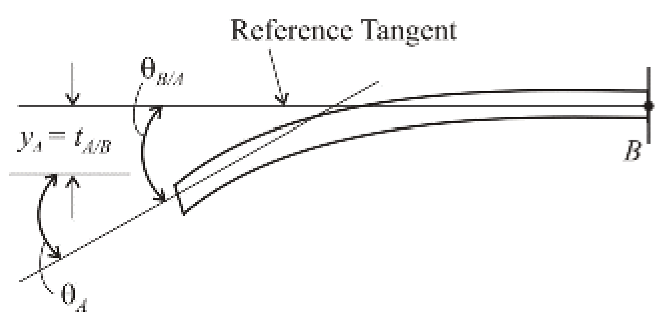
(b)

Reference tangent diagram



97-

Reference Tangent:



99-

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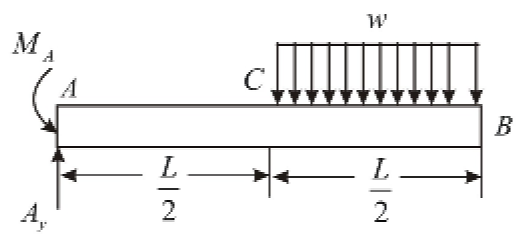
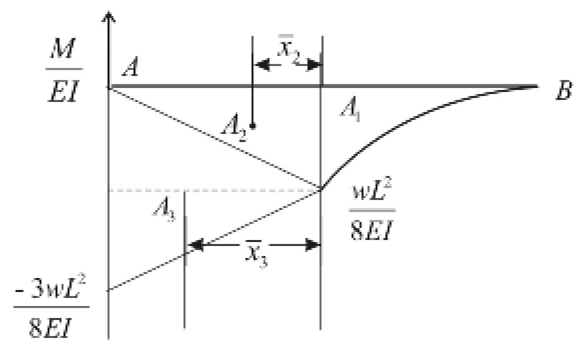
Free body diagram:

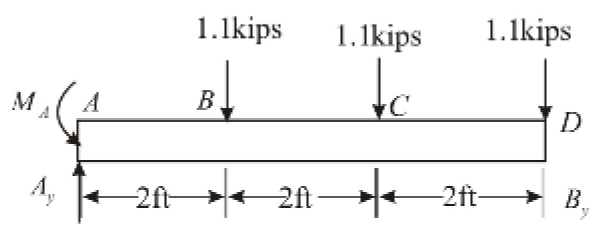


Bending momnet diagram $\frac{M}{EI}$:

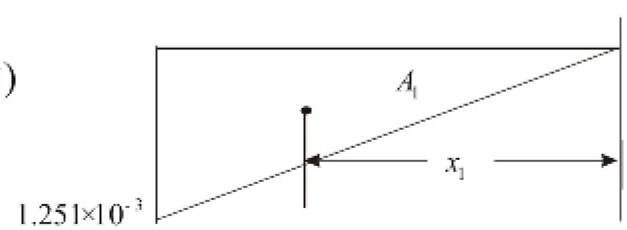


101-

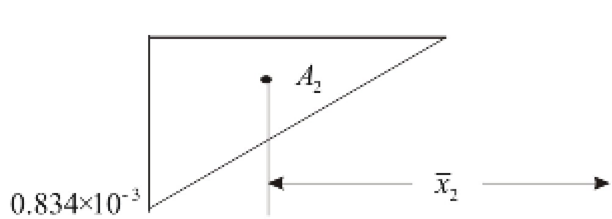
Free body diagram:



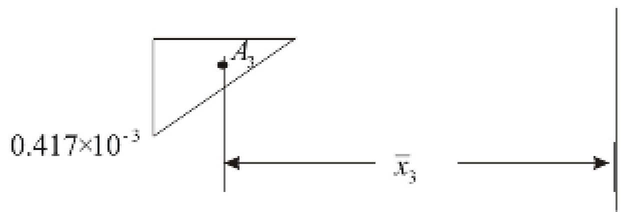
Bending momnet diagram $\frac{M}{EI}$: (i)



(ii)

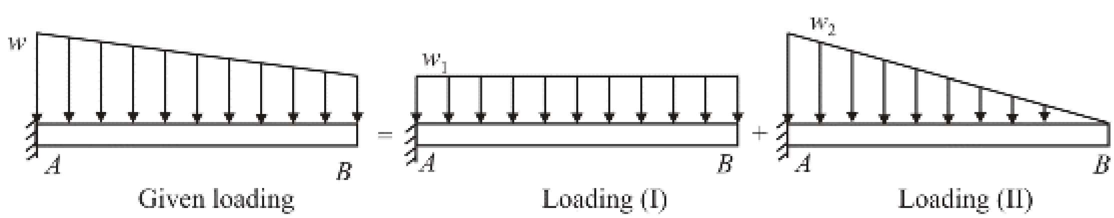


(iii)



103-

We replace the given loading by the two equivalent loadings shown in figure



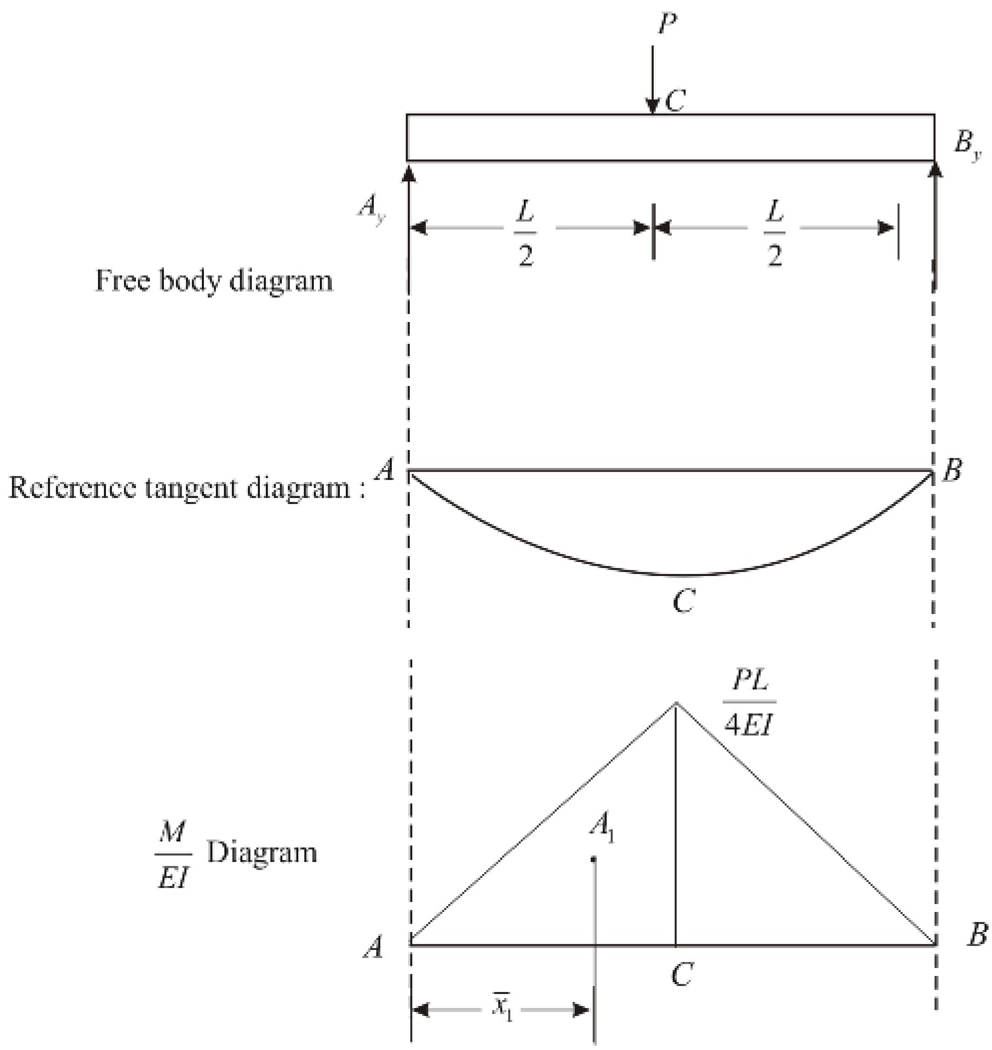
105-

We choose the horizontal tangent at the fixed end reference tangent.

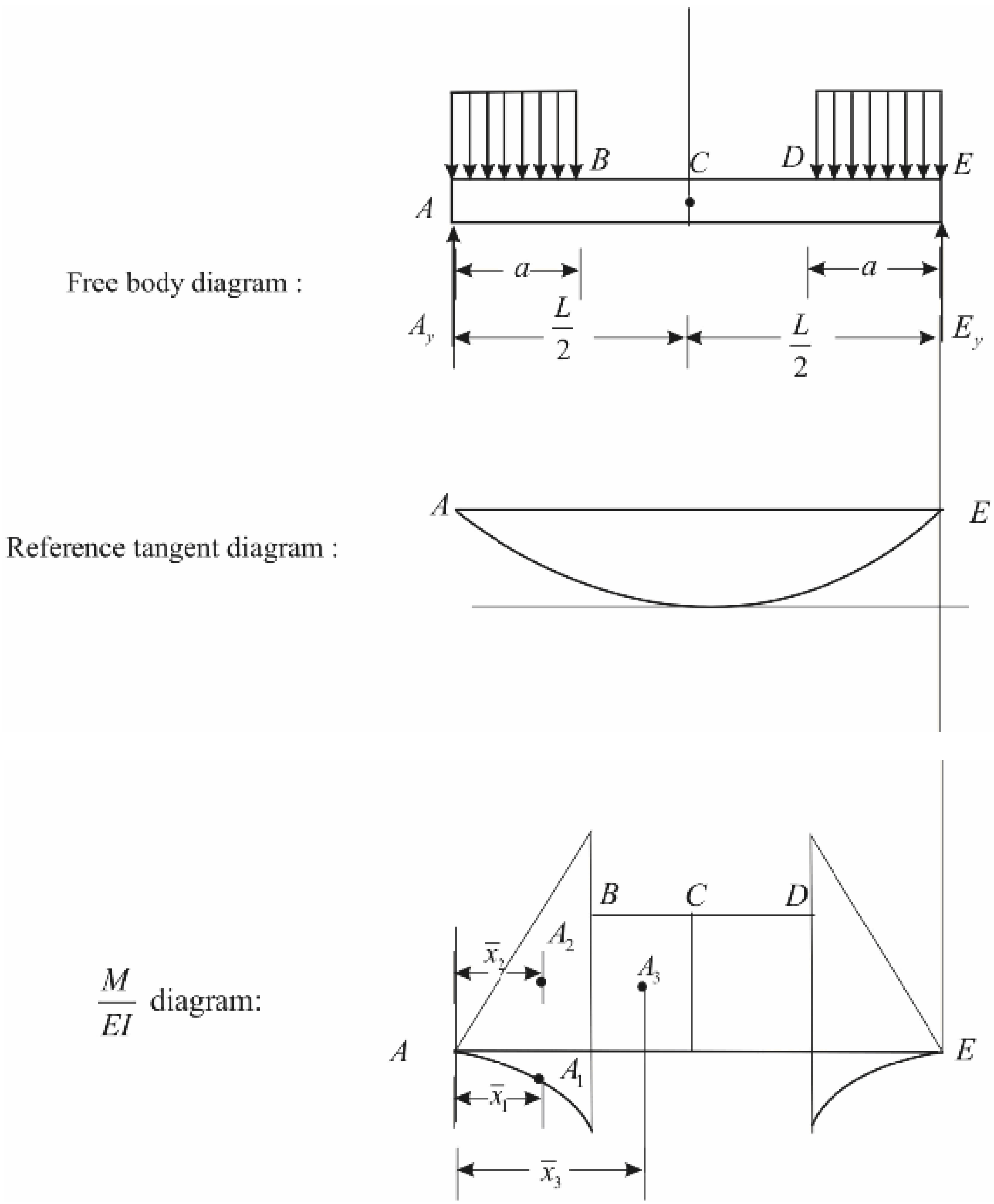
Since $\theta_A = 0$ and $y_A = 0$

We note that, $\theta_C = +\theta_{A/C}$

$y_C = t_{C/A}$

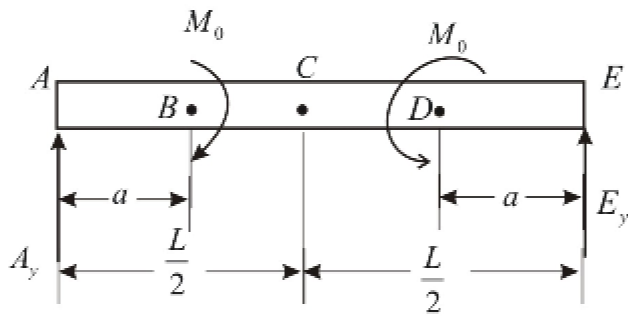

P
C
B_y
A_y
$\frac{L}{2}$
$\frac{L}{2}$
Free body diagram
Reference tangent diagram :
A
B
C
$\frac{PL}{4EI}$
$\frac{M}{EI}$ Diagram
A_1
A
B
C
$\bar{x}_1$

