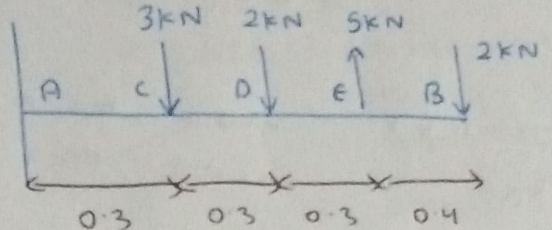
Shubham Raj Signature: Shubham

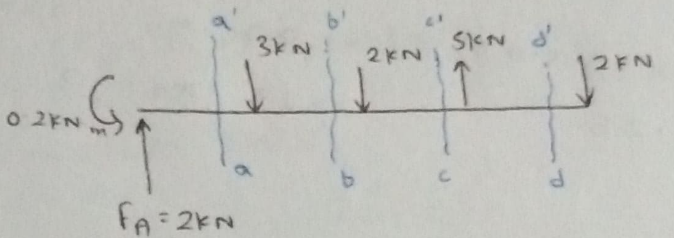
CC19B030

Strength of Materials ~~[illegible]~~ (CE2101)

1)

1)





$\Sigma F_y \Rightarrow F_A - 2 = 0$

$\Rightarrow F_A = 2KN$

$\Sigma M_A = 0$

$\Rightarrow -3 \times 0.3 - 2 \times 0.6$

$+ 5 \times 0.9 - 2 \times 1.3$

$= -0.9 - 1.2 + 4.5 - 2.6$

$\Rightarrow -0.2$ KN m

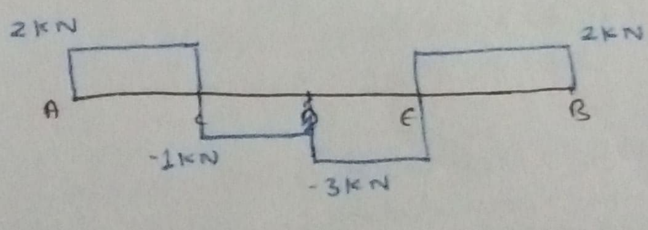
a) For shear force,

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·m

$x = 0.3$ $M_x = 0.4$ kN·m

bb' ⇒ $2x - 0.2 - 3(x - 0.3)$

$= 0.7 - x$ at $x = 0.3$ $M_x = 0.4$ kN·m

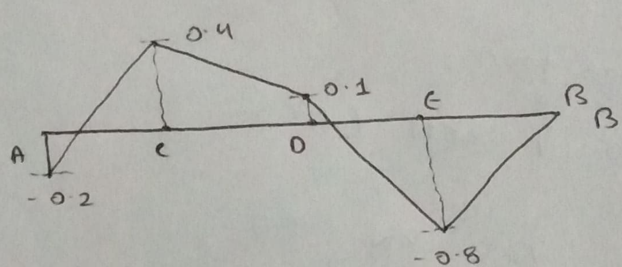
$x = 0.6$ $M_x = 0.1$ kN·m

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

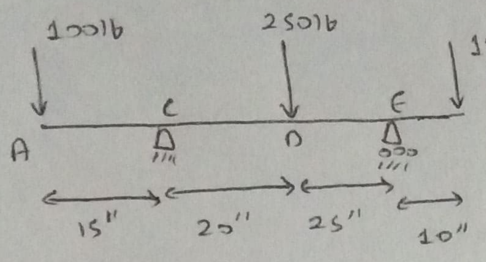
⇒ $1.9 - 3x$ $x = 0.9$ $M_x = -0.8$ kN·m

