University of Technology
Building and Construction Engineering Department
Final Examination 2015-2016

Subject: Strength of Materials II
Class: 2nd

Date: 21 / 5 /2016
Time: 3 hr.

Note: Answer FOUR questions only

Q1: A gray cast iron channel - shaped member, as shown in figure (1), acts as horizontal beam. When vertical forces are applied to the member the distance AB increases by (0.02) mm and the distance CD decreases by (0.018) mm. what is the sense of the applied moment, and what normal stresses occur in the extreme fibers? (E=100 Gpa).

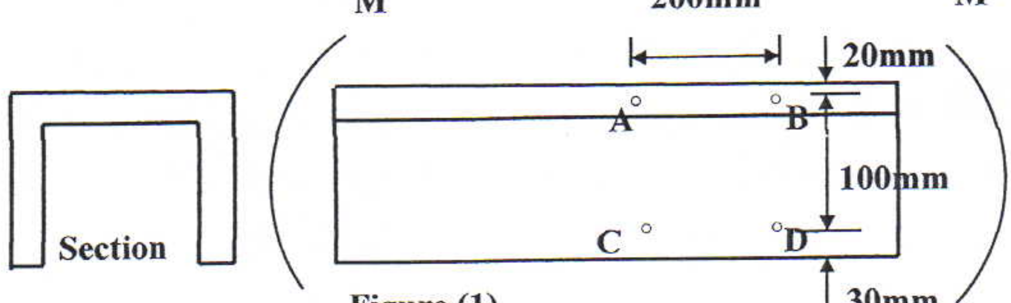


Figure (1)

Q2: The section of a built-up timber beam which is subjected to (8) kN vertical shear shown in figure (2). Knowing that the longitudinal spacing of the nails is (50) mm c/c and cast nail is (90) mm long; determine the shearing force in each nail.

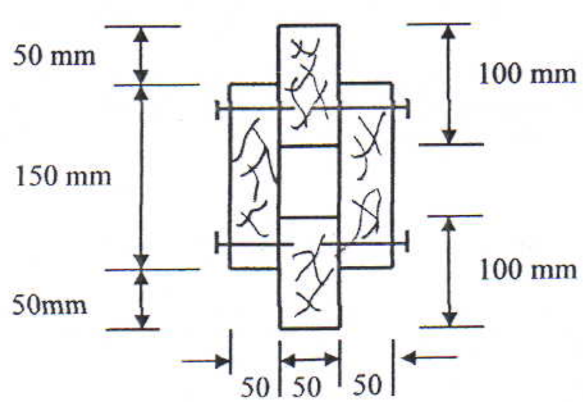


Figure (2)

Q3: A short (100) mm square steel bar with 50mm diameter axial hole is built in at the base and is loaded at the top as shown in figure (3). Determine the value of the force (P) so that the maximum normal stress at the built-in end would not exceed (140) Mpa.

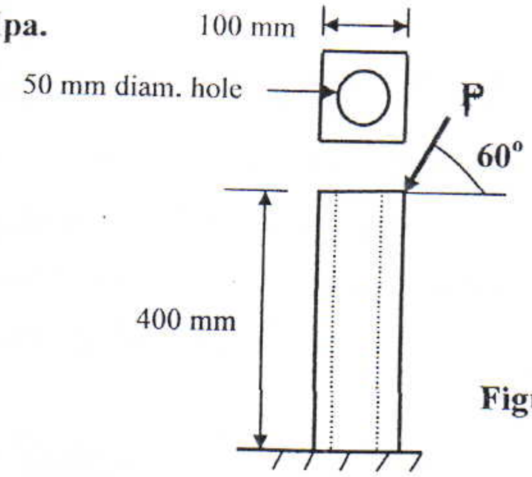


Figure (3)

Q4: For the state of plane stress shown in figure (4), determine (a) the principal planes and the principal stresses, (b) the stress components exerted on the element obtained by rotating the given element counterclockwise through 30°.