111-

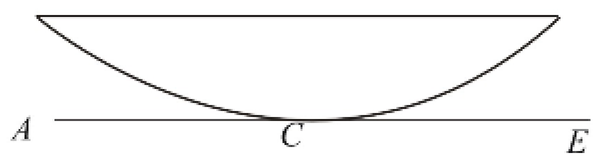

Free body diagram :
A
B
C
D
E
a
a
A_y
$\frac{L}{2}$
$\frac{L}{2}$
E_y
Reference tangent diagram :
A
E
$\frac{M}{EI}$ diagram:
A
B
C
D
E
A_1
A_2
A_3
$\bar{x}_1$
$\bar{x}_2$
$\bar{x}_3$

113-

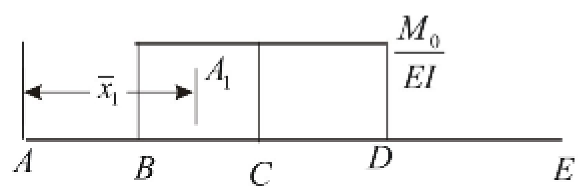
Free body diagram :



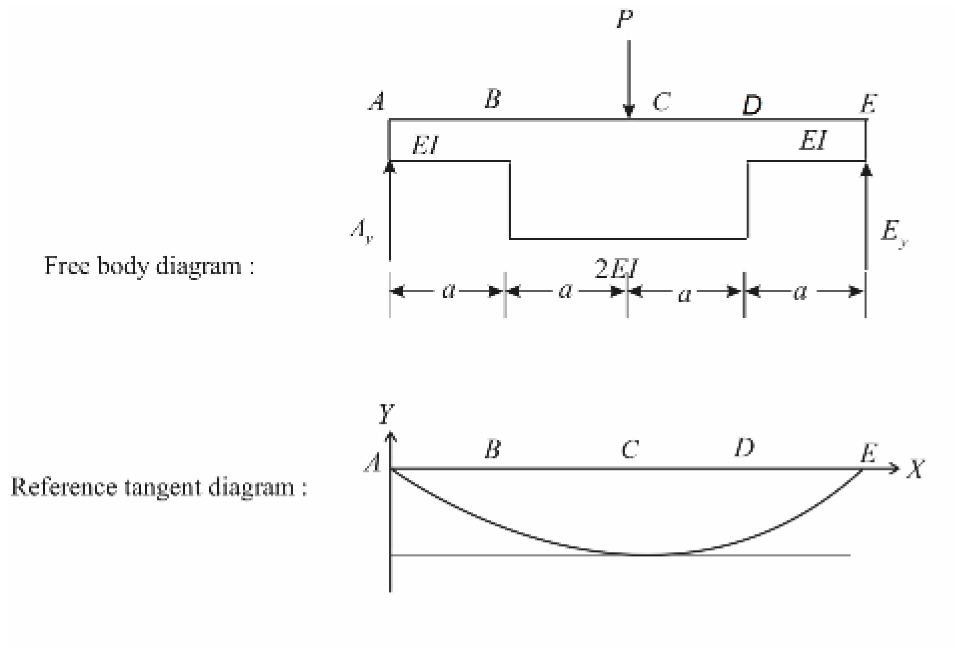
Reference tangent diagram :

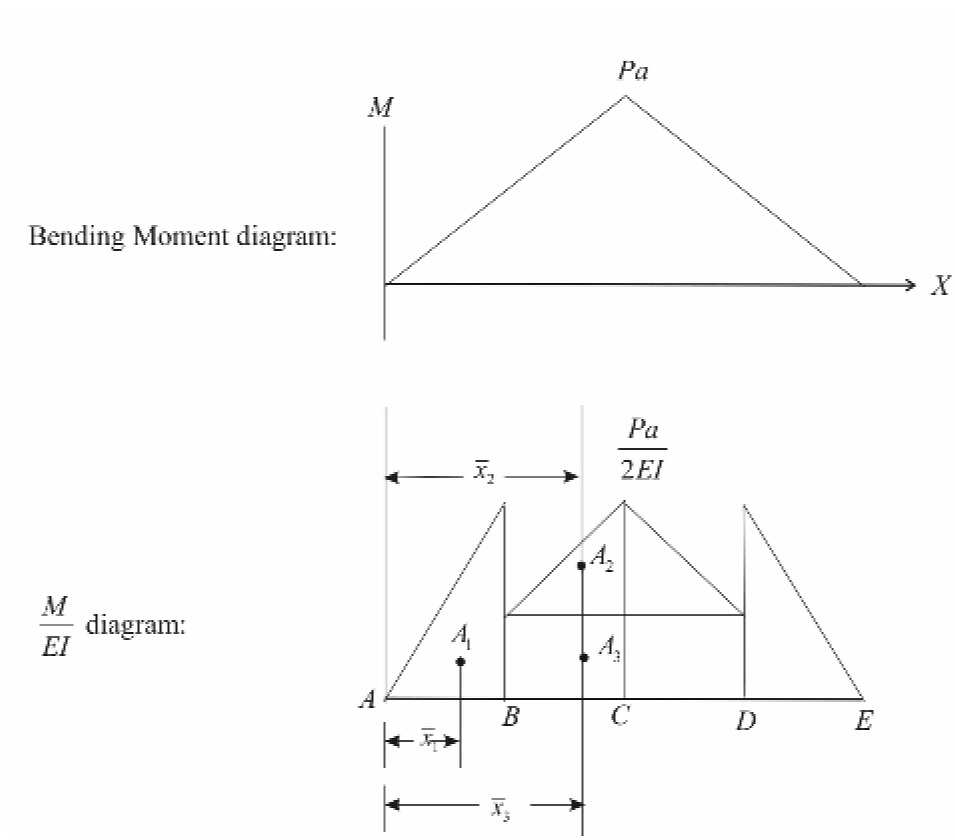


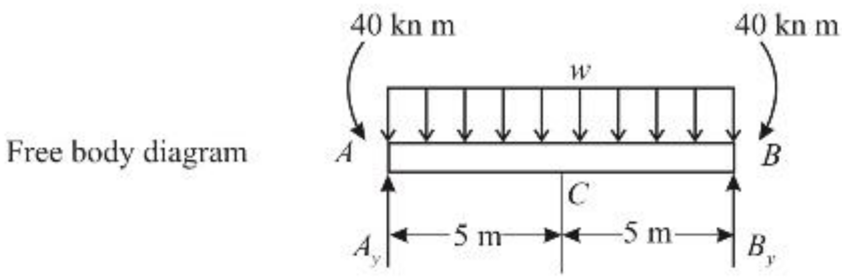
$\frac{M}{EI}$ diagram:

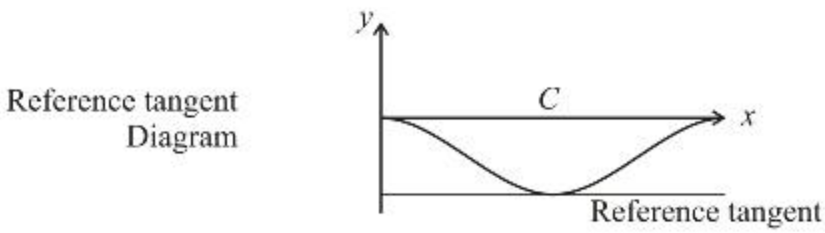


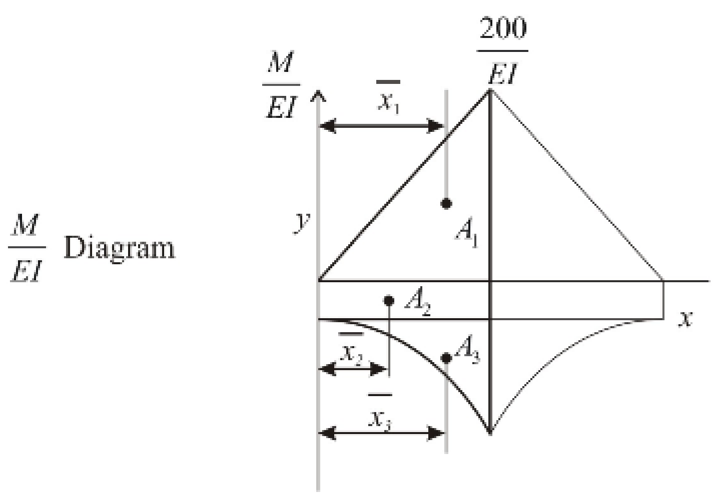
115-


Free body diagram :
P
A
B
C
D
E
EI
EI
2EI
A_y
E_y
a
a
a
a
Reference tangent diagram :
Y
A
B
C
D
E
X


Bending Moment diagram:
M
Pa
X
$\frac{M}{EI}$ diagram:
$\frac{Pa}{2EI}$
$\bar{x}_2$
A_1
A_2
A_3
A
B
C
D
E
$\bar{x}_1$
$\bar{x}_3$

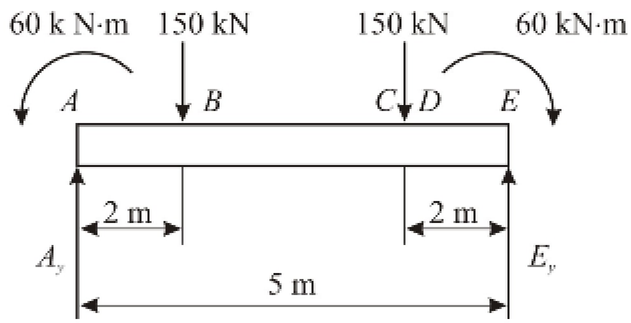

40 kn m
40 kn m
w
Free body diagram
A
B
C
A_y
5 m
5 m
B_y


Reference tangent
Diagram
y
C
x
Reference tangent

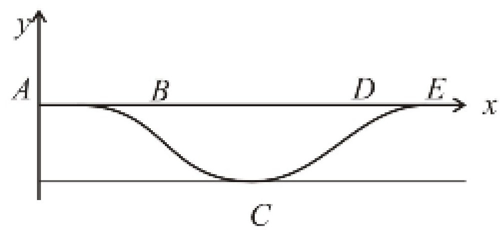

$\frac{200}{EI}$
$\frac{M}{EI}$
$\bar{x}_1$
y
A_1
$\frac{M}{EI}$ Diagram
A_2
$\bar{x}_2$
A_3
x
$\bar{x}_3$

119-

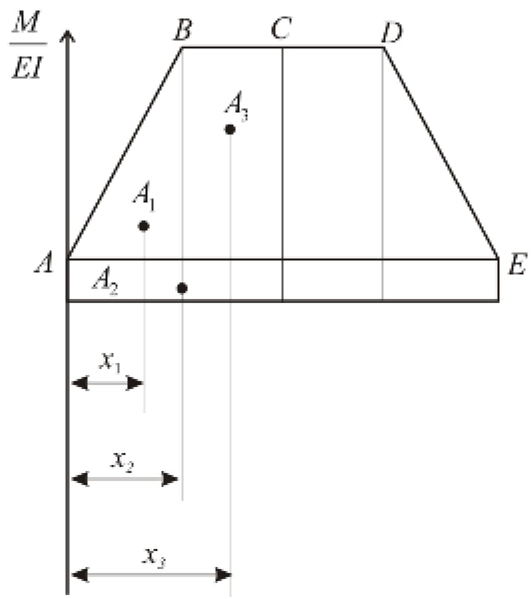
Free body diagram:



Reference tangent
Diagram



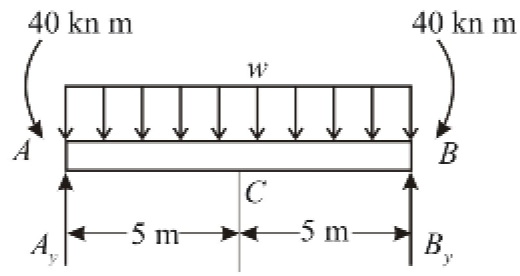
$\frac{M}{EI}$ Diagram



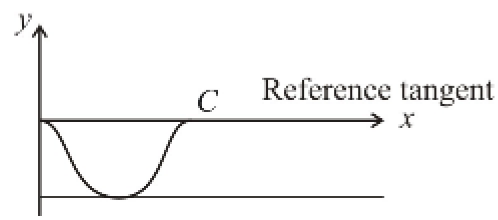
e

121-

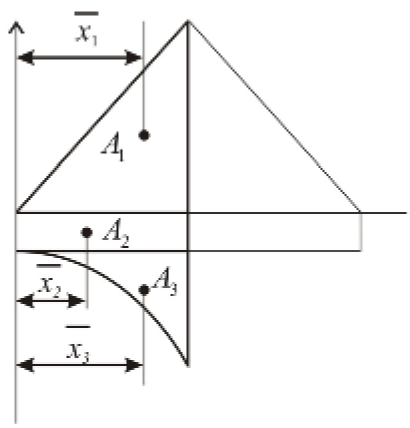
Free body diagram



Reference tangent
Diagram

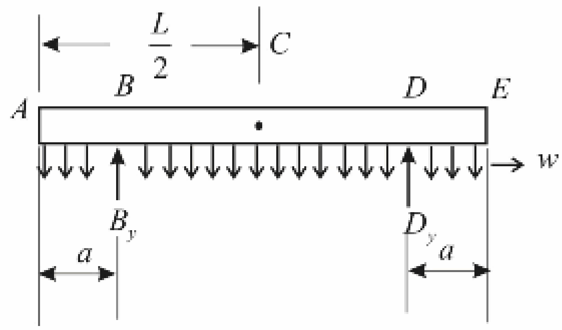


$\frac{M}{EI}$ Diagram

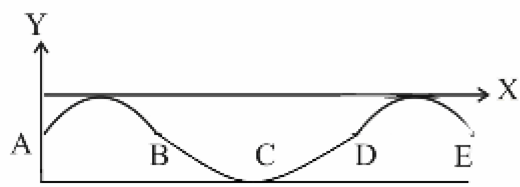


123-

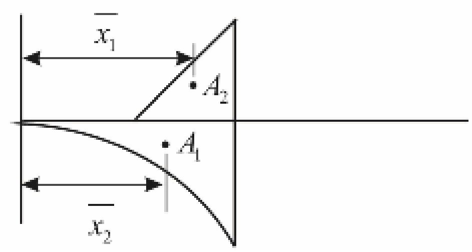
Free body diagram:



Reference tangent diagram

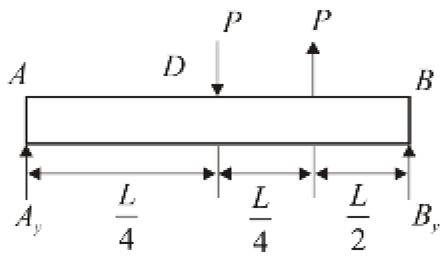


$\frac{M}{EI}$ diagram

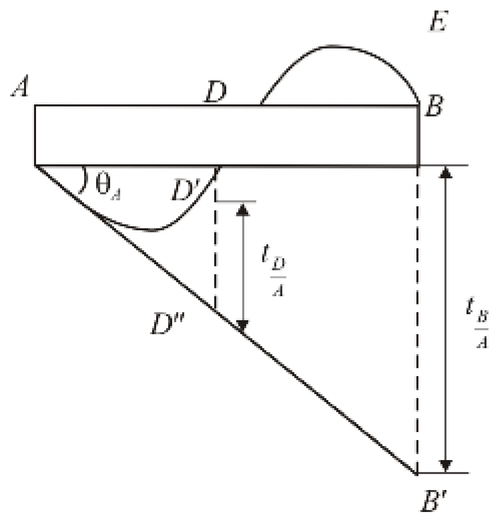


125-

Free body diagram

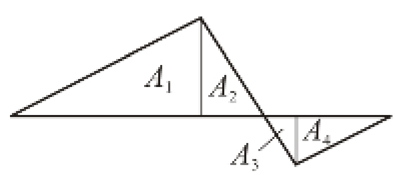


Reference tangent



- -

$\frac{M}{EI}$ Diagram



127-

Reactions:
Using the free-body diagram of the entire beam.

$$\sum M_B = 0$$

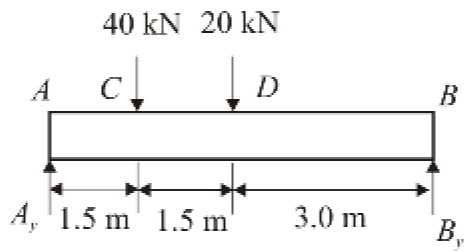
$$R_A L - \left(\frac{1}{2} w_0 L\right)\left(\frac{1}{3}\right) = 0$$

$$R_A = \frac{1}{6} w_0 L$$

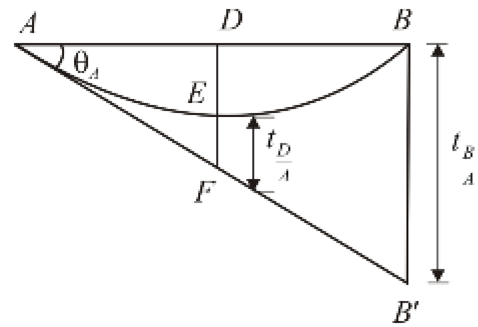
$$R_A = \frac{1}{6} w_0 L$$

129-

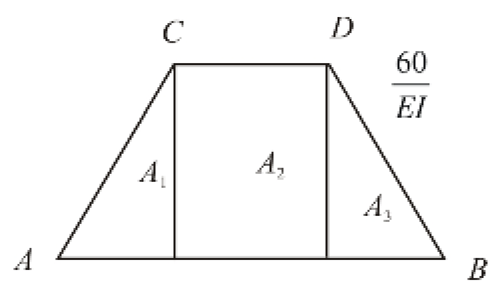
Free body diagram



Reference tangent diagram

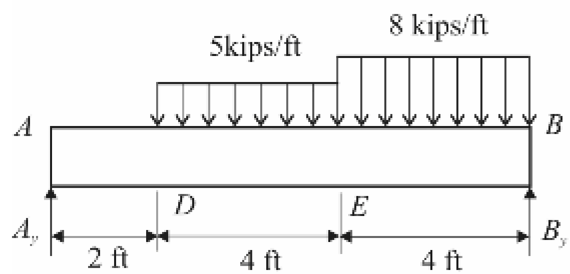


$\frac{M}{EI}$ Diagram

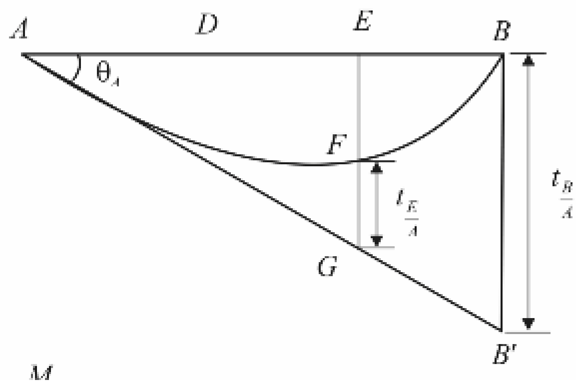


131-

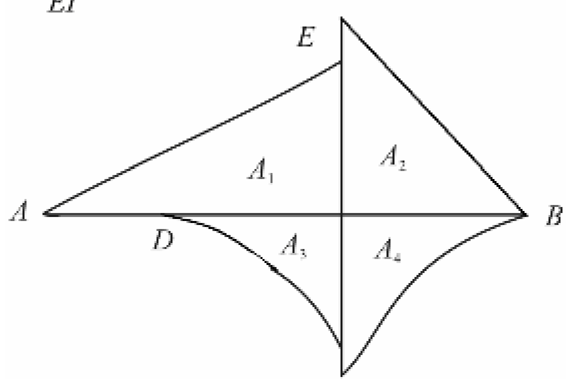
Free body diagram



Reference tangent diagram



$\frac{M}{EI}$ Diagram



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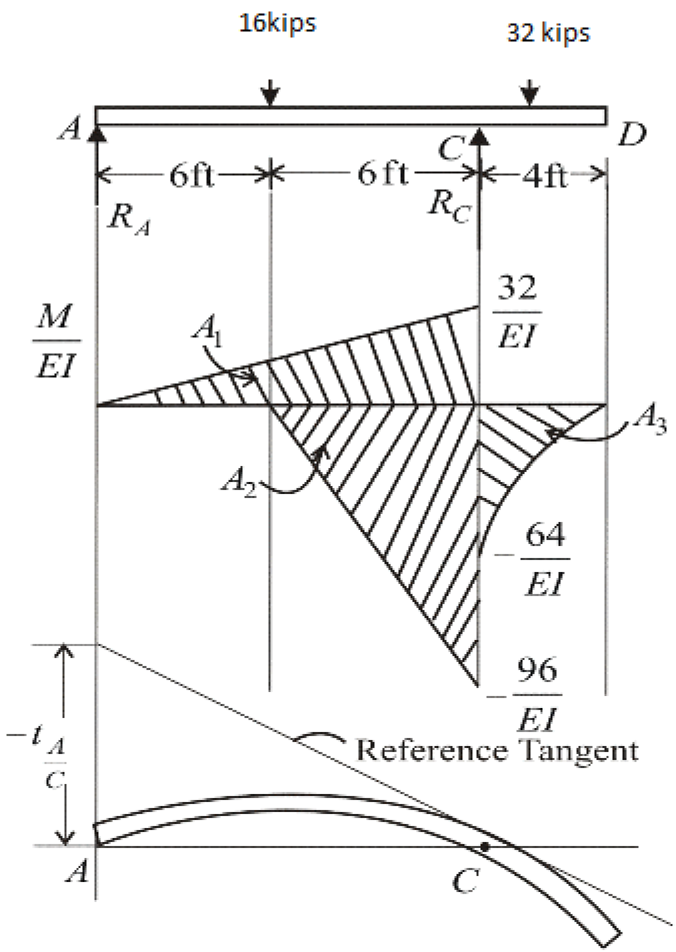
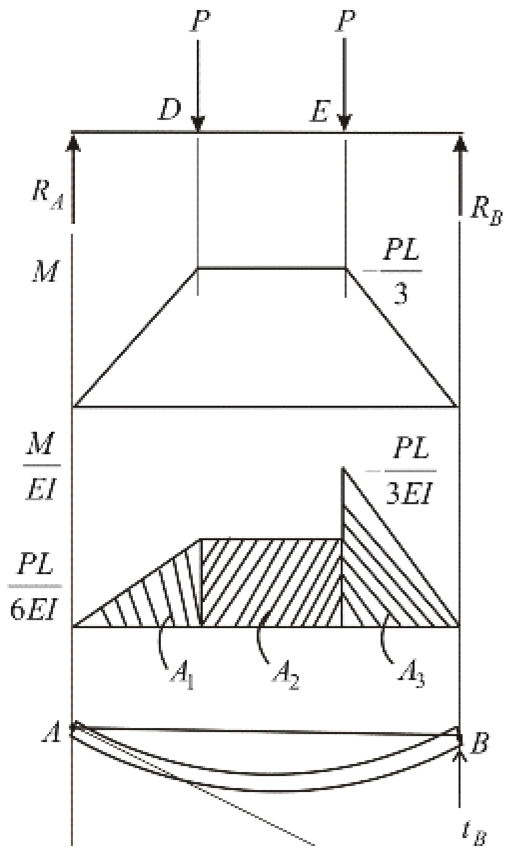
135-



16kips
32 kips
A
D
C
6ft
6 ft
4ft
R_A
R_C
$\frac{M}{EI}$
A_1
$\frac{32}{EI}$
A_3
A_2
$-\frac{64}{EI}$
$-\frac{96}{EI}$
$-t_{\frac{A}{C}}$
Reference Tangent
A
C

