Shubham Raj

Signature: Shubham

CE19B030

(1)

Strength of Materials (CE2101)

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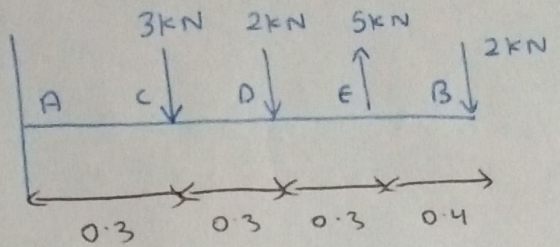
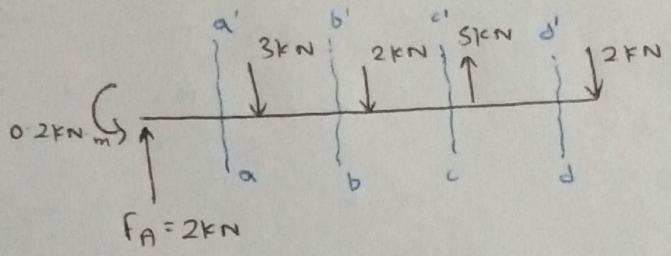
1)

i)





$\Sigma f_y \Rightarrow f_A = 0$

$\Rightarrow f_A = 2KN$

$\Sigma M_A = 0$

$\Rightarrow -3\times0.3 - 2\times0.6 + 5\times0.9 - 2\times1.3$

$= -0.9 - 1.2 + 4.5 - 2.6$

$\Rightarrow -0.2\ KN\ m$

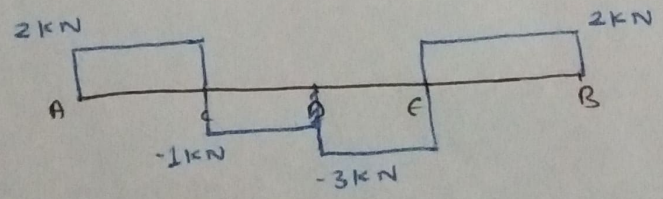
a) For shear force,

aa' $\Rightarrow V_x = 2KN$ (AC)

bb' $\Rightarrow V_x = -1KN$ (AD)

cc' $\Rightarrow V_x = -3KN$ (AE)

dd' $\Rightarrow V_x = 2KN$ (AB)



b) for Bending moment,

aa' ⇒ $2x - 0.2$ at $x = 0$ $M_x = -0.2\ kN\cdot m$

$x = 0.3$ $M_x = 0.4\ kN\cdot m$

bb' ⇒ $2x - 0.2 - 3(x - 0.3)$

$= 0.7 - x$ at $x = 0.3$ $M_x = 0.4\ kN\cdot m$

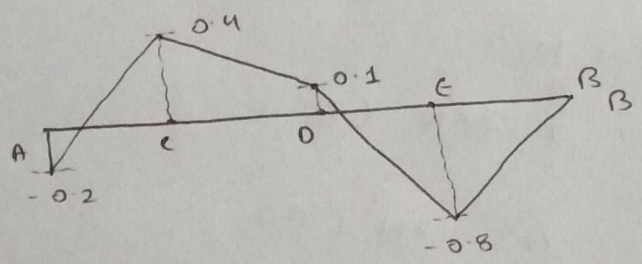
$x = 0.6$ $M_x = 0.1\ kN\cdot m$

cc' ⇒ $0.7 - x - 2(x - 0.6)$ $x = 0.6$ $M_x = 0.1\ kN\cdot m$

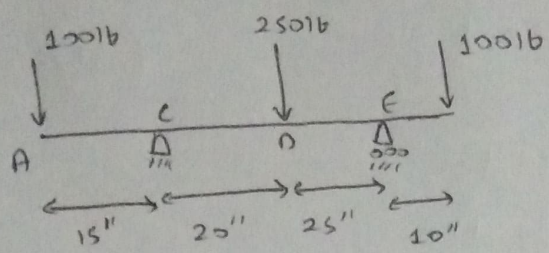
$\Rightarrow 1.9 - 3x$ $x = 0.9$ $M_x = -0.8\ kN\cdot m$

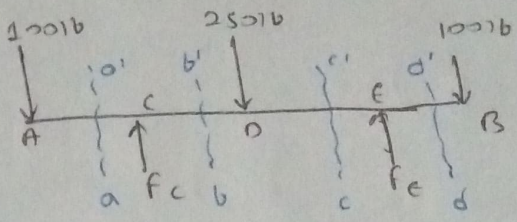
dd' ⇒ $1.9 - 3x + 5(x - 0.9)$ $x = 0.9$ $M_x = -0.8\ kN\cdot m$

$\Rightarrow 2x - 2.6$ $x = 1.3$ $M_x = 0$



11)





(3)

B $\Sigma M_c = 0 \Rightarrow 100\times 15 - 250\times 20 + f_E \times 45 - 100\times 55 = 0$