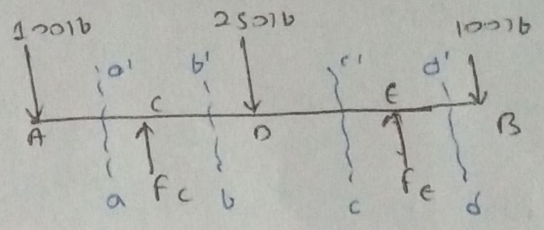
dd' ⇒ $1.9 - 3x + 5(x - 0.9)$ $x = 0.9$ $M_x = -0.8$ kN·m

⇒ $2x - 2.6$ $x = 1.3$ $M_x = 0$



11)





$\cancel{B}$ $\Sigma M_C = 0 \Rightarrow 100\times15 - 250\times20 + F_E\times45 - 100\times55 = 0$

$\Rightarrow 45F_E = 100(55-15) + 250\times20$

$= 100\times40 + 5000$

$= 9,000$

$F_E = 200\,lb$

$\Sigma F_y = 0 \Rightarrow F_C = 250\,lb$

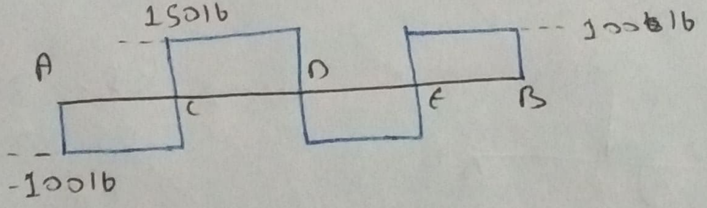
a) For shear force,

aa' $\Rightarrow V_x = -100\,lb$

bb' $\Rightarrow V_x = \cancel{100lb}\ 150\,lb$

cc' $\Rightarrow V_x = \cancel{150lb}\ -100\,lb$

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' => $x = 0$ $\quad M_x = 0$

$x = 15$ $\quad M_x = -1500$ lb·in

for bb' => $x = 15$ $\quad M_x = -1500$ lbin

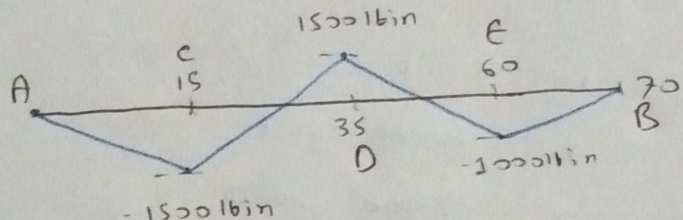
$x = 35$ $\quad M_x = 1500$ lbin

for cc' => $x = \cancel{x}35$ $\quad M_x = 1500$lbin

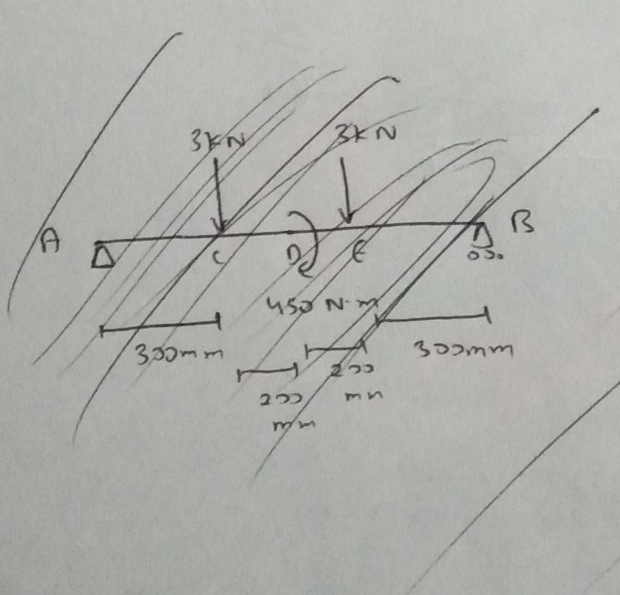
$x = 60$ $\quad M_x = -1000$lbin

for dd' => $x = 60$ $\quad M_x = -1000$lbin

$x = 70$ $\quad M_x = 0$



iii)