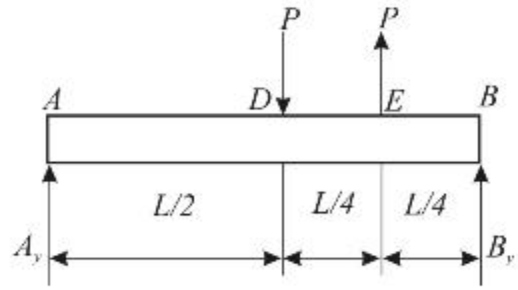
139-



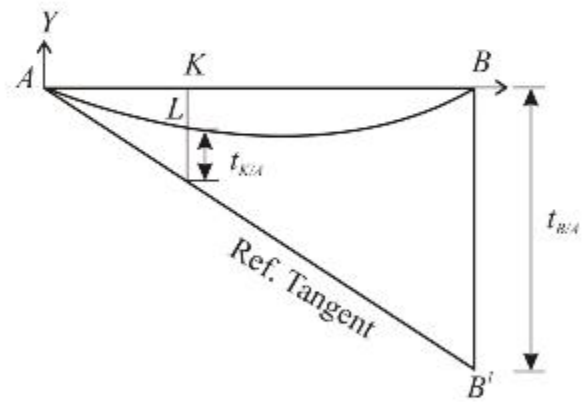
P
P
D
E
R_A
R_B
M
$\frac{PL}{3}$
$\frac{M}{EI}$
$\frac{PL}{3EI}$
$\frac{PL}{6EI}$
A_1
A_2
A_3
A
B
t_B

141-

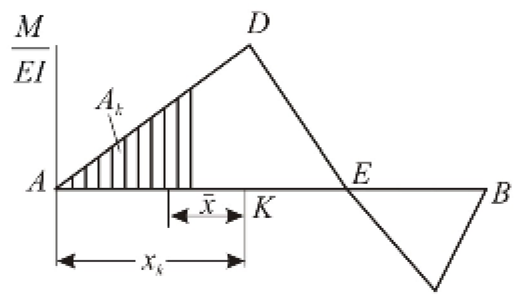
Free body diagram



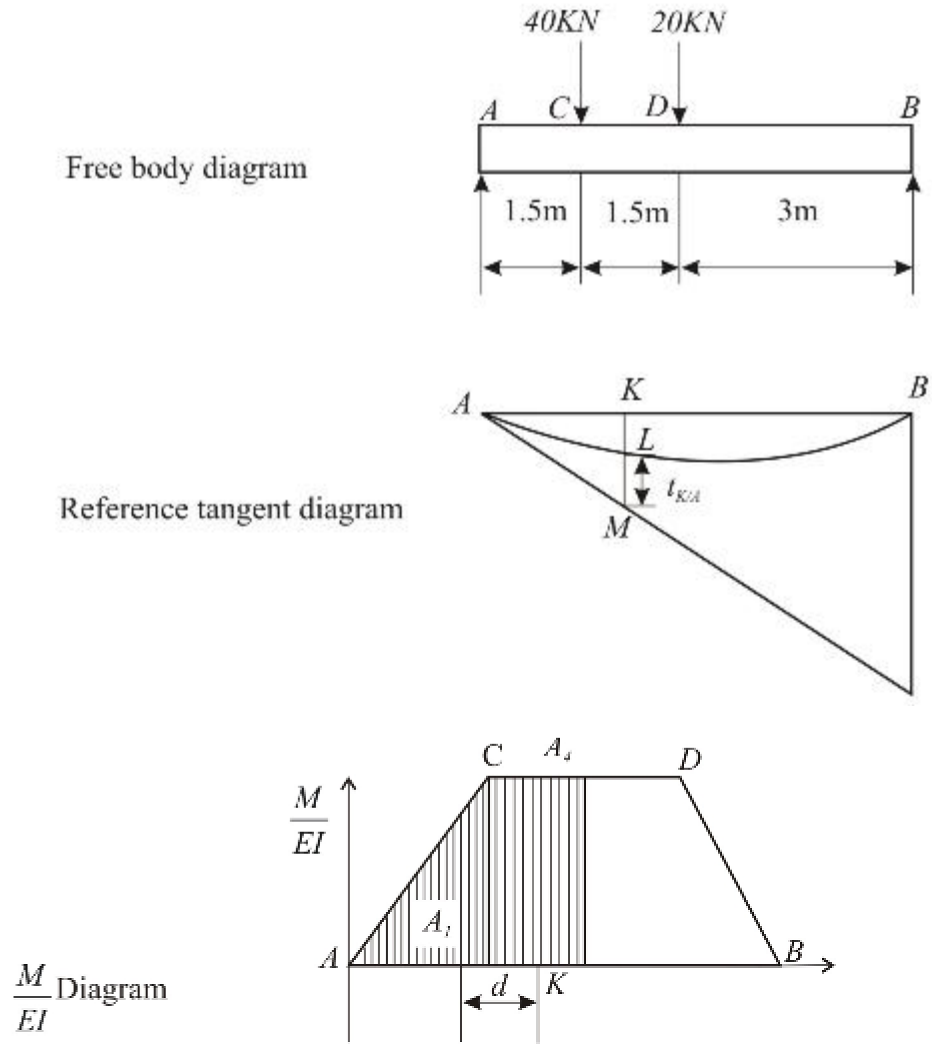
Reference tangent diagram



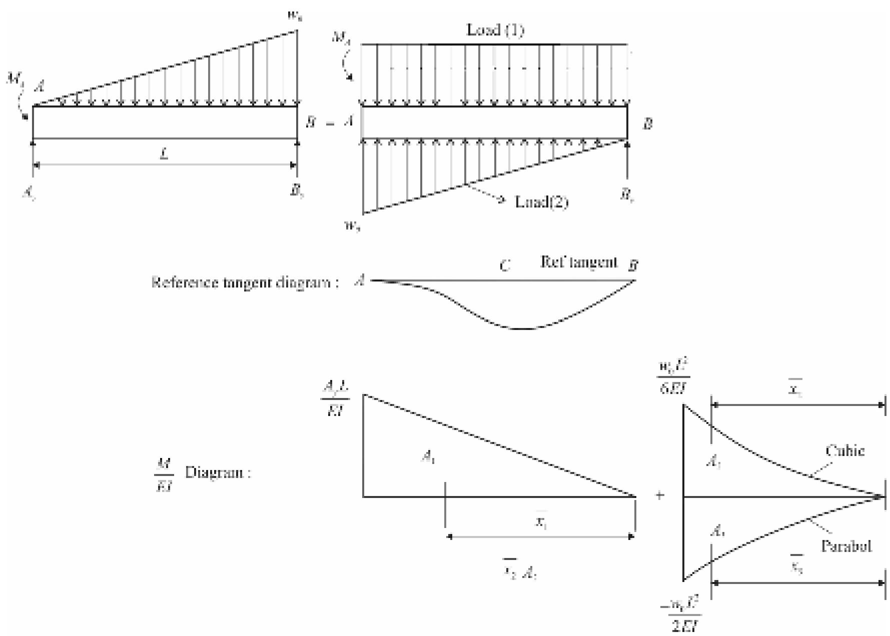
$\frac{M}{EI}$ Diagram



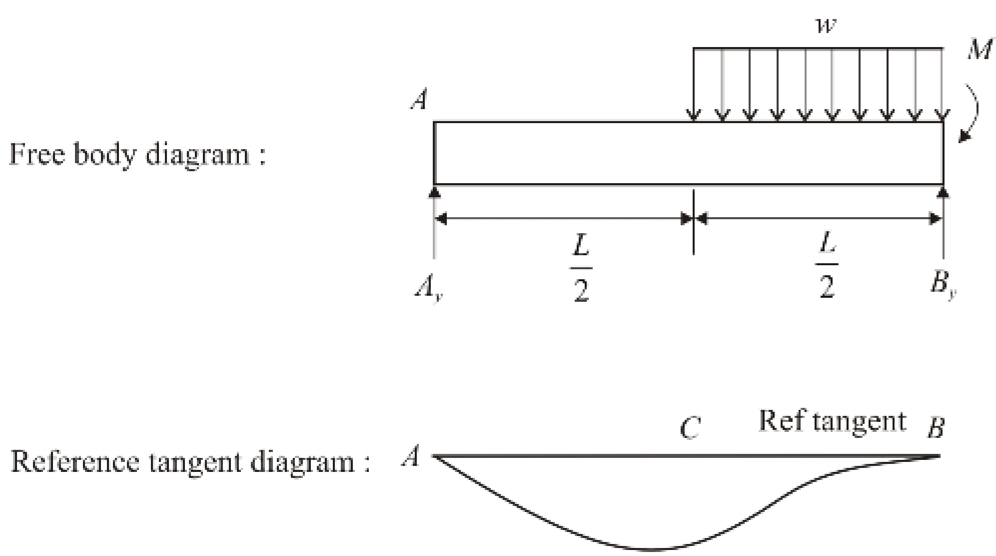
143-


40KN
20KN
A
C
D
B
Free body diagram
1.5m
1.5m
3m
A
K
B
L
$t_{K/A}$
M
Reference tangent diagram
C
A_4
D
$\frac{M}{EI}$
A_1
A
B
d
K
$\frac{M}{EI}$ Diagram

147-



149-



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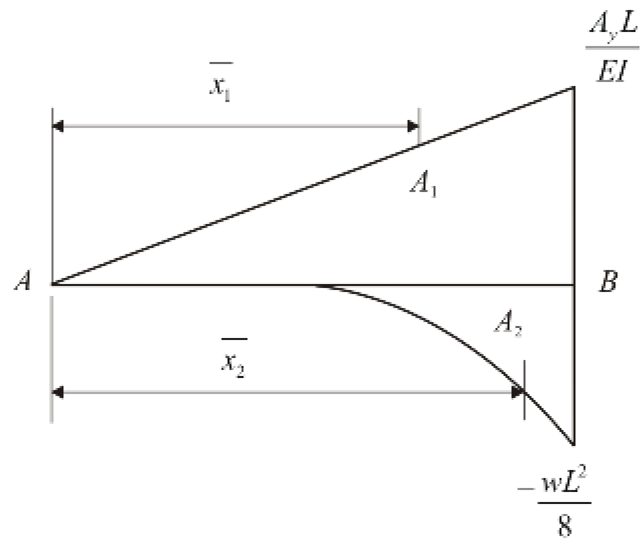
$\frac{M}{EI}$ Diagram :



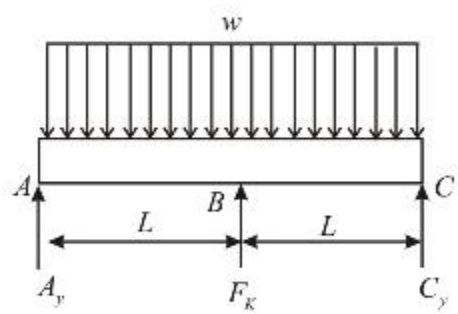
151-

Principle of Super Position:

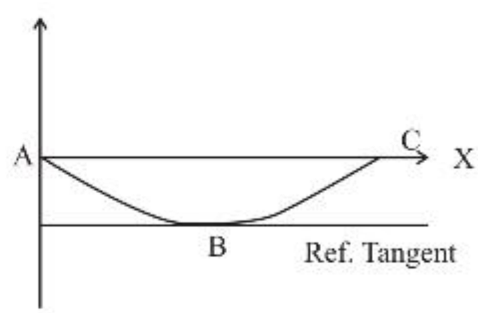
The given loading can be obtained by superposing the loadings shown in the following "picture equation".