$\Rightarrow 45 f_E = 100(55-15) + 250\times 20$

$= 100\times 40 + 5000$

$= 9{,}000$

$f_E = 200$ lb

$\Sigma F_y = 0 \Rightarrow f_E = 250$ lb

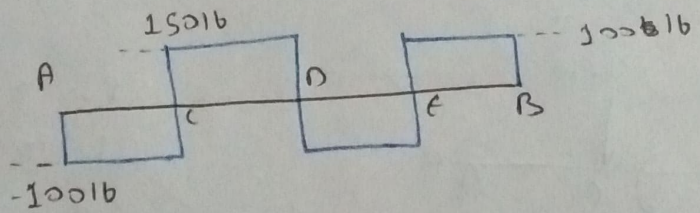
a) For shear force,

aa' $\Rightarrow V_x = -100$ lb

bb' $\Rightarrow V_x = 150$ lb

cc' $\Rightarrow V_x = -100$ lb

dd' $\Rightarrow V_x = 100$ lb



b) For Bending moment,

aa' $\Rightarrow M_x = -100x$

bb' $\Rightarrow M_x = -100x + 250(x-15)$

$= 150x - 3{,}750$

cc' $\Rightarrow M_x = 150x - 3{,}750 - 250(x-35)$

$= 5000 - 100x$

dd' $\Rightarrow M_x = 5000 - 100x + 200(x-60)$

$= 100x - 7{,}000$

for aa' :- $x = 0$ $M_x = 0$

$x = 15$ $M_x = -1500$ lb·in

(4)

for bb' :- $x = 15$ $M_x = -1500$ lbin

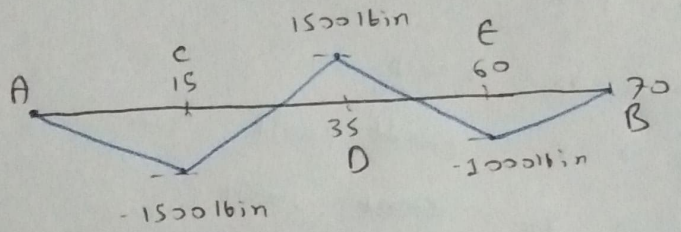
$x = 35$ $M_x = 1500$ lbin

for cc' :- $x = 35$ $M_x = 1500$lbin

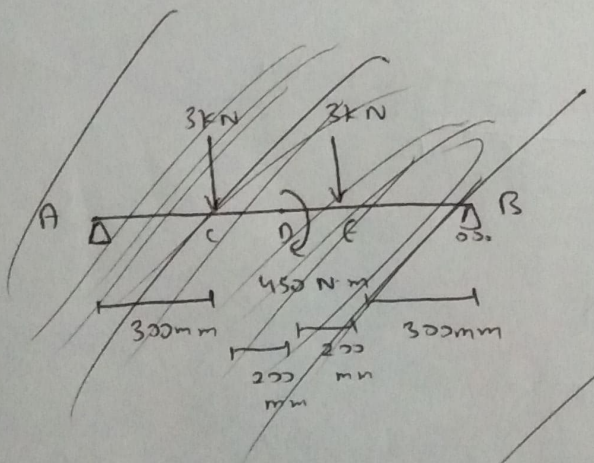
$x = 60$ $M_x = -1000$lbin

for dd' :- $x = 60$ $M_x = -1000$lbin

$x = 70$ $M_x = 0$



iii)



Using $\Sigma F_x = 0$

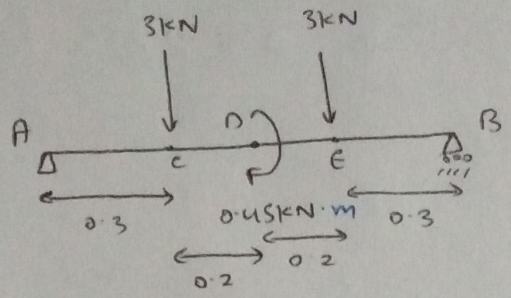
$\Sigma F_y = 0$

$\Sigma M_D = 0$

$F_A = 2.55kN$

$F_B = 3.45kN$

111)



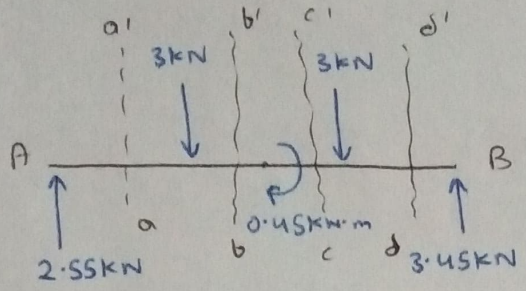
Using $\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_D = 0$

$f_A = 2.55kN$

$f_B = 3.45kN$



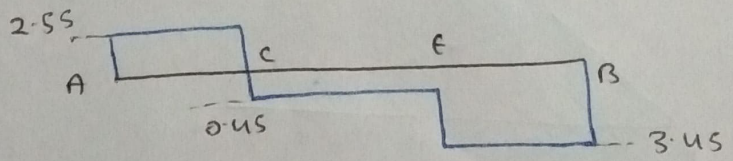
a) for shear,

$aa' \Rightarrow V_x = 2.55kN$

$bb' \Rightarrow V_x = -0.45kN$

$cc' \Rightarrow V_x = -0.45kN$

$dd' \Rightarrow V_x = 3kN - 3.45kN$



b) for moment diagram,

$aa' \Rightarrow 2.55x$ at $x = 0$ $M_x = 0$

$x = 0.3$ $M_x = 0.765$

$bb' \Rightarrow 2.55x - 3(x - 0.3)$ at $x = 0.3$ $M_x = 0.765$

$\Rightarrow 0.9 - 0.45x$

$x = 0.5$ $M_x = 0.675$

cc' ⇒ 0.9 - 0.45x + 0.45

∴ 1.35 - 0.45x

at x = 0.5

M_x = 1.125 kN m

at x = 0.7

M_x = 1.035 kN·m

dd' ⇒ 1.35 - 0.45x - 3(x - 0.7)