Using $\Sigma F_x = 0$

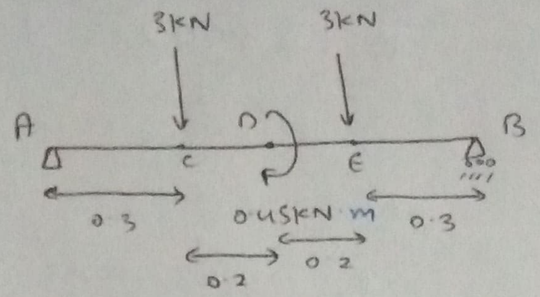
$\Sigma F_y = 0$

$\Sigma M_D = 0$

$F_A = 2.55$kN

$F_B = 3.45$kN

III)



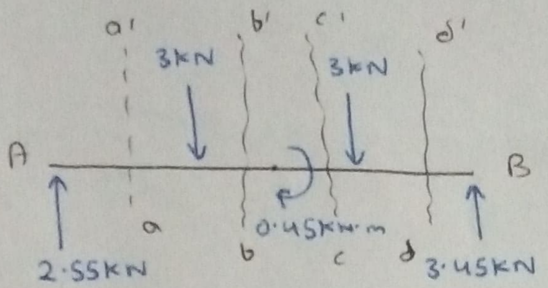
Using $\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_D = 0$

$F_A = 2.55KN$

$F_B = 3.45KN$



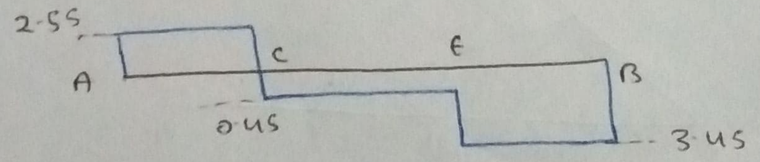
a) For shear,

$aa' \rightarrow V_x = 2.55KN$

$bb' \Rightarrow V_x = -0.45KN$

$cc' \Rightarrow V_x = -0.45KN$

$dd' \Rightarrow V_x = \cancel{3KN} - 3.45KN$



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 $x = 0.3$ $M_x = 0.765$

$\Rightarrow 0.9 - 0.45x$ $x = 0.5$ $M_x = 0.675$

$cc' \Rightarrow 0.9 - 0.45x + 0.45$ at $x = 0.5$

$\Rightarrow 1.35 - 0.45x$ $M_x = 1.125 \, kN\,m$

at $x = 0.7$

$M_x = 1.035 \, kN \cdot m$

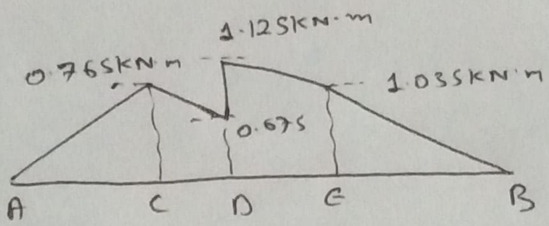
$dd' \Rightarrow 1.35 - 0.45x - 3(x - 0.7)$ at $x = 0.7$

$M_x = 1.035 \, kN \cdot m$

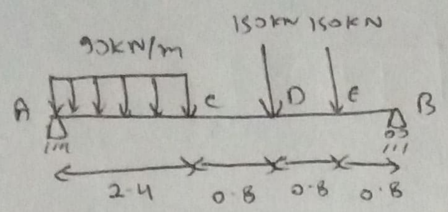
$\Rightarrow 3.45 - 3.45x$

at $x = 1$

$M_x = 0$



iv)



Using

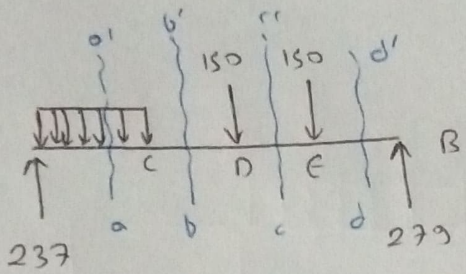
$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_A = 0$