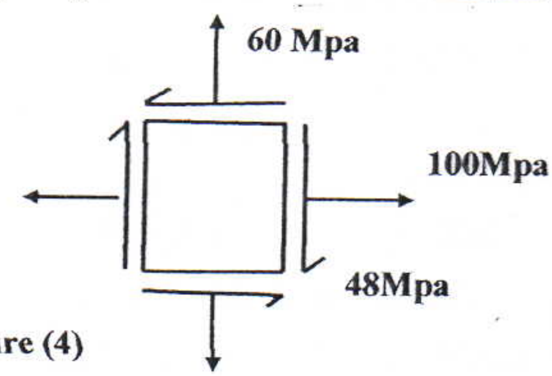


Figure (4)

Q5: A beam of length (6) meter is simply supported at its ends and carries two points loads of (48) kN and (40) kN as shown in figure (5). Find the maximum deflection and the point at which maximum deflection occurs. Use $E = 2*10^5\ N/mm^2$ and $I = 85*10^6\ mm^4$.

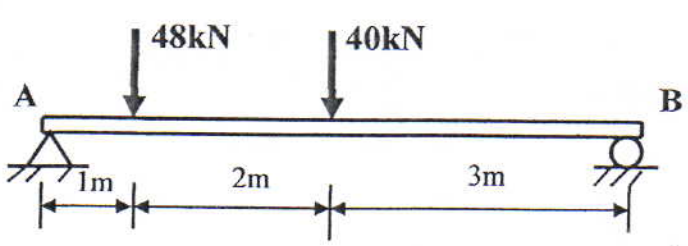
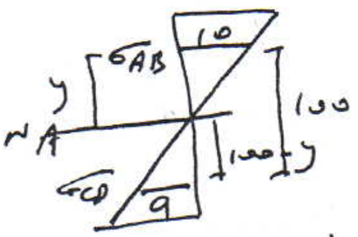
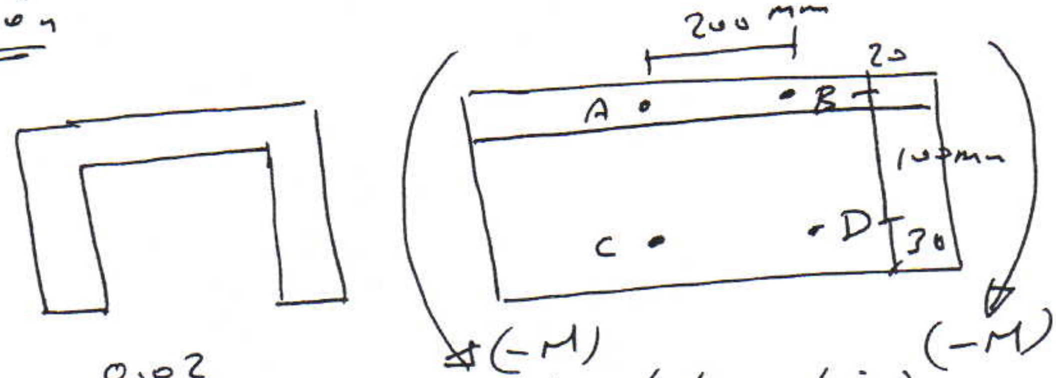


Figure (5)

Q_1 Solution





$$\epsilon_{AB} = \frac{\Delta L}{L_{AB}} = \frac{0.02}{200} = 0.0001 \text{ mm/mm (elongation)}$$

$$\therefore \sigma_{AB} = \epsilon_{AB} \cdot E = 0.0001 * 100 \frac{kN}{mm^2} * 1000 \frac{N}{kN} = 10 \text{ N/mm}^2 \text{ (tensile stress)}$$

$$\epsilon_{CD} = \frac{\Delta l}{L_{CD}} = \frac{0.018}{200} = 0.00009 \text{ mm/mm (Shortening)}$$

$$\therefore \sigma_{CD} = \epsilon_{CD} \cdot E = 0.00009 * 100\,000 = 9 \text{ N/mm}^2 \text{ (comp.)}$$