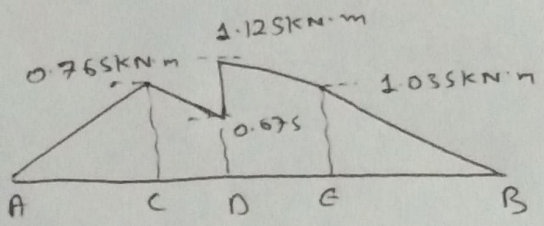
∴ 3.45 - 3.45x

at x = 0.7

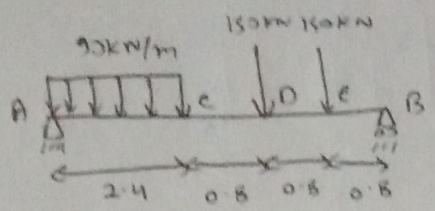
M_x = 1.035 kN·m

at x = 1

M_x = 10



(7)



Using

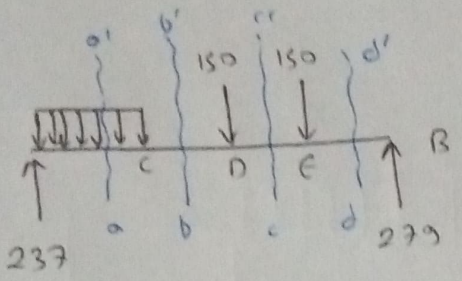
$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_A = 0$

$F_B = 279\,kN$

$F_A = 237\,kN$



a) for shear force,

aa' :) ~~23~~ $V_x = 237 - 90x$ at $x = 0$ $V_x = 237\,kN$

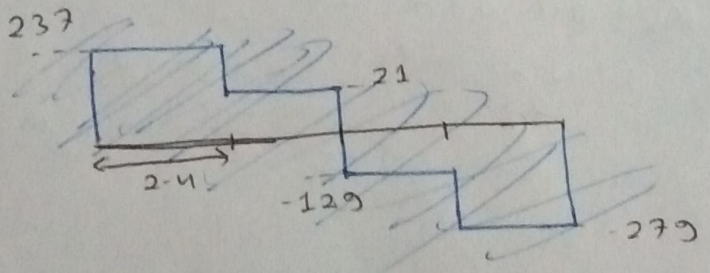
$x = 2{\cdot}4$ $V_x = 21\,kN$

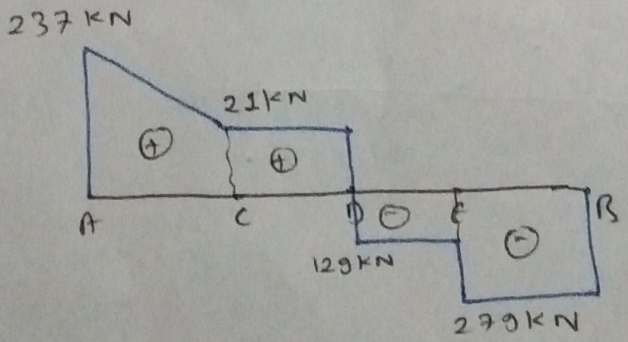
bb' :) $V_x = 237 - 90 \times 2{\cdot}4 = 21\,kN$

cc' :) $V_x = 237 - 90 \times 2{\cdot}4 - 150$ ~~$(x - 3{\cdot}2)$~~

$= -129\,kN$

dd' :) $V_x = -279\,kN$





b) For Bending moment,

aa' ⇒ $M_x = 237x - 90x \cdot \frac{x}{2}$

$= 8237x - \frac{90x^2}{2}$

$= 237x - 45x^2$ at $x = 0$ $M_x = 0$

$x = 2.4$ $M_x = 568.8 - 259.2$

$= 309.6$ KN m

bb' ⇒ $M_x = 237x - 90 \times 2.4(x - 1.2)$

$= 21x + 259.2$ at $x = 2.4$ $M_x = 309.6$ KN m

$x = 3.2$ $M_x = 326.4$ KN m

cc' ⇒ $M_x = 21x + 259.2 - 150(x - 3.2)$

$= 480 + 259.2 - 129x$

$= 739.2 - 129x$ at $x = 3.2$

$M_x = 326.4$ KN m

$x = 4$

$M_x = 223.2$ KN m

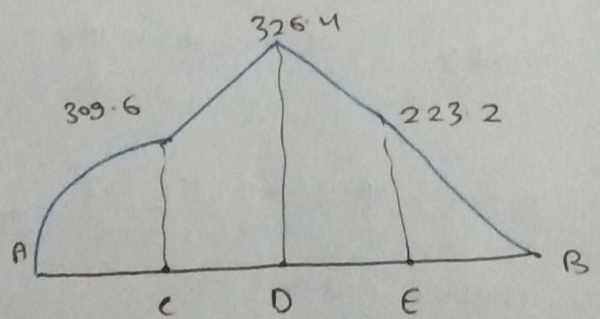
dd' ⇒ $M_x = 739.2 - 129x - 150(x - 4)$

$= 1,339.2 - 279x$ at $x = 4$

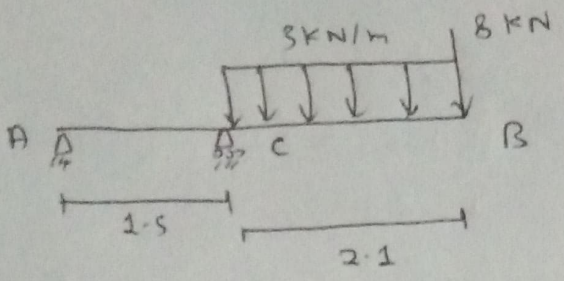
$M_x = 223.2$ KN m

$x = 4.8$

$M_x = 0$



v)



Using

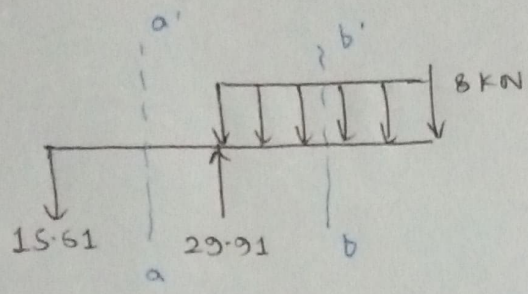
$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_c = 0$