$F_B = 279\,kN$

$F_A = 237\,kN$



a) for shear force,

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

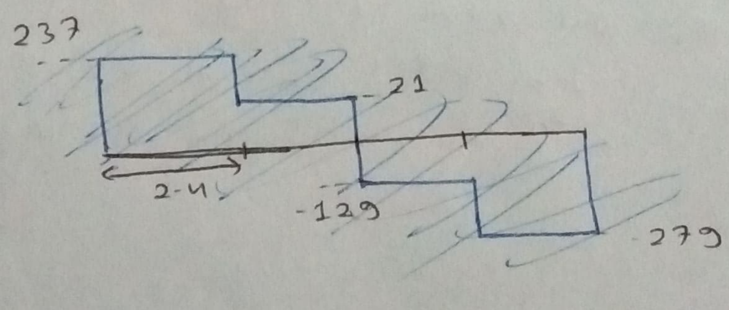
$x = 2.4$ $V_x = 21\,kN$

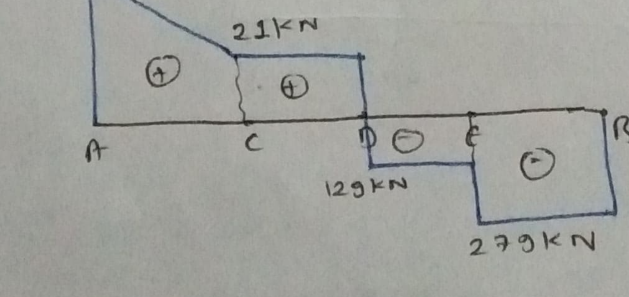
bb' :) $V_x = 237 - 90 \times 2.4 = 21\,kN$

cc' :) $V_x = 237 - 90 \times 2.4 - 150$

$= -129\,kN$

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





b) for Bending moment,

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

$= \cancel{8}237x - \frac{90x^2}{2}$

$= 237x - 45x^2$ 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 $x = \cancel{2.8}3.2$

$M_x = 326.4$ KN m

$x = 4$

$M_x = 223.2$ KN m

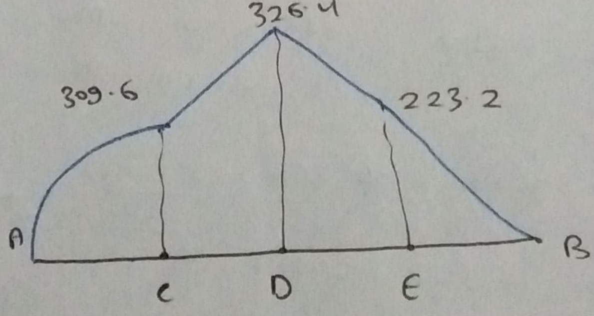
dd' => $M_x = 739.2 - 129x - 150(x - 4)$

$= 1,339.2 \quad 279x$ at $x = 4$

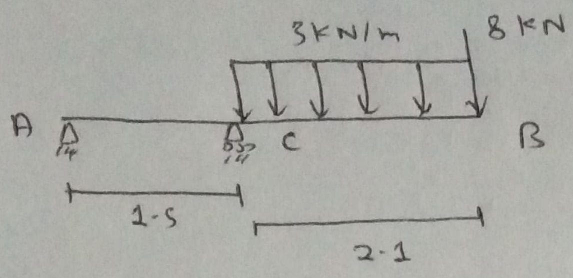
$M_x = 223.2$ KN m

$x = 4.8$

$M_x = 0$



v)