155-

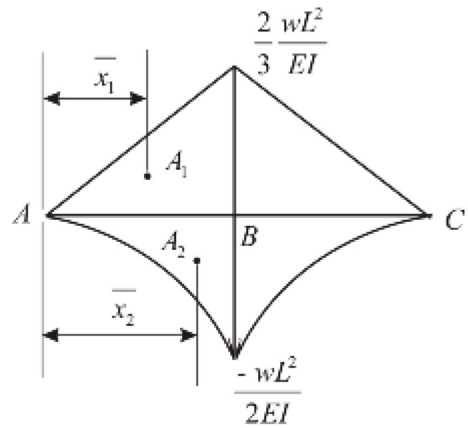
Free body diagram:



Reference tangent diagram:

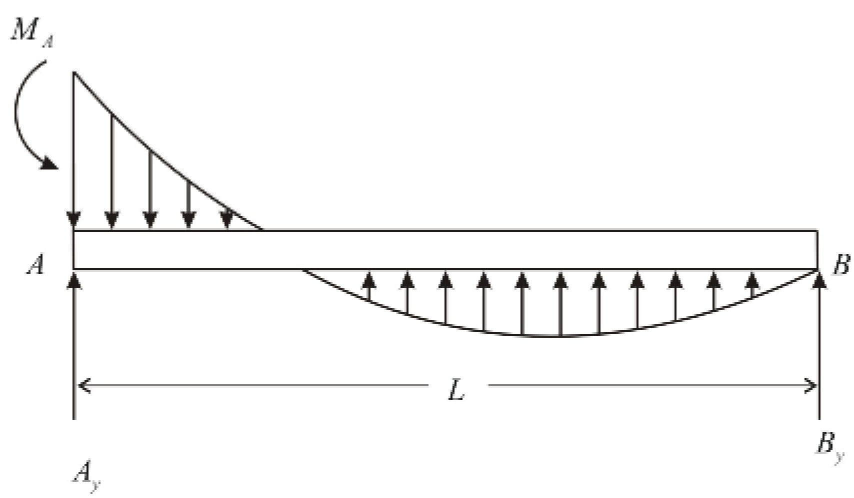


$\frac{M}{EI}$ diagram



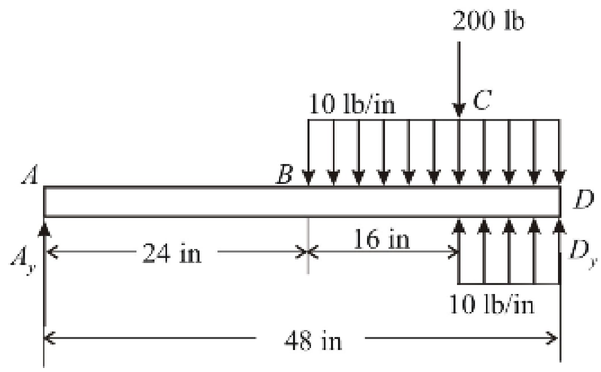
159-

Consider free body diagram of the given beam:



161-

Consider free body diagram of the beam replacing given distributed loading by two equivalent open-ended loadings shown in figure.



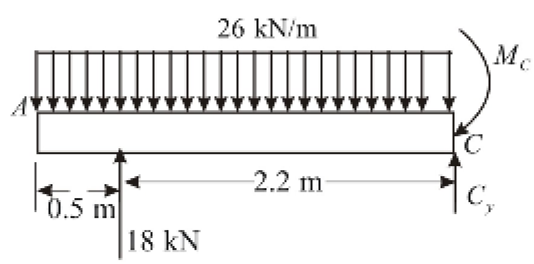
163-

Principle of superposition:

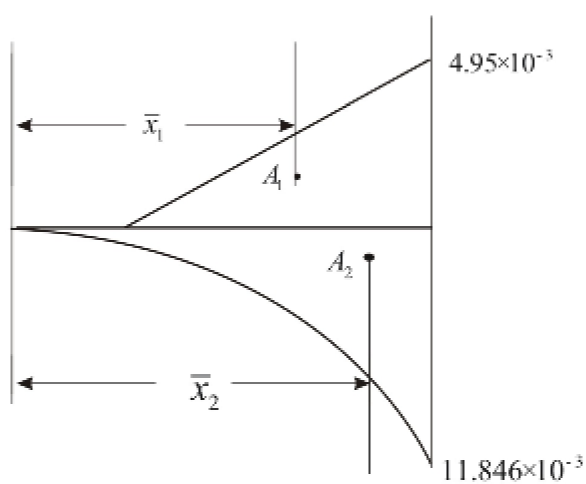
The given loading can be obtained by superposing the loading shown in the following "picture equation"

165-

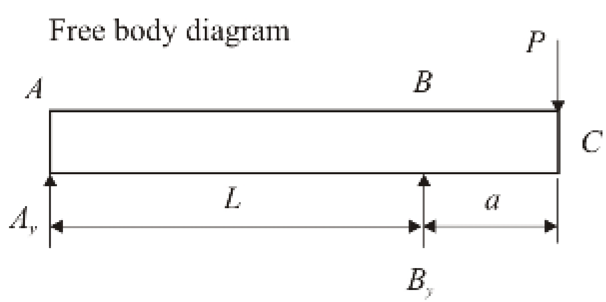
Free body diagram:

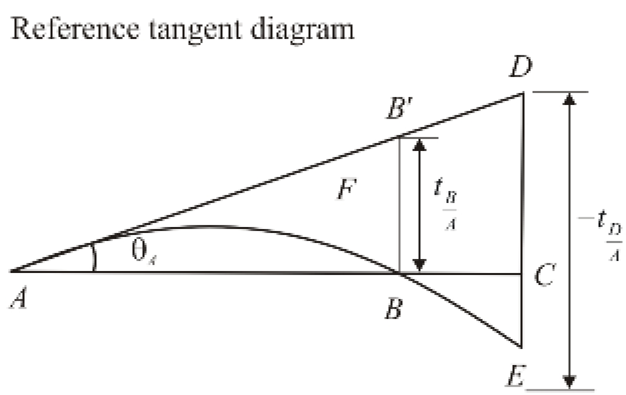


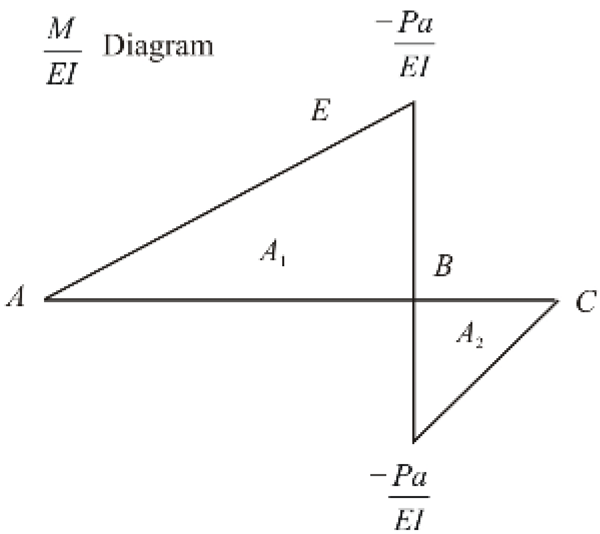
Bending momnet diagram $\frac{M}{EI}$:



167-

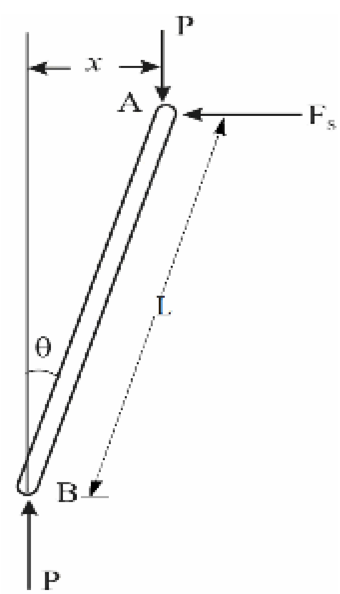

Free body diagram
P
A
B
C
A_y
L
a
B_y


Reference tangent diagram
D
B′
F
$t_{B/A}$
$-t_{D/A}$
θ_A
A
B
C
E



CHAPTER 10:

1-



3-

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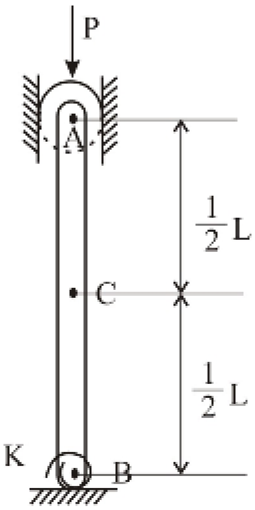


7-

Given
Spring constant, $k = 2\,\text{kips/in}$
$h = 2\text{ft}$
$= (2 \times 12)\text{in}$
$= 24\text{in}$

9-

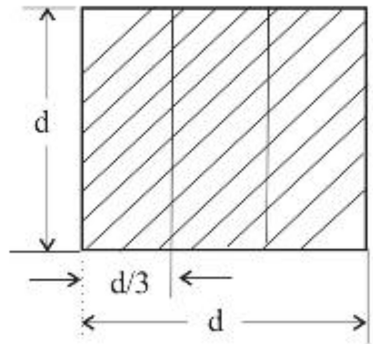
Length of round wooden dowel L $= 48$ in
(a) $d = 0.375$ in
(b) $d = 0.5$ in
Modulus of elasticity $E = 1.6 \times 10^6$ psi

11-

Effective length of solid aluminium rod $= 20$ in
Percentage reduction in weight $= 25\%$
Young's modulus $E = 10.6 \times 10^6$ psi

13-

For a square block:



17-

Effective length $L_e = 27$ ft

$= 27 \times 12$ in

Material type: $C8 \times 11.5$ steel channel

Factor of safety F.S $= 1.85$

Young's modulus $E = 29 \times 10^6$ psi

Distance $d = 4.0$ in

19-

Given

Length of the channel, $L_{AB} = 2.5$ m;

$F = 200$ GPa

For C shapes

$I_y = I_{\min} = 0.229 \times 10^6\ \text{mm}^4$

$= 0.229 \times 10^{-6}\ \text{m}^4$

23-

Side of the square aluminum strut $= 1$ in
Length of part AB $L_{AB} = 3$ ft
Youngs modulus $E = 10.4 \times 10^6$ psi

25-

Allowable centric load $P = 15$ kips
Factor of safety $F.S = 2.2$
Young's modulus $E = 29 \times 10^6$ psi
Material: $W10 \times 22$ rolled steel shape.

27-

Width of the column $b = 12$ mm
Depth of the column $d = 22$ mm
Centric load $P = 3.8$ kN
Youngs modulus $E = 200$ GPa

31-

Effective length: Since the column has both ends hinged, its effective length is

$$L_e = L = 20 \text{ ft}$$
$$= 240 \text{ in}$$

Modulus of elasticity, $E = 29 \times 10^6$ psi
Section $W8 \times 35$
$x = 0.6$ in

33-

Diameter of steel rod $d = 1.375$ in
Load $P = 21$ kips
Youngs modulus $E = 29 \times 10^6$ psi
Horizontal deflection $y_{max} = 0.03$ in

35-

Eccentricity $e = 0.25$ in
Youngs modulus $E = 10.1 \times 10^6$ psi
Horizontal deflection $y_{max} = 0.5$ in

37-

Eccentricity $e = 12$ mm
Material type: $W\,310 \times 60$ rolled – steel
Length of column $L = 4.5$ m
Youngs modulus $E = 200$ GPa
Horizontal deflection $y_{max} = 15$ mm

43-

Material : $W\,10 \times 30$
Eccentricity $e = 0.5$ in
Yield point stress $\sigma_y = 36$ ksi
Young's modulus $E = 29 \times 10^6$ psi
Factor of safety $F \cdot S = 2.4$
Length of the column $L = 7.5$ ft

45-

Length of steel tube $L = 3.5$ m
Stress $\sigma_y = 250$ MPa
Young's modulus $E = 200$ GPa
Factor of safety $F \cdot S = 2.6$
Area of section $A = 3400\ \text{mm}^2$
Moment of inertia $I = 7.93 \times 10^{-6}\ \text{m}^4$
Distance $r = 48.3$ mm

47-

Axial load $P = 250$ kN
Material: $W\,200 \times 35.9$ rolled − steel
Eccentricity $e = 6$ mm
Allowable stress in the column $\sigma_{all} = 80$ MPa
Young's modulus $E = 200$ GPa

49-

Axial load $P = 20$ kips
Material : $W\ 8 \times 15$ rolled − steel
Allowable stress $\sigma_{all} = 12$ ksi
Young's modulus $E = 29 \times 10^6$ psi

51-

Since the column has one end fixed and one end free,
Effective length, $L_e = 2L$
$= 2 \times 4$ ft
$= 96$ in
Axial load, $P = 12$ kip
$e = 0.375$ in
Allowable stress, $\sigma_{all} = 15$ ksi
Modulus of elasticity, $E = 29 \times 10^6$ psi

53-

Since the column has one end fixed and one end free,
Effective length, $L_e = 2L$
$= 2 \times 1.8$ m
$= 3.6$ m
Axial load, $P = 220 \times 10^3$ N
$e = 6$ mm
Allowable stress, $\sigma_{all} = 120$ MPa

55-

Axial load $P = 175$ kN
Material: $W\,250 \times 44.8$ rolled-steel
Eccentricity $e = 12$ mm
Allowable stress $\sigma_y = 250$ MPa
Young's modulus $E = 200$ GPa