$F_A = -15.61 KN$

$F_C = 29.31 KN$



a) for shear force,

$aa' \Rightarrow V_x = -15.61$

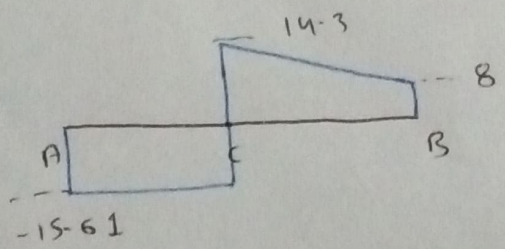
$bb' \Rightarrow -15.61 + 29.91 - 3(x - 1.5)$

$\Rightarrow 14.3 - 3x + 4.5$

$\Rightarrow 18.8 - 3x$

at $x = 1.5$ $\quad V_x = 14.3$

$x = 3.6$ $\quad V_x = 8$



b) for moment,

$aa' = -15.61x$ at $x = 0$ $\quad M_x = 0$

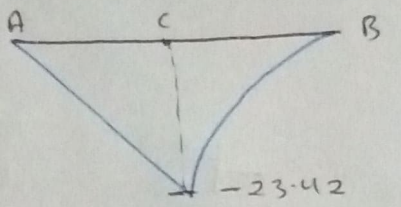
$x = 1.5$ $\quad M_x = -23.42 KN \cdot m$

bb' :> $M_x = -15.61x + 29.93(x-1.5) - \frac{3(x-1.5)^2}{2}$

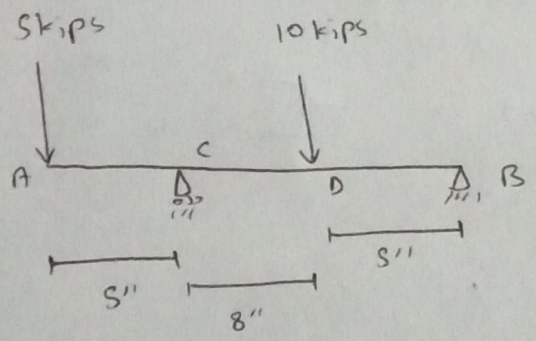
$= 18.8x - 1.5x^2 - 48.24$

at $x = 1.5$ $\quad M_x = -23.42$

$x = 3.6$ $\quad M_x = 0$



vi)



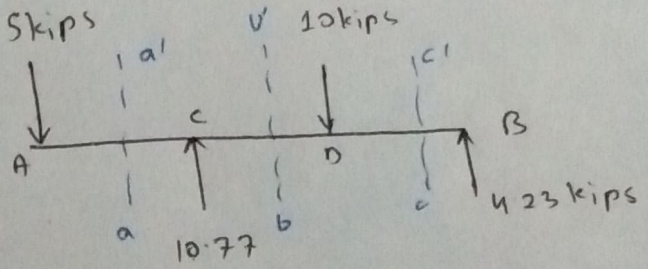
$\Sigma M_C = 0$

$\Rightarrow +5\times 5 - 10\times 8 + F_B \times 13 = 0$

$\Rightarrow 13F_B = 80.25$

$F_B = 4.23$ kips

$F_C = 10.77$ kips

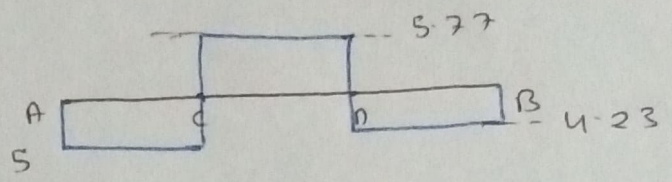


a) for Shear,

aa' => $V_x = -5$ kips

bb' => $V_x = 5.77$ kips

cc' => $V_x = -4.23$ kips



b) for Bending,

aa' => $M_x = -5x$

$x = 0 \quad M_x = 0$

$x = 5 \quad M_x = -25$

bb' => $M_x = -5x + 10(x-5)$

$= 5x - 50$

$x = 5 \quad M_x = -25$

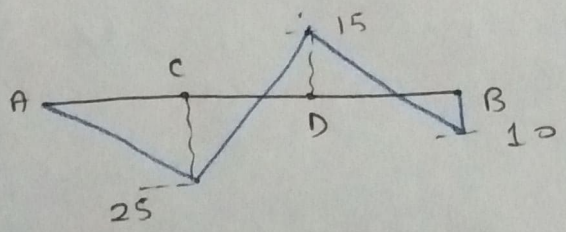
$x = 13 \quad M_x = 15$

cc' => $M_x = 5x - 50 - 10(x-13)$

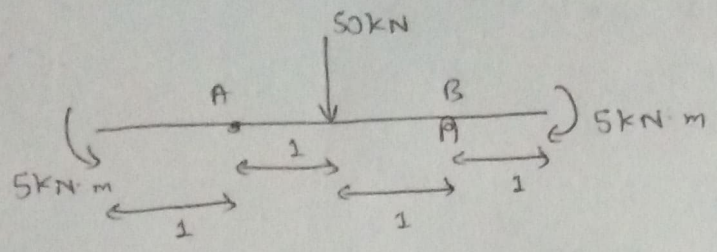
$\Rightarrow 80 - 5x$

$x = 13 \quad M_x = 15$

$x = 18 \quad M_x = -10$



vii)