Using

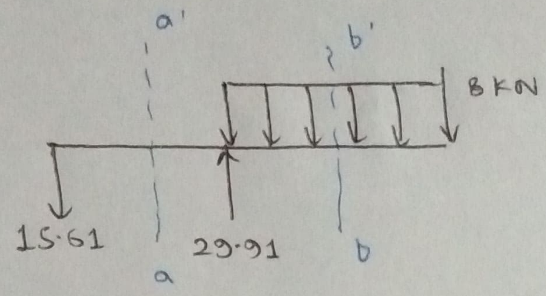
$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_c = 0$

$F_A = -15.61 KN$

$F_C = 29.91 KN$



a) for shear force,

$aa' \Rightarrow V_x = -15.61$

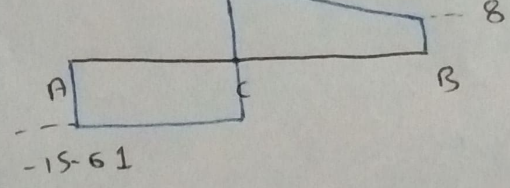
$bb' \Rightarrow -15.61 + 29.91 - 3(x-1.5)$

$= 14.3 - 3x + 4.5$

$\Rightarrow 18.8 - 3x$

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

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



b) for moment,

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

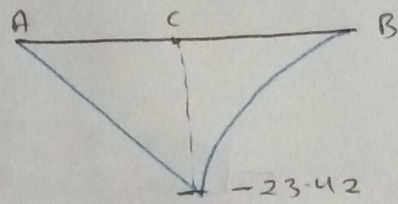
$x = 1.5$ $\quad M_x = -23.42 KN\cdot m$

bb' $\Rightarrow M_x = -15.61x + 28.91(x-1.5) - \frac{3(x-1.5)^2}{2}$

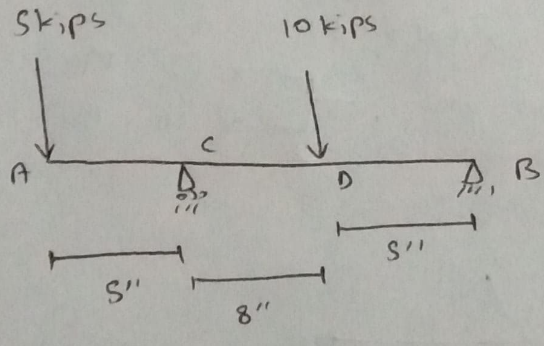
$= 18.8x - 1.5x^2 - 4824$

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

$x = 3.6 \quad M_x = 0$



vi)