من تشابه ΔΔ

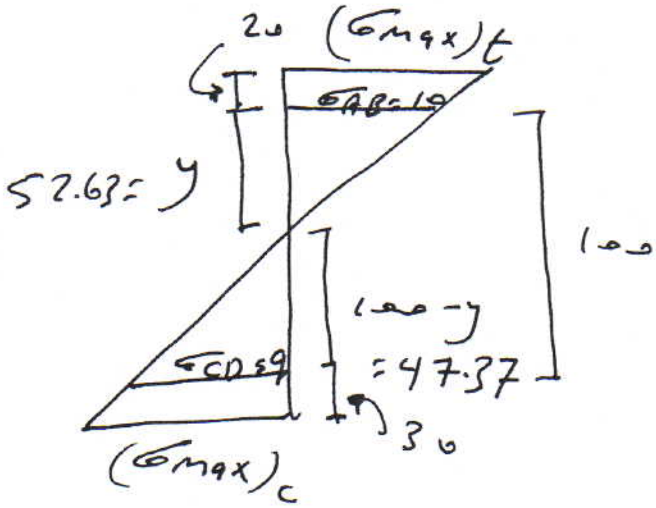
$$\frac{10}{y} = \frac{9}{100-y}$$

$$9y = 10(100-y)$$

$$9y = 1000 - 10y$$

$$19y = 1000$$

$$\therefore y = 52.63 \text{ mm}$$

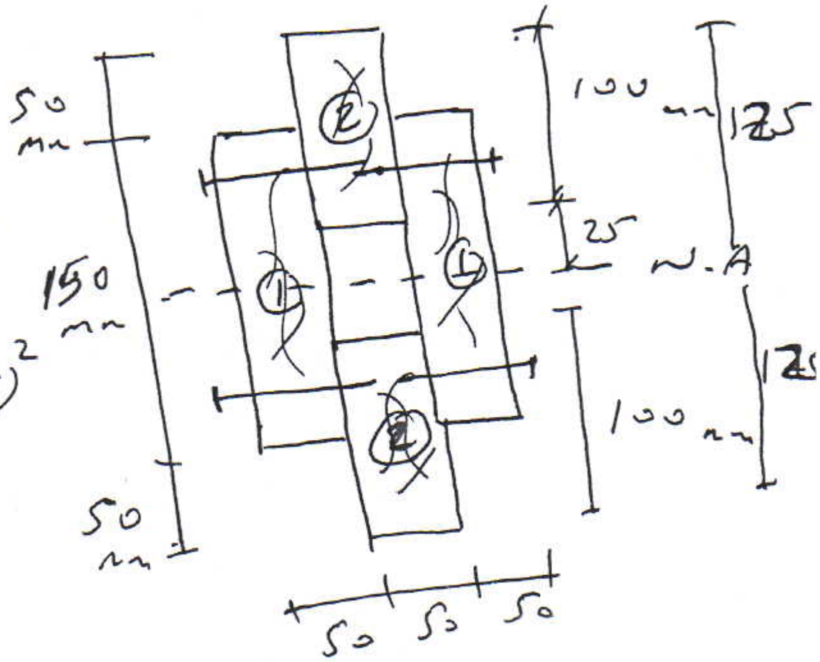


من تشابه ΔΔ

$$\therefore \frac{(\sigma_{max})_c}{9} = \frac{77.37}{47.37} \Rightarrow (\sigma_{max})_c = 14.7 \text{ Mpa}$$

$$\frac{(\sigma_{max})_t}{10} = \frac{72.63}{52.63} \Rightarrow (\sigma_{max})_t = 13.8 \text{ Mpa}$$