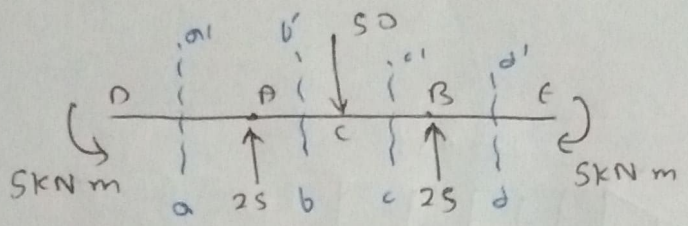
Using $\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_B = 0$

$F_A = 25kN$

$F_B = 25kN$



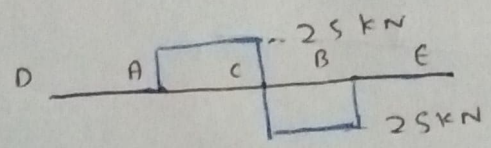
a) for shear,

aa' ⇒ $V_x = 0$

bb' ⇒ $V_x = 25kN$

cc' ⇒ $V_x = -25kN$

dd' ⇒ $V_x = 0kN$



b) for moment,

aa' ⇒ $M_x = -5kN·m$

bb' ⇒ $M_x = -5 + 25(x-1)$ → $x=1$, $m_x = -5$

$= 25x - 30$ → $x=2$, $m_x = 20$

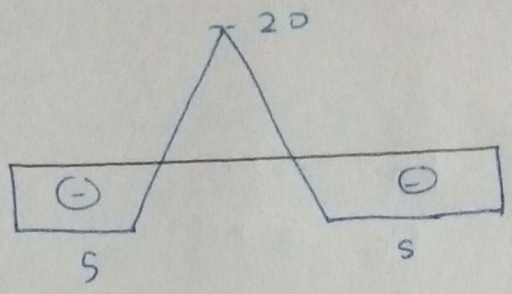
cc' ⇒ $M_x = 25x - 30 - 50(x-2)$ → $x=2$, $m_x = 20$

$= 70 - 25x$ → $x=3$, $m_x = -5$

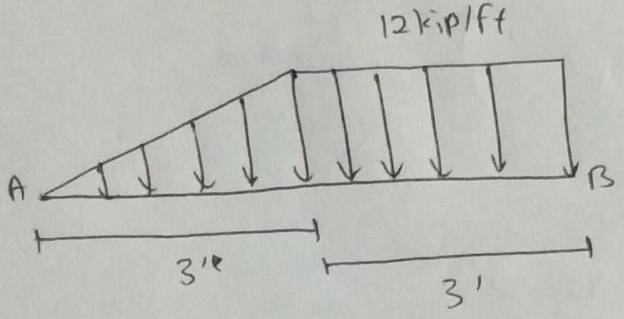
dd' ⇒ ~~$m_x = 70 - 2$~~

$\partial D' \Rightarrow M_x = 70 - 25x + 125(x-3)$

$= -5$

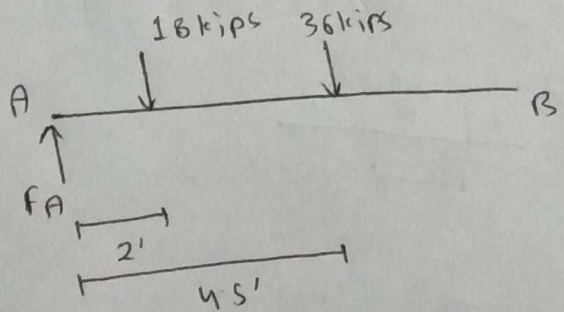


viii)



Total load: $\frac{1}{2} \times 12 \times 3 \Rightarrow$ 18kip (Triangle)

Total load: $12 \times 3 = 36$ (Rectangle)