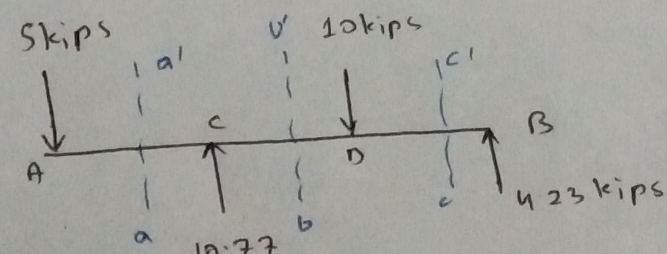
$\Sigma M_c = 0$

$\Rightarrow +5\times5 - 10\times8 + F_B\times13 = 0$

$\Rightarrow 13F_B = 80-25$

$F_B = 4.23$ kips

$F_C = 10.77$ kips

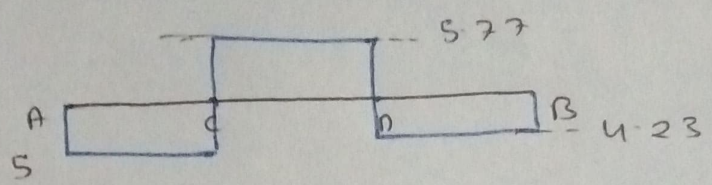


a) for Shear,

aa' ⇒ $V_x = -5$ kips

bb' ⇒ $V_x = 5.77$ kips

cc' ⇒ $V_x = -4.23$ kips

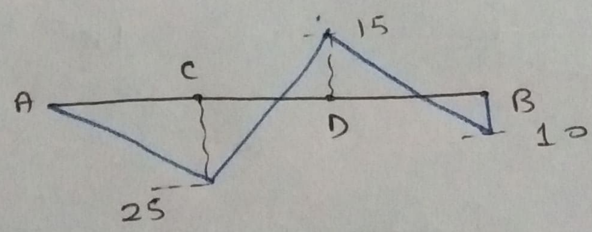


b) for Bending,

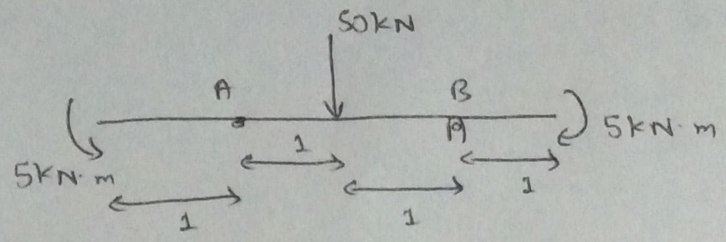
aa' ⇒ $M_x = -5x$ → $x = 0$: $M_x = 0$; $x = 5$: $M_x = -25$

bb' ⇒ $M_x = -5x + 10(x-5)$
$= 5x - 50$ → $x = 5$: $M_x = -25$; $x = 13$: $M_x = 15$

cc' ⇒ $M_x = \cancel{5x - 50 - 10(x - 8)}$
$5x - 50 - 10(x-13)$
⇒ $80 - 5x$ → $x = 13$: $M_x = 15$; $x = 18$: $M_x = -10$



vii)



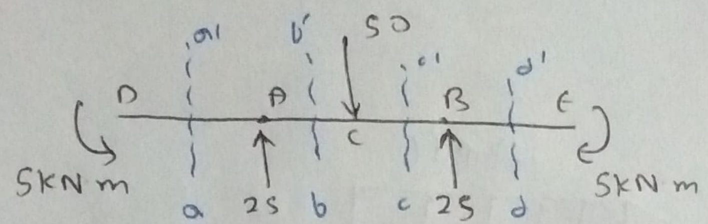
Using $\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_B = 0$

$F_A = 25KN$

$F_B = 25KN$



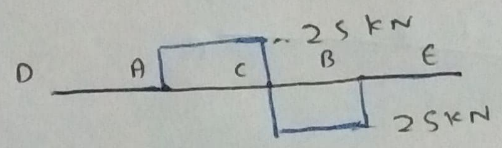
a) for shear,

$aa' \Rightarrow V_x = 0$

$bb' \Rightarrow V_x = 25KN$

$cc' \Rightarrow V_x = -25KN$

$dd' \Rightarrow V_x = 0KN$



b) for moment,

$aa' \Rightarrow M_x = -5KN\cdot m$

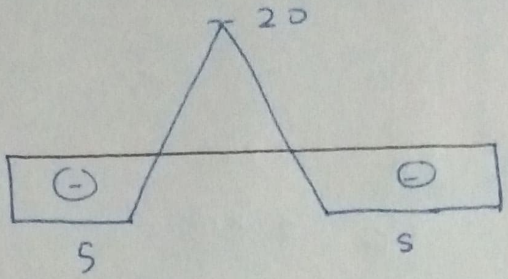
$bb' \Rightarrow M_x = -5 + 25(x-1) = 25x - 30$; $x = 1$: $M_x = -5$; $x = 2$: $M_x = 20$

$cc' \Rightarrow M_x = 25x - 30 - 50(x-2) = 70 - 25x$; $x = 2$: $M_x = 20$; $x = 3$: $M_x = -5$