57-

Effective length $L_e = 6$ m

a) $W\,200 \times 35.9$

b) $W\,200 \times 86$

Allowable stress $\sigma_y = 250$ MPa
Young's modular $E = 200$ GPa

59-

Yield stress $\sigma_y = 36$ ksi
Modulus of elasticity $E = 29 \times 10^6$ psi

a) effective length $L_e = 18$ ft

b) effective length $L_e = 26$ ft

61-

Effective length $L_e = 5$ ft
Material : $2014 - T6$
Tick ness $t = 0.375$ in

63-

Effective length, $L_e = 18\,\text{ft}$
$= 216$ in
Column stress, $\sigma_c = 1200$ psi
Modulus of elasticity, $E = 470 \times 10^3$ psi
Area, $A = 7.5 \times 5.5 = 41.25\,\text{in}^2$
$d = 5.5$ in

67-

Effective length $L_e = 9\text{m}$
Thickness of plate $t = 10$ mm
Material: $W\ 250 \times 80$ rolled-steel
Yield stress $\sigma_y = 345\text{MPa}$
Young's modulus $E = 200 \times 10^9$ Pa

73-

Allowable centric load $P_{all} = 72\text{kN}$
Material: aluminum alloy 6061 – T6
Length of column $L = 0.45\text{m}$
Cross section dimension $= 2b \times b$

75-

Given
Centric load, $P = 18$ kip
Effective length, $L_e = 22$ ft
$= 264$ in
Compressive stress, $\sigma_c = 1050$ psi
Modulus of elasticity, $E = 440 \times 10^3$ psi
$b = 2d$
Area, $A = 2d^2$

$$\frac{L}{d} = \frac{264}{d}$$

77-

Effective length $L_e = 4.5$ m
Centric load $P = 900$ kN
Yield points stress $\sigma_y = 345$ MPa
Young's modulus $E = 200$ GPa
Nominal depth $d = 250\text{mm}$

79-

Effective length $L_e = 22.5\text{ft}$
Centric load $P = 288$ kips
Nominal depth $d = 1.4\text{in}$
Yield point stress $\sigma_y = 50$ ksi
Young's modulus $E = 29 \times 10^6$ psi

81-

Effective length $L_e = 20$ ft

$$= 20 \times 12$$
$$= 240 \text{ in}$$

Centric load $P = 65$ kips
Wall thickness $t = \frac{1}{4}$ in to $\frac{3}{4}$ in with increase of $\frac{1}{16}$ in.
Yield point stress $\sigma_y = 36$ ksi
Young's modulus $E = 29 \times 10^6$ psi
Outer side $b_o = 6$ in
Inner side $b_i = b_o - 2$ t

83-

Given

Effective length, $L_e = 6$ ft

$= 72$ in

Load, $P = 54$ kips

Yield stress, $\sigma_Y = 36$ ksi

Modulus of elasticity, $E = 29\times10^6$ psi

$$C_c = \sqrt{\frac{2\pi^2 E}{\sigma_Y}}$$

$$= \sqrt{\frac{2\pi^2\left(29\times10^3\right)}{36}}$$

$$= 126.1$$

85-

Given

Effective length, $L_e = 5.8$ mm

$= 5800$ mm

$$\frac{P_D}{P_L} = 1.35$$

Dead load factor, $Y_D = 1.2$

Live load factor, $Y_L = 1.6$

Resistance factor, $\phi = 0.9$

Modulus of elasticity, $E = 200\times10^3$ MPa

Yield stress, $\sigma_Y = 345$ MPa

87-

Given
Effective length, $L_e = 5.5$ m
Dead load, $P_D = 310$ kN
Live load, $P_L = 375$ kN
Yield stress, $\sigma_Y = 250$ MPa
Modulus of elasticity, $E = 200$ GPa
Dead load factor, $Y_D = 1.2$
Live load factor, $Y_L = 1.6$
Resistance factor, $\phi = 0.90$

91-

Effective length $L_e = 5.5\text{m}$
Material = Aluminum alloy $2014-T6$
Allowable sending stress $\sigma_b = 220$ MPa
(a) eccentricity $e = 0$
(b) eccentricity $e = 40\text{mm}$

93-

Given
Width of the column, $b = 7.5$ in
Depth of the column, $d = 5$ in
Effective length, $L_e = 8.5$ ft
$= 102$ in
$\sigma_c = 1180$ psi
Modulus of elasticity, $E = 440\times10^3$ psi

95-

Since column has both ends hinged,
Effective length, $L_e = L$

$= 14$ ft

$= 168$ in

Yield stress, $\sigma_Y = 36$ ksi

Modulus elasticity, $E = 29\times10^6$ psi

Outer width, $b_0 = 4$ in

Inner width, $b_i = b_0 - 2t$

$$= 4-\left(2\times\frac{3}{8}\right)$$

$= 3.25$ in

97-

Since compression member AB has one end fixed and one free its effective length is
Yield stress, $\sigma_Y = 250$ MPa

Modulus of elasticity, $E = 200$ GPa

101-

Centric load $P = 85$ kN
Compression parallel to the grain $\sigma_C = 8.3$ MPa

Modulus of elasticity $E = 11.1$ GPa

Eccentricity $e = 25$ mm

Depth $d = 180$ mm

Width $b' = 240$ mm

105-

Given

Effective length: Since column has both ends pinned its effective length is

$L_e = L = 1.5\text{ m}$

Eccentric load, $P = 85\text{ kN}$

Area, $A = \frac{\pi}{4}d^2$

Moment of inertia, $I = \frac{\pi}{64}d^4$

$C = \frac{d}{2}$

Radius of gyration, $r = \sqrt{\frac{I}{A}}$

$= \frac{d}{4}$

109-

Outside diameter $d_0 = 3\text{ in}$

Centric load $P = 10\text{ kips}$

Eccentricity $e = 0.6\text{ in}$

Material: $2014 - T6$ aluminum alloy

wall thickness = increments of $\frac{1}{16}$ in up to $\frac{1}{2}$ in

Outer radius $r_o = \frac{d_o}{2}$

Central axis distance $c = \frac{d_o}{2}$

$= \frac{3}{2}$

$= 1.5\text{ in}$

Using formulae for the material $2014 -\ T6$

$\frac{L_e}{r} \geq 55$ Condition

Effective length $L_e = 2.2$ m
Load $P = 41$ kN
Allowable compression stress $\sigma_C = 8.1$ MPa
Young's modulus $E = 8.3$ GPa
Eccentricity $e = 80$ mm

113-

Effective length $L_e = 24$ ft
Eccentricity $e = 8$ in
Nominal depth $= 14$ in
Yield stress $\sigma_y = 36$ ksi
Young's modulus $E = 29\times10^6$ psi
Centric load $P = 120$ kips

115-

Given
Effective length, $L_e = 7.2$ m;
Load, $P = 83$ kN
Modulus of elasticity, $E = 200$ GPa;
Yield stress, $\sigma_Y = 250$ MPa

117-

Given
Spring constant $= k$
Length of the bar AD $= l$
Distance between B & C $= a$

119-

(a)
Critical load for steel strut:
Given:
Modulus of elasticity, $E = 29\times10^6$ psi
Length, $L = 4$ ft
$= 48$ in
$d = \frac{1}{2}$in
Moment of inertia, $I = \frac{1}{12}\left(\frac{1}{2}\right)^4$
$= \frac{1}{192}\text{in}^4$
Effective length of strut, $L_e = L$

121-

Diameter of AB and CD members $= 30$ mm
Diameter of BC and AD members $= 22$ mm
Factor of safety $F \cdot S = 2.75$
Modulus of elasticity, $E = 200$ GPa

123-

Effective length $L_e = 13.5$ ft
Stress $\sigma_y = 36$ ksi
Young's modulus $E = 29\times10^6$ psi

125-

Axial load $P = 560$ kN
Distance $e = 6$ mm
Material: $W200\times46.1$
Length of the column $L = 2.3$ m

127-

Length of the column $= L = 85$ mm
Cross $-$ section of column $= 30\text{mm}\times10\text{mm}$
Area of the column $A = 30\times10$
$= 300\ \text{mm}^2$
$= 300\times10^{-6}\ \text{m}^2$

CHAPTER 11:

1-

Modulus of resilience of material (u_Y)

$$u_Y = \frac{\sigma_Y^2}{2E}$$

Where σ_Y = yield strength

E = modulus of elasticity of the material

3-

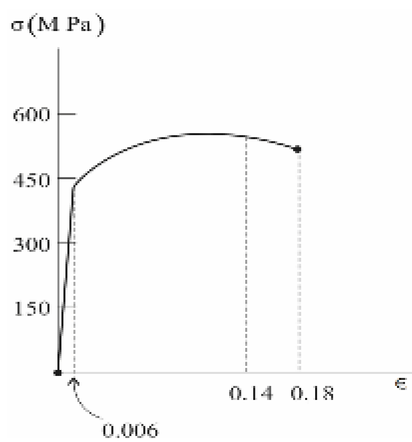
Modulus of resilience of material (u_Y)

$$u_Y = \frac{\sigma_Y^2}{2E}$$

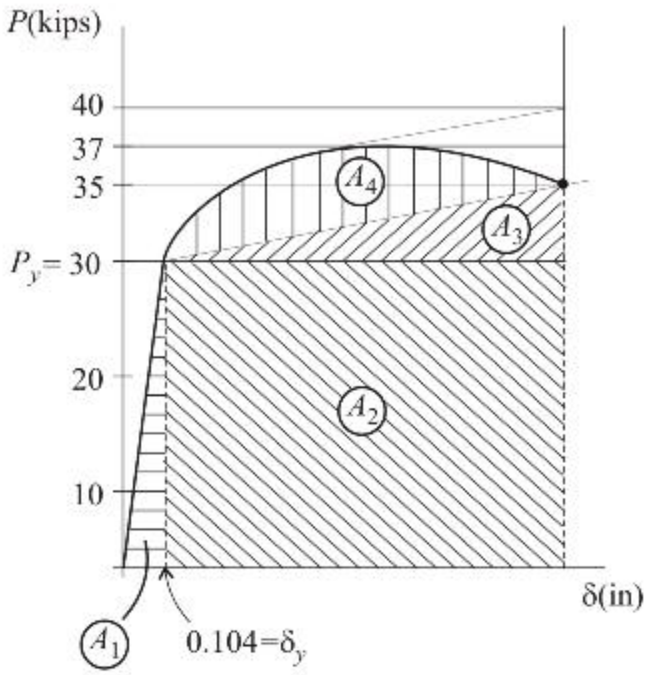
Where σ_Y = yield strength

E = modulus of elasticity of the material

5-



7-



9-

Given data:

Diameter of rod AB $d_{AB} = \dfrac{5}{8}$ in

Diameter of rod BC $d_{BC} = \dfrac{3}{4}$ in

Load $P = 8$ kips

$= 8000$ lb

Modulus of elasticity $E = 29 \times 10^6$ psi

13-

Given Data:

The diameter of steel pin $d_{pin} = 6$ mm;

The width of aluminum strip $b = 20$ mm;

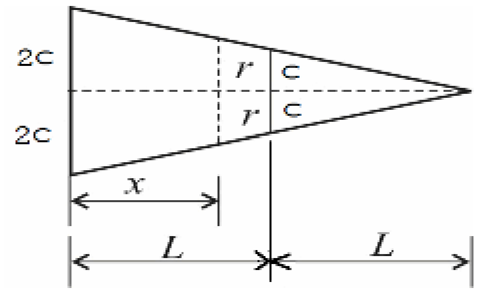
The thickness of aluminum strip $d = 5$ mm;

The modulus of elasticity for steel $(E_s) = 200$ MPa

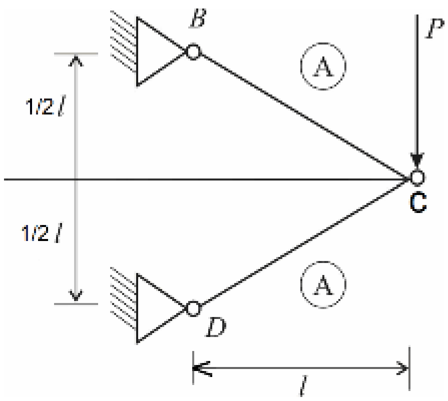
The modulus of elasticity for aluminum $(E_a) = 70$ MPa