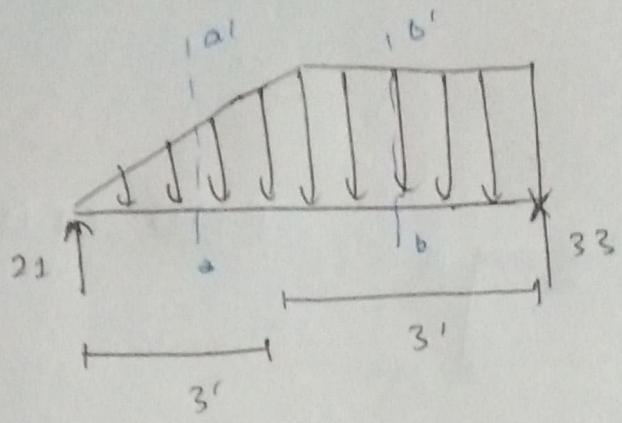


$\Sigma M_A \Rightarrow -18 \times 2 - 36 \times \frac{2}{3} + F_B \times 6 = 0$

$\Rightarrow 6F_B = 18 \times 11$

$F_B = 33$ kips

$F_A = 21$ kips



a) For shear,

$aa' \Rightarrow V_x = 21 - \frac{1}{2} x \cdot 4x^2$

$= 21 - 2x^2$

$x = 0 \quad V_x = 21$

$x = 3 \quad V_x = 3$

$bb' \Rightarrow V_x = 21 - \frac{1}{2} \times 12 \times 3 - 12(x-3)$

$\Rightarrow -12x + 39$

$x = 3 \quad V_x = 3$

$x = 6 \quad V_x = -33$

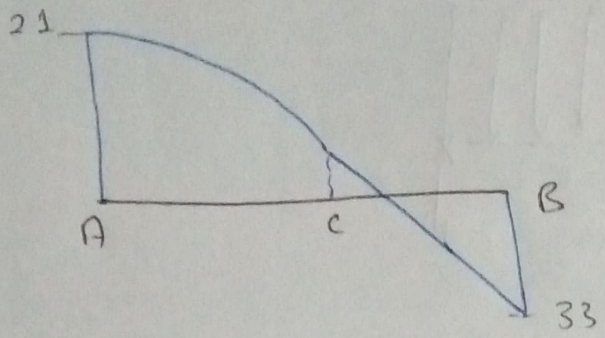
b) For moment,

$aa' \Rightarrow M_x = 21x - \frac{1}{2} \cdot x \cdot 2x^2 \cdot \frac{x}{3}$

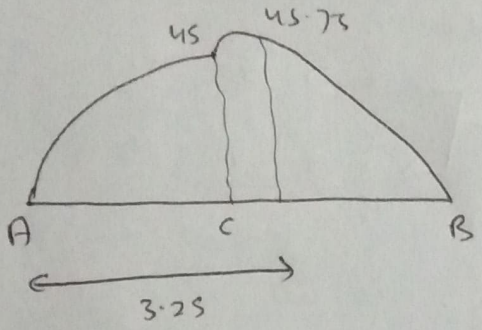
$= 21x - \frac{2x^3}{3}$

$bb' \Rightarrow M_x = 21x - 18(x-2) - 12\frac{(x-3)^2}{2}$

$= 21x - 18(x-2) - 6(x-3)^2$

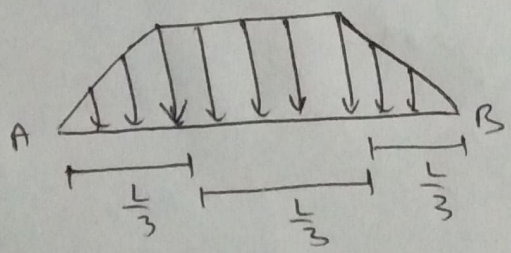


~~BMD~~ SFD

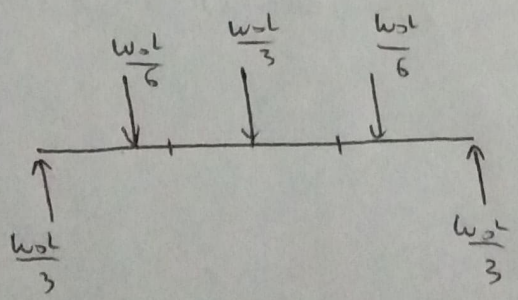


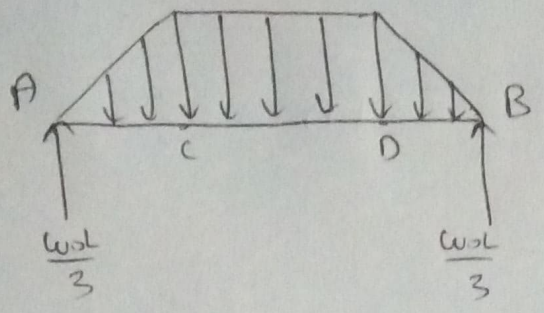
~~SFD~~ BMD

1*)



from symmetry,





a) For shear,

$$AC \rightarrow V_x = \frac{w_0 L}{3} - \frac{1}{2} x \frac{w_0}{L} 3x$$

$$= \frac{w_0 L}{3} - \frac{3 w_0 x^2}{2L}$$

$$AD \rightarrow V_x = \frac{w_0 L}{3} - \frac{w_0 L}{6} - w_0 \left(x - \frac{L}{3}\right)$$

$$= \frac{w_0 L}{2} - w_0 \left(x - \frac{L}{3}\right)$$

$$AB \rightarrow V_x = \frac{w_0 L}{2} - w_0 \left(x - \frac{L}{3}\right) - \frac{w_0 L}{3} + \frac{3 w_0}{2} \left(x - \frac{2L}{3}\right)^2$$

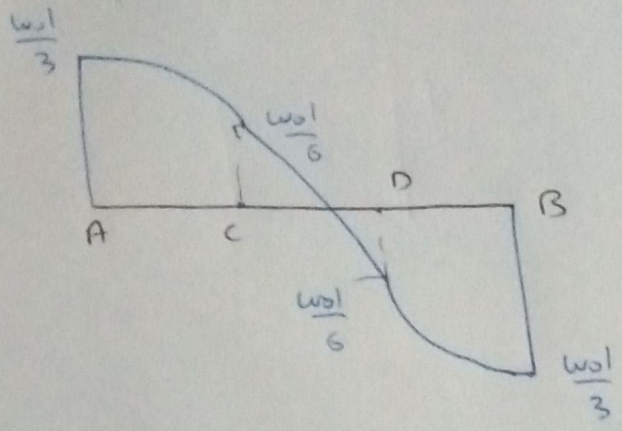
b) For Bending,

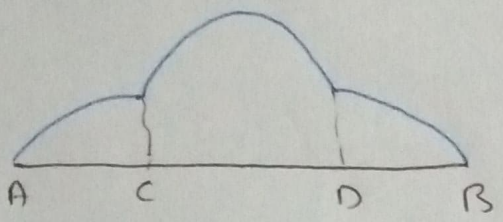
$$AC \rightarrow M_x = \frac{w_0 b x}{3} - \frac{w_0 x^3}{2L}$$

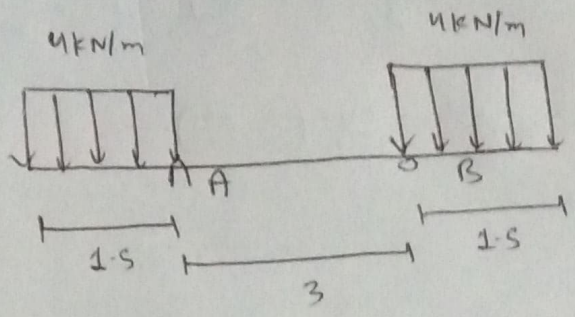
$$AD \rightarrow M_x = \frac{w_0 L x}{3} - \frac{w_0 L}{6} \left(x - \frac{2L}{3}\right) - \frac{w_0}{2} \left(x - \frac{L}{3}\right)^2$$