Q2 Solution



$$I_1 = \frac{50*150^3}{12} = 14062500 \text{ mm}^4$$

$$I_2 = \frac{50*100^3}{12} + 50*100*(75)^2$$

$$I_2 = 32291666.67 \text{ mm}^4$$

$$I_{total} = 2I_1 + 2I_2$$

$$= 2(14062500 + 32291666.67)$$

$$\therefore I_{total} = 92708333.33 \text{ mm}^4$$

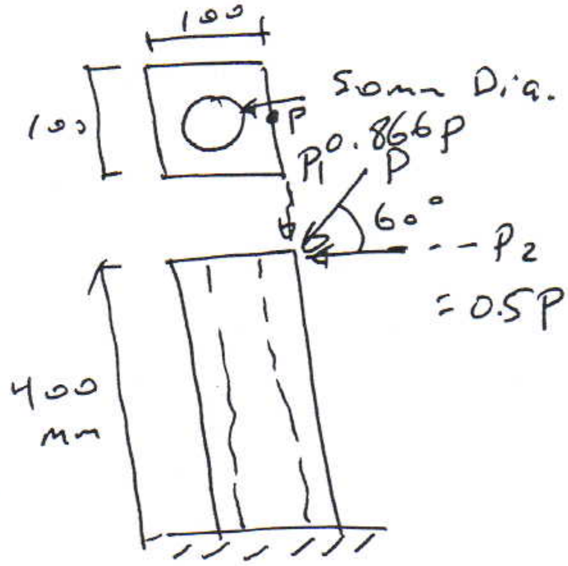
$$Q_2 = 100*50*75 = 375000 \text{ mm}^3$$

$$q = \frac{VQ_2}{I} = \frac{8 \text{ kN} * 1000 \frac{N}{kN} * 375000}{92708333.33} = 32.36 \text{ N/mm}$$

$$q \text{ for one side} = \frac{32.36}{2} = 16.18 \text{ N/mm}$$

$$F = q*S = 16.18*50 = 809 \text{ N}$$

Q3 solution



$P_1 = P \sin 60 = 0.866P$

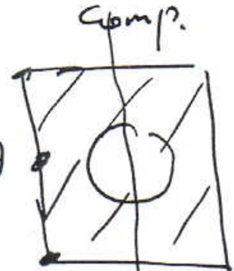
$P_2 = P \cos 60 = 0.5P$

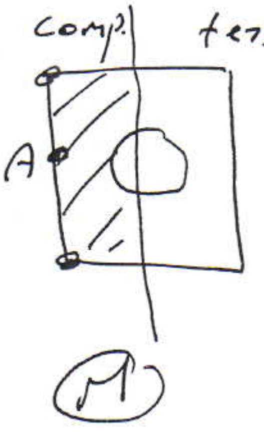
$P_{normal\ load} = P_1 = 0.866P$

$M = 0.5P * 400 - 0.866P * 50$

$\therefore M = 156.7P$ N.mm

$\sigma_{A\,max} = -\frac{P}{A} - \frac{M.C}{I}$





$+140 \frac{N}{mm^2} = +\frac{0.866P}{8036.5} + \frac{156.7P * 50}{8026537.176}$

(P)