The allowable shearing tress $(\sigma_{all})_{pin} = 85$ MPa

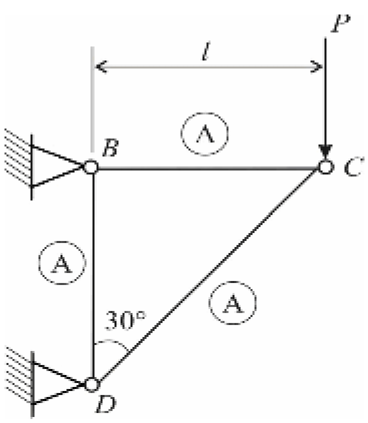
17-



19-



21-



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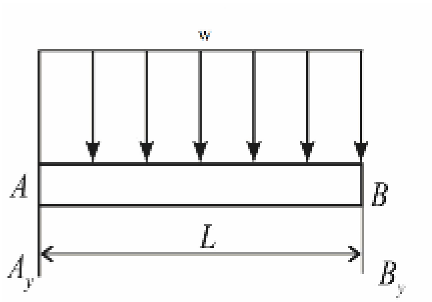
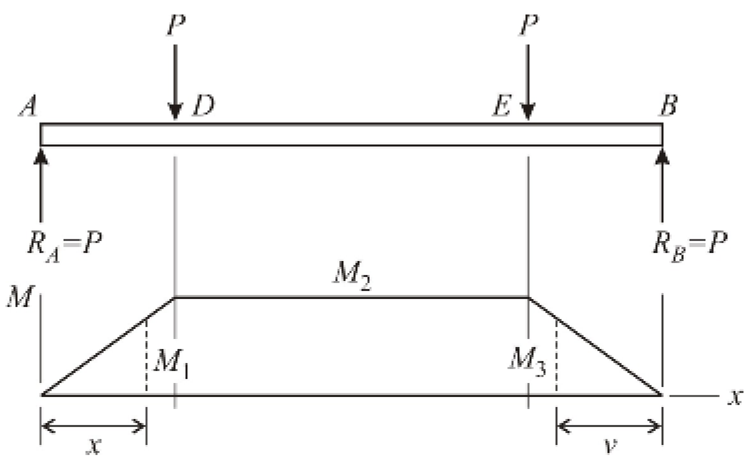
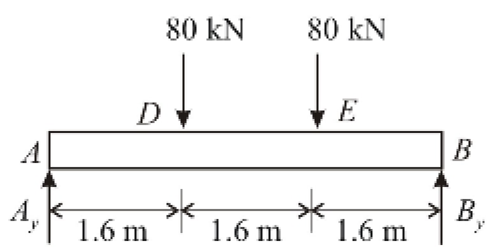
25-


w
A
B
L
A_y
B_y

27-

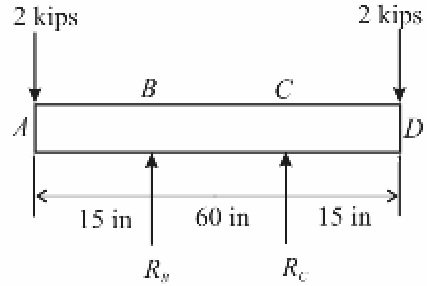

P
P
A
D
E
B
$R_A=P$
$R_B=P$
M
M_2
M_1
M_3
x
x
v

29-


80 kN
80 kN
D
E
A
B
A_y
1.6 m
1.6 m
1.6 m
B_y

31-

Solution:-



33-

Given data:

The depth of drilling $L = 5000$ ft

$= 1524$ m

Outer diameter of pipe $d_0 = 8$ in

$d_0 = 0.2032$ m

Wall thickness $t = 0.5$ in

$= 0.0127$ m

Inner diameter $d_i = d_0 - 2t$

$= 0.2032 - 2(0.0127)$

$d_i = 0.1778$ m

Number of revolutions of drill pipe = 2

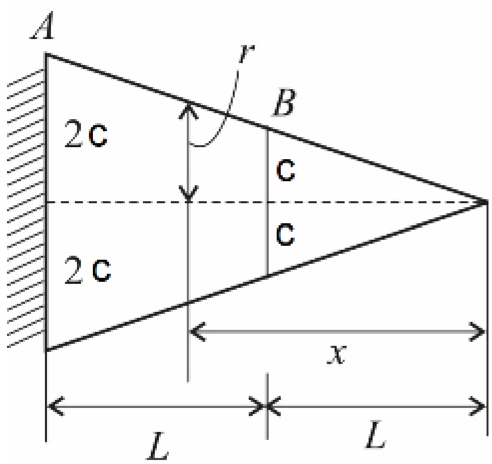
Angle of twist $\phi = 2(2\pi)$

$\phi = 4\pi$ radians

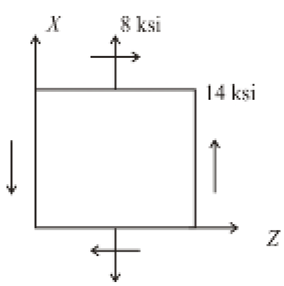
Rigidity modulus $G = 11.2 \times 10^6$ psi

$= 77.2$ GPa

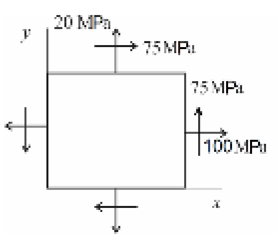
35-



37-



39-



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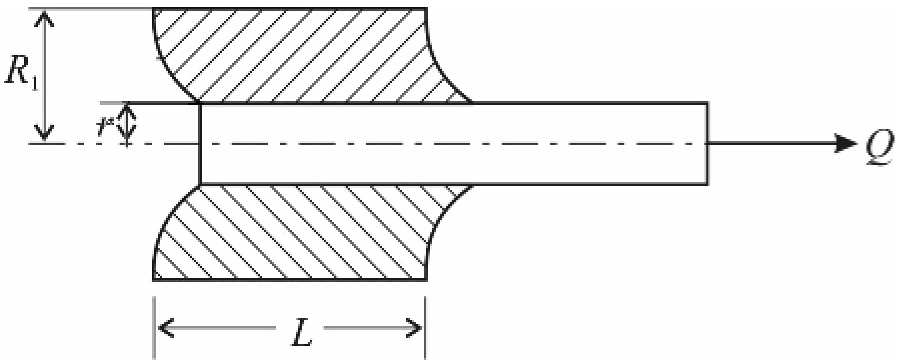
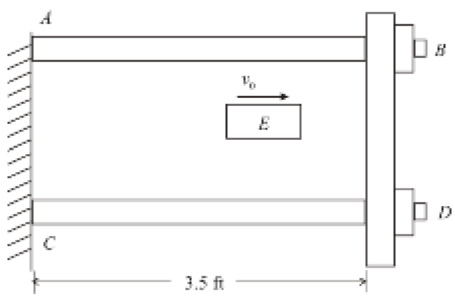
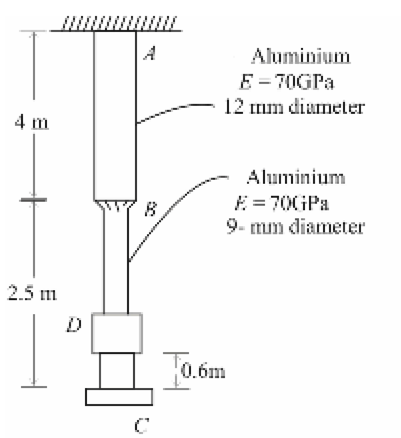
41-



43-



45-



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49-

Given Data:

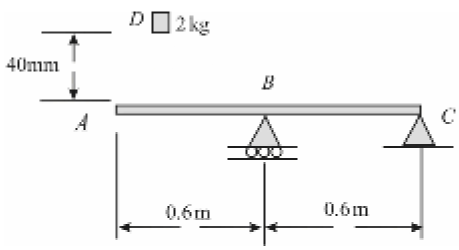
The mass of a block $m = 45\text{kg}$

The speed of a block $V_o = 2\text{m/s}$

The young's modulus E=200 GPa

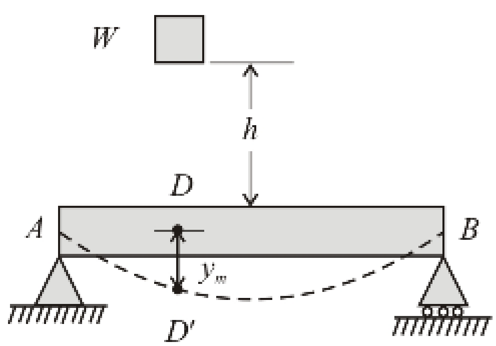
The length of a steel beam $L = 3\text{m}$

53-

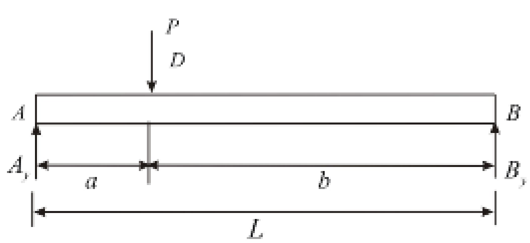


57-

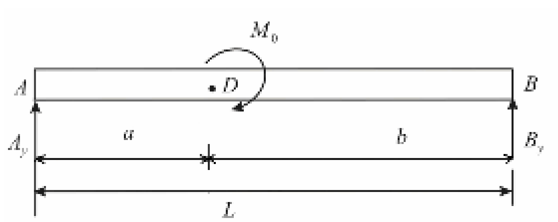
(a)



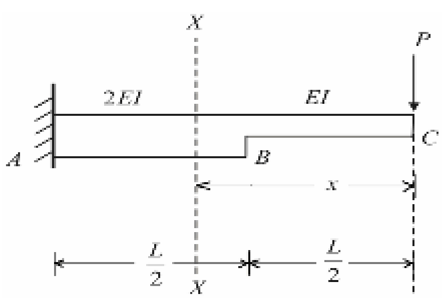
59-



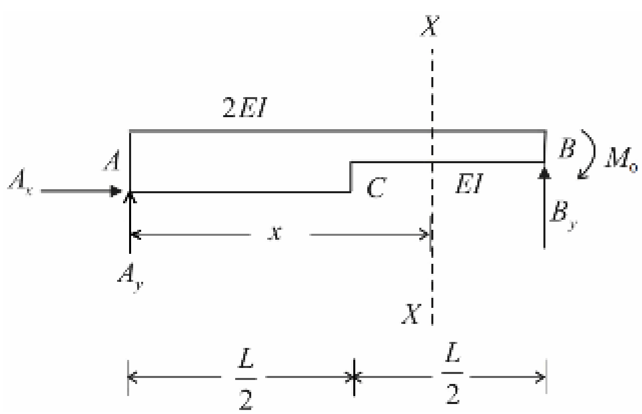
61-



63-



65-



67-

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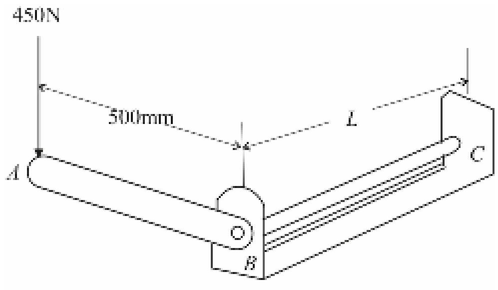
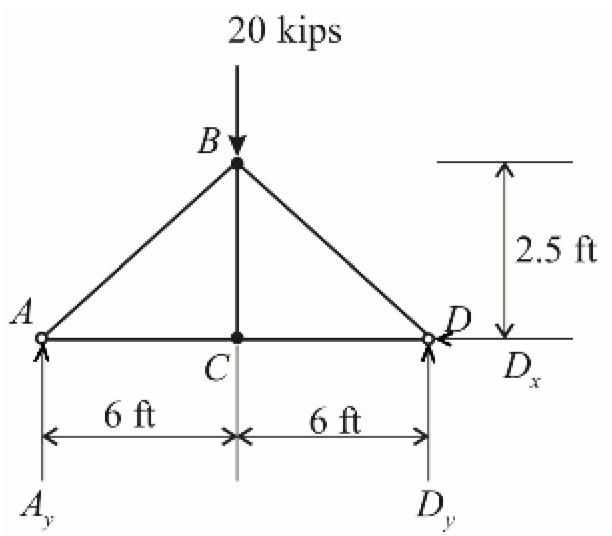
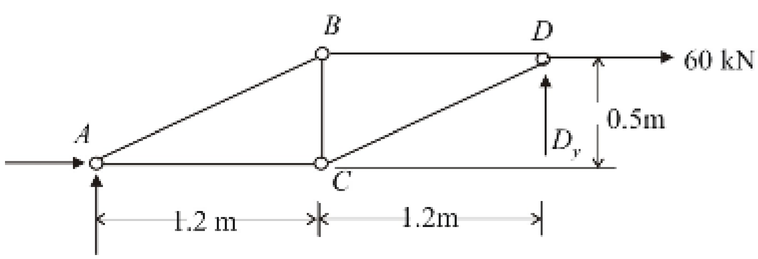