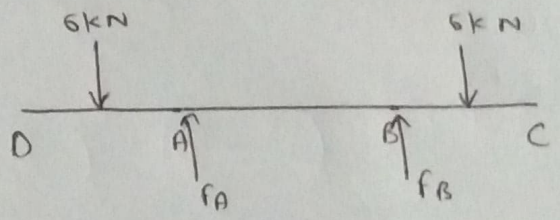
$$AB \rightarrow M_x = \frac{w_0 L x}{3} - \frac{w_0 L}{6} \left(x - \frac{2L}{3}\right) - \frac{w_0 L}{3} \left(x - \frac{L}{3}\right) - \frac{w_0}{2L} \left(x - \frac{2L}{3}\right)^3$$

SFD



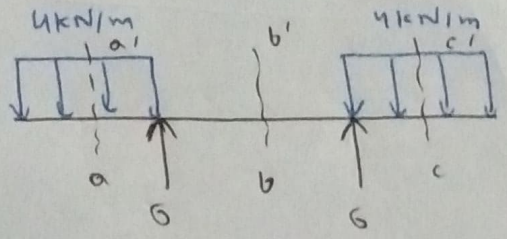






By symmetry,

$$R_A = R_B = 6$$



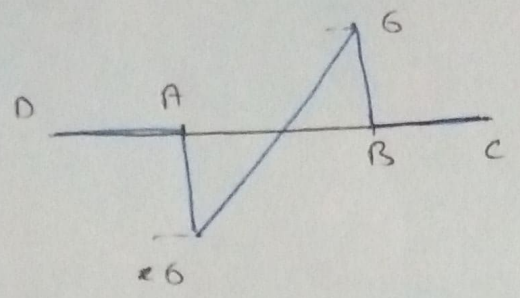
a) For Shear Force,

$aa' \Rightarrow -4x$ → $x = 0$, $V_x = 0$; $x = 1.5$, $V_x = -6$

$bb' \Rightarrow 6 - 4 \times 1.5 = 0$

$cc' \Rightarrow 6 = 4x$ → $x = 4.5$

$cc' \Rightarrow 6 - 4(x - 4.5)$ → $x = 4.5$, $V_x = 6$; $x = 6$, $V_x = 0$



b) For Moment diagram,

$aa' \Rightarrow -4x \cdot \frac{x}{2} \Rightarrow -2x^2$ — $x = 0$, $M_x = 0$; $x = 1.5$, $M_x = -4.5$

$bb' \Rightarrow -4 \times 1.5 (x - 0.75) + 6(x - 1.5)$

$\Rightarrow -6(x - 0.75) + 6(x - 1.5)$

$\Rightarrow 6[x - 1.5 - x + 0.75)$

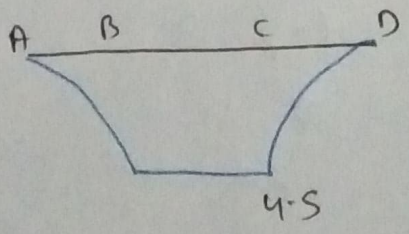
$\Rightarrow -4.5$

$cc' \Rightarrow -4.5 - 4(x - 4.5)\frac{(x - 4.5)}{2}$

$\Rightarrow -4.5 - \frac{4(x - 4.5)^2}{2}$ — $x = 4.5$, $M_x = -4.5$; $x = 6$

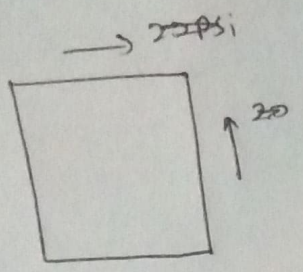
$M_x = -4.5 - \frac{4^2 \times 2.25}{2}$

$= -9$



2)

a)



(20)

$\sigma_x = \sigma_y = 0$

$\tau_{xy} = 250\ psi$

$\theta = +-15°$

$2\theta = -30°$

$$\sigma_\theta = \left(\frac{\sigma_x + \sigma_y}{2}\right) + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin 2\theta$$

$= \tau_{xy}\sin 2\theta$

$= 250 \sin(-30)$

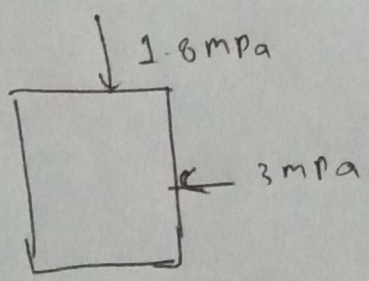
$= -125\ psi$ (compression)

$$\tau_\theta = -\left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta + \tau_{xy}\cos 2\theta$$

$= \tau_{xy}\cos 2\theta$

$= 216.5\ psi$

b)



$\sigma_x = -1.8\ mPa$

$\sigma_y = -3mPa$

$\tau_{xy} = 0$

$\theta = -15°$

$2\theta = -30°$

$$\sigma_\theta = \left(\frac{\sigma_x + \sigma_y}{2}\right) + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin 2\theta$$