$140 = 0.000107 7P + 0.000976P$

$140 = 0.0010838\,P$

$\therefore P = 129170.7\ N$

$\therefore P = 129.17\ kN$

$A = 100^2 - \frac{\pi \times 50^2}{4}$

$A = 8036.5\ mm^2$

$I = \frac{100 \times 100^3}{12} - \frac{\pi \times 50^4}{64}$

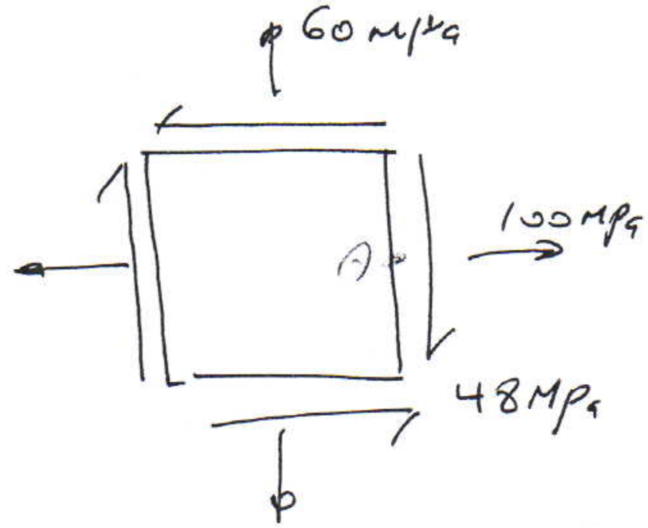
$\therefore I = 8026537.176\ mm^4$

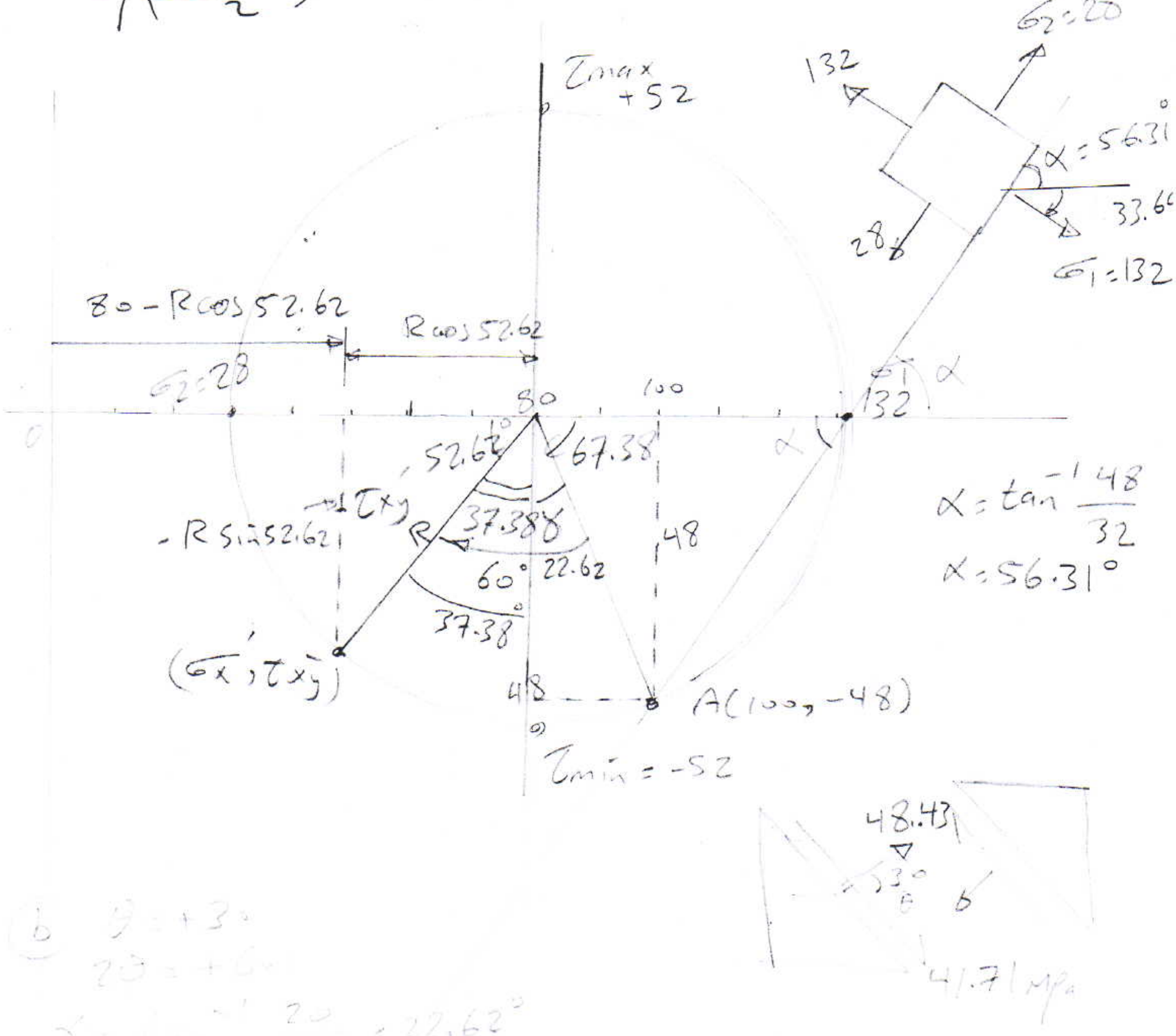
Q4 Solution

$$OC = \frac{\sigma_x + \sigma_y}{2} = \frac{100+60}{2} = 80$$

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \sqrt{\left(\frac{100-60}{2}\right)^2 + (48)^2} = 52$$