450N
500mm
L
A
B
C

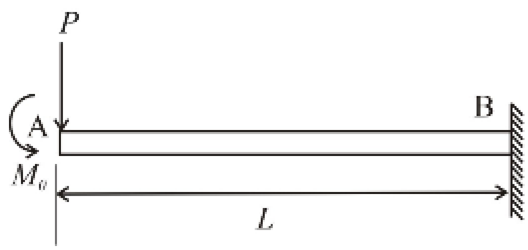
73-


20 kips
B
2.5 ft
A
D
C
D_x
6 ft
6 ft
A_y
D_y

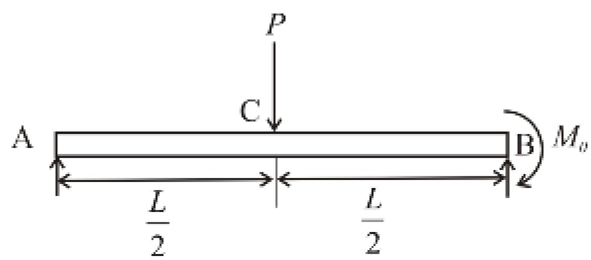
75-


B
D
60 kN
0.5m
A
D_y
C
1.2 m
1.2m

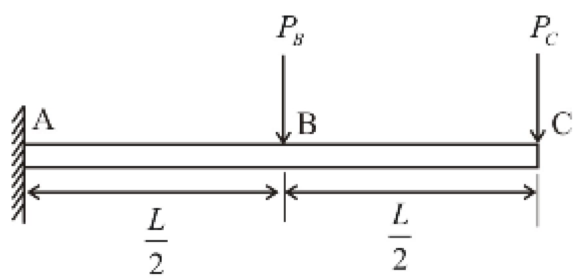
77-



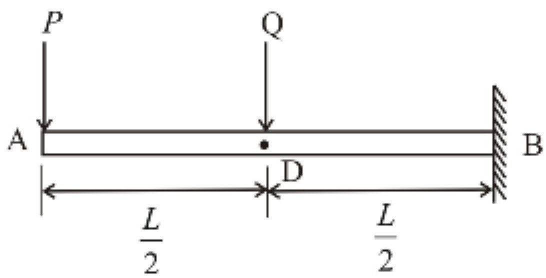
79-



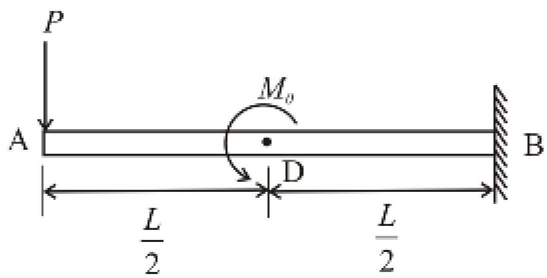
81-



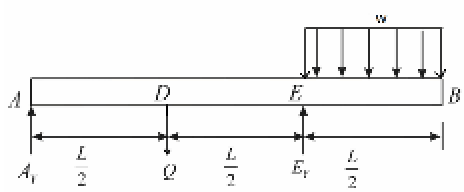
83-



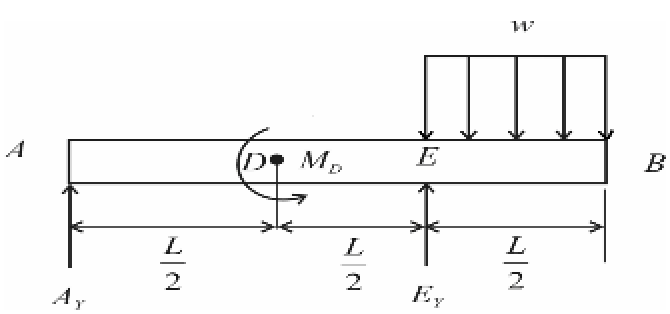
85-



87-



89-



91-

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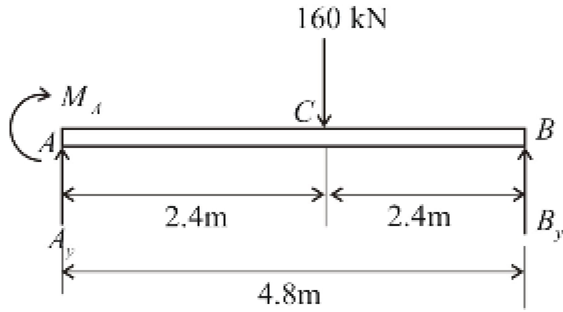
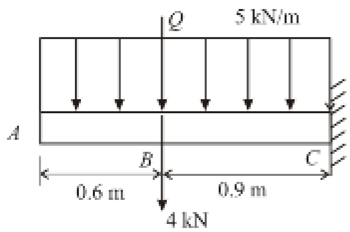
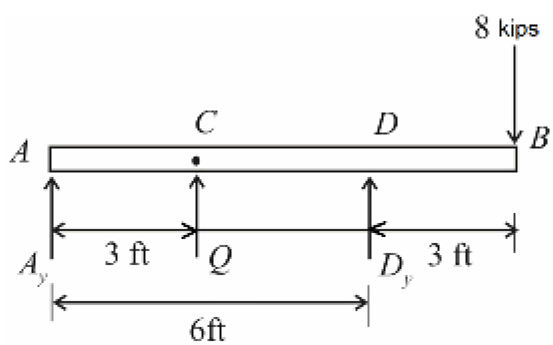
Solution:-



95-



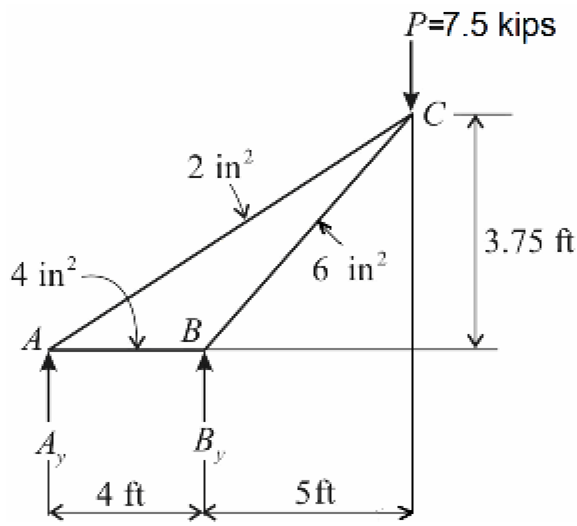
97-



101-

Castilian's Theorem: since no vertical load is applied at joint B, we introduce the dummy load Q as shown. Using Castilian's Theorem, and denoting by F_i the force in a given member I caused by the combined loading of 4.8 kN and Q, we have, since $E =$ constant.

103-



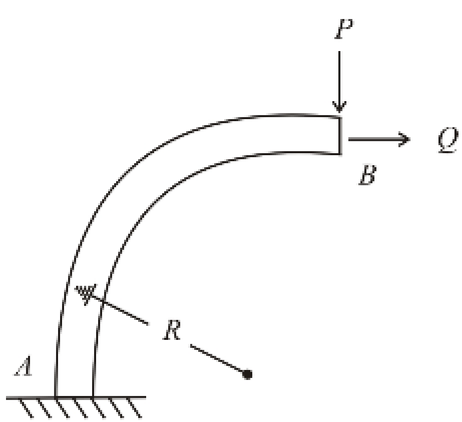
105-

Castigliano's theorem:
Since no horizontal load and couple is applied at point C, we introduce the dummy load Q and dummy couple M_C as shown.

107-

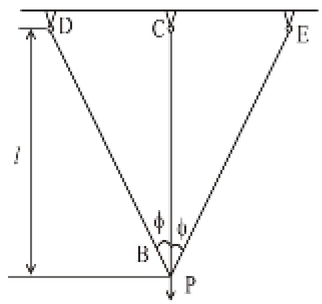
Castigliano's Theorem: Since no vertical load applied at point D and couple at point C, we introduce the dummy load Q and dummy couple M_C as shown.

109-

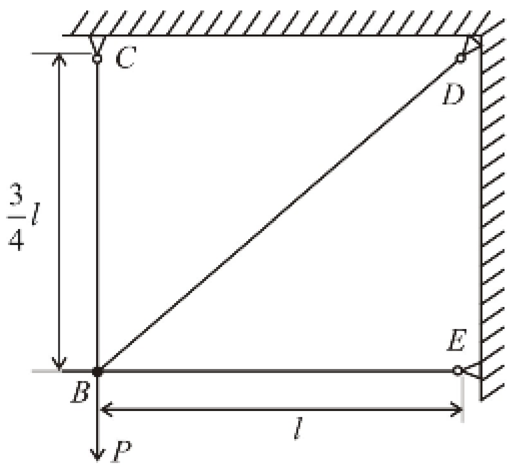


117-

Solution:-

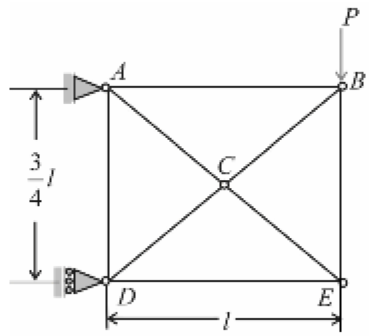


119-



121-

Solution:



123-

Diameter of rod AB $d_{AB} = 12$ mm

$d_{AB} = 0.012$ m

Diameter of rod BC $d_{BC} = 8$ mm

$d_{BC} = 0.008$ m

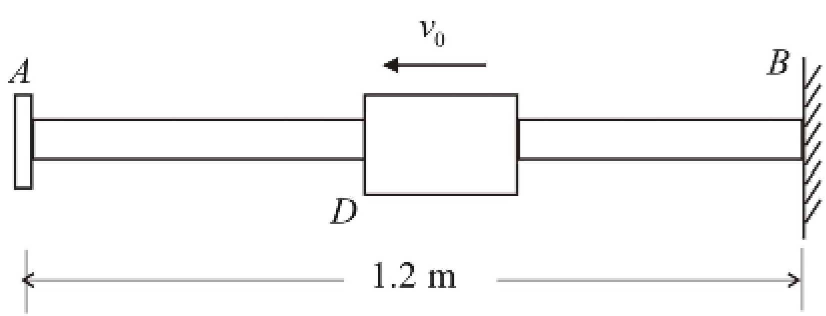
Yield strength $\sigma_Y = 300$ MPa

$= 300\times10^6$ Pa

Modulus of elasticity $E = 200$ GPa

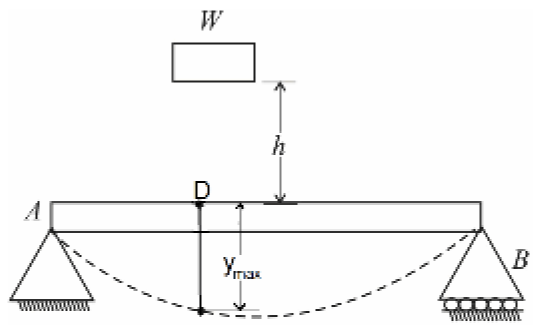
$= 200\times10^9$ Pa

125-



127-

Weight of the block is W



129-

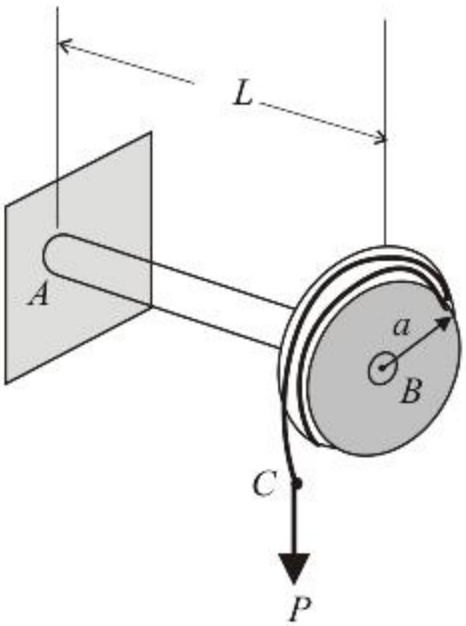
Data:

The diameter of a steel shaft $d = 0.75\text{in}$

The modulus of rigidity $G = 11.2 \times 10^6\ \text{psi}$

The torque of end A $T_A = 750\text{lb} \cdot \text{in}$

131-



133-

The steel bar square cross section of side =0.75
The load $P = 50\,\mathrm{lb}$
The young's modulus $E = 29\times10^{6}$ psi