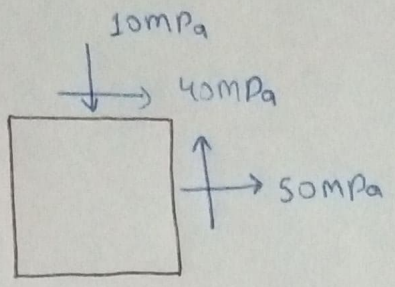
$$= \left(\frac{-1.8 - 3}{2}\right) + \left(\frac{-1.8 + 3}{2}\right)\cos(-30^\circ)$$

$$= -1.88 \text{ mPa}$$

$$\tau_\theta = -\left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta + \tau_{xy}\cos 2\theta$$

$$= 0.3 \text{ mPa}$$

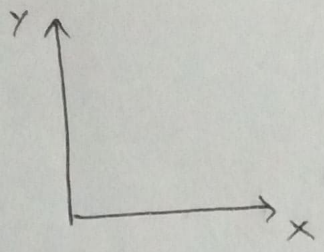
3>



Sign conventions,

Tensile stress (+ve)

Shear stress producing anti-clockwise rotation (+ve)



$\sigma_x = 50 \quad \sigma_y = -10$

$\tau_{yx} = -40 \quad \tau_{xy} = 40$

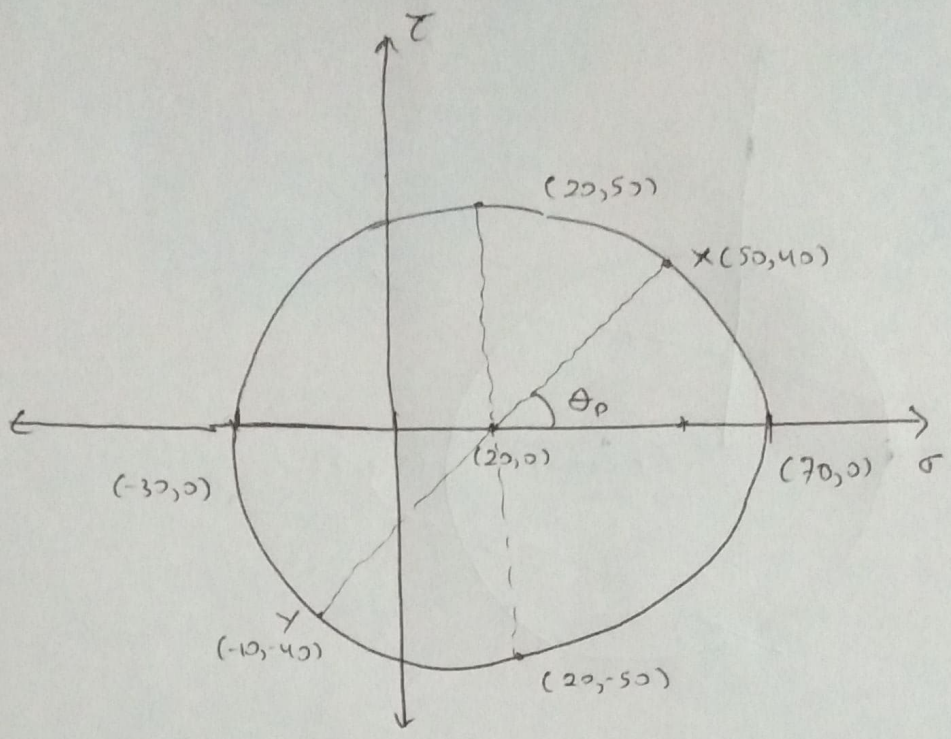
We will use Mohr's circle,

$$\left[\sigma_{x'} - \left(\frac{\sigma_x + \sigma_y}{2}\right)\right]^2 + \tau^2_{x'y'} = \left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau^2_{xy}$$

Centre C of circle $= \left(\frac{50-10}{2}, 0\right) = (20, 0)$

$$R = \sqrt{\left(\frac{50+10}{2}\right)^2 + 1600} = 50$$

$X = (50, 40) \qquad Y = (-10, -40)$



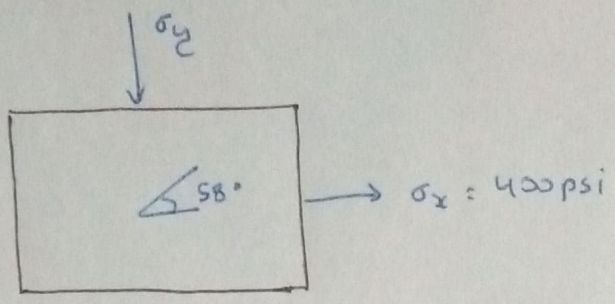
a) $\tan\theta_p = \frac{40}{50} \Rightarrow \theta_p = \tan^{-1}\left(\frac{4}{5}\right)$

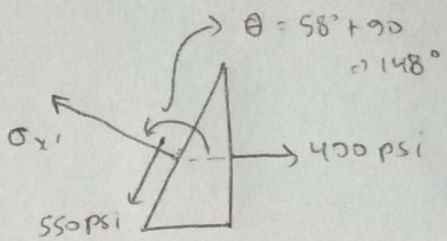
$= 38.66°$

b) $\sigma_{max} = 70\,MPa$ $\sigma_{min} = 30\,MPa$

c) $\tau = 50$ $\sigma_{average} = 20$

4)





we know that,

$$\tau_{x'y'} = -\left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta + \tau_{xy}\cos 2\theta \quad (\tau_{xy} \to 0)$$

$$\Rightarrow 550 = -\left(\frac{400 - \sigma_y}{2}\right)\sin 296° + 0$$

$$\Rightarrow 550 = \left(\frac{400 - \sigma_y}{2}\right)\cdot 0.89$$

$$\Rightarrow \frac{1,100}{0.89} = (400 - \sigma_y)$$

$$\Rightarrow 400 - \sigma_y = 1235.95$$

$$\Rightarrow \sigma_y = -835.95 \text{ psi}$$