$$\alpha = \tan^{-1}\frac{48}{32}$$

$$\alpha = 56.31^\circ$$

b) $\theta = +30$

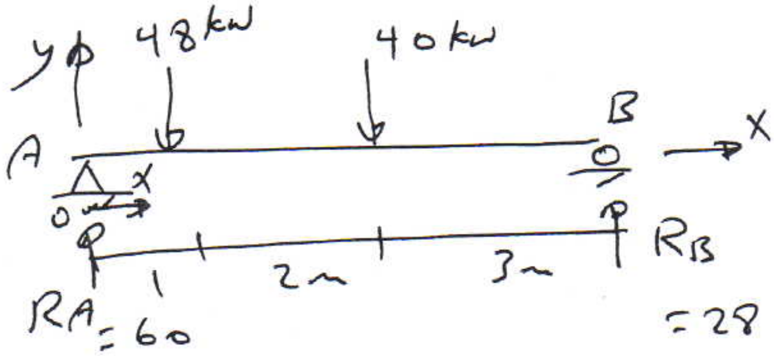
$2\theta = +60$

$\gamma = \tan^{-1}\frac{20}{48} = 22.62^\circ$

$\therefore \sigma_x' = 80 - R\cos 52.62 = +80 - 52\cos 52.62 = +48.43$ MPa

$\tau_{x'y'} = -R\sin 52.62 = -52\sin 52.62 = -41.71$ MPa

Q5 Solution



$\Sigma M_A = 0$ (+↺)

$48 \times 1 + 40 \times 3 - R_B \times 6 = 0$

$\therefore R_B = +28$ kN ↑

$\Sigma F_y = 0$ ↑+

$R_A - 48 - 40 + 28 = 0$

$\therefore R_A = 60$ kN ↑

$$EIv'' = M = 60 x - 48\langle x-1\rangle^1 - 40\langle x-3\rangle^1$$

$$EIv' = 60\frac{x^2}{2} - \frac{48}{2}\langle x-1\rangle^2 - \frac{40}{2}\langle x-3\rangle^2 + C_1$$

$$EIv = 60\frac{x^3}{6} - \frac{48}{6}\langle x-1\rangle^3 - \frac{40}{6}\langle x-3\rangle^3 + C_1 x + C_2$$

B.C

① @ $x = 0$, $EIv(0) = 0$

$0 = 0 - 0 - 0 + 0 + C_2 \Rightarrow \boxed{C_2 = 0}$

② @ $x = 6$, $EIv(6) = 0$

$0 = 10(6)^3 - 8(5)^3 - \frac{40}{6}(3)^3 + 6C_1$

$\therefore C_1 = -163.33$

$$\therefore \begin{cases} EIv' = 30x^2 - 24\langle x-1\rangle^2 - 20\langle x-3\rangle^2 - 163.333 \\ EIv = 10x^3 - 8\langle x-1\rangle^3 - \frac{40}{6}\langle x-3\rangle^3 - 163.333\,x \end{cases}$$

✓

To find the location of max. deflection ($x \leq 3.0$)

$EIv' = 0 = 30x^2 - 24(x-1)^2 - 20(x-3)^2 - 163.33$ (zero)

$x = 2.87$ m < 3.0 o.k

$\therefore EIv_{max}(2.87) = 10(2.87)^3 - 8(2.87-1)^3 - 163.333(2.87)$

$= -284.67 \times 10^{12}$

$$\therefore v_{max} = \frac{-284.67 \times 10^{12}}{2 \times 10^{5} \times 85 \times 10^{6}} = -16.745 \, mm$$