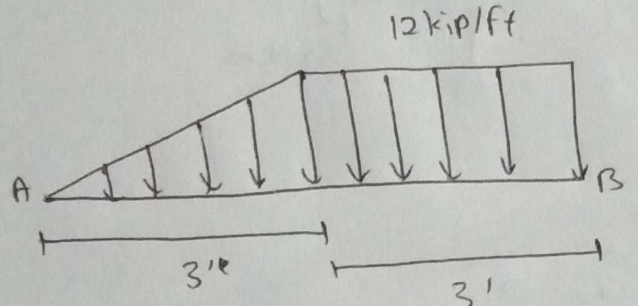
~~dd' ⇒ Mx = 70·2~~

$DD' \Rightarrow M_x = 70.25x + 25(x-3)$

$= -5$

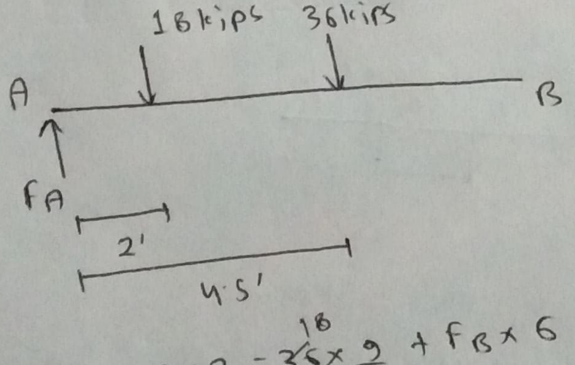


viii)



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

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

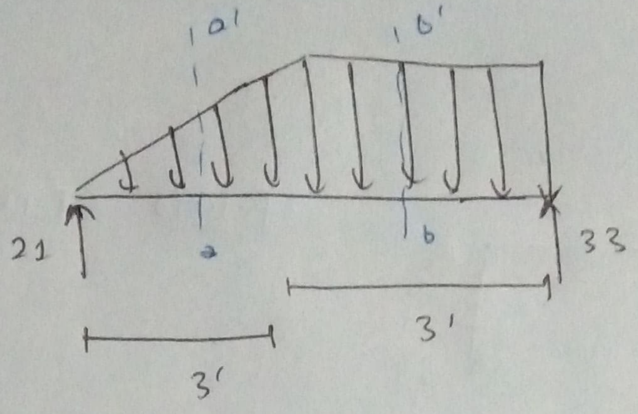


$$\Sigma M_A \Rightarrow -18 \times 2 - \overset{18}{\cancel{36}} \times \frac{9}{\cancel{2}} + F_B \times 6 = 0$$

$$\Rightarrow \cancel{6} F_B = \overset{3}{\cancel{18}} \times 11$$

$$F_B = 33 \text{ kips}$$

$$F_A = 21 \text{ kips}$$



a) for shear,

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

$= 21 - 2x^2$ — $x = 0$, $V_x = 21$; $x = 3$, $V_x = 3$

bb' $\Rightarrow V_x = 21 - \frac{1}{2} \times 12 \times 3 - 12(x-3)$ — $x = 3$, $V_x = 3$; $x = 6$, $V_x = -33$

$\Rightarrow -12x + 39$

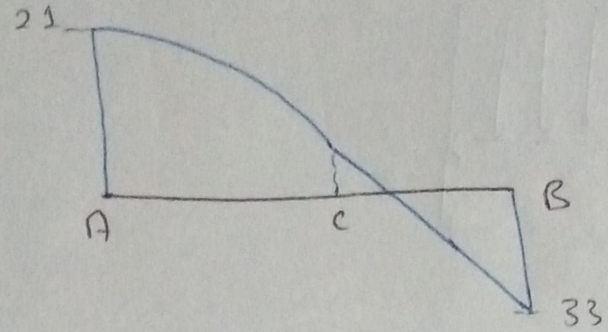
b) for moment,

aa' $\Rightarrow M_x = 21x - \frac{1}{2} \cdot x \cdot 4x \cdot \frac{x}{3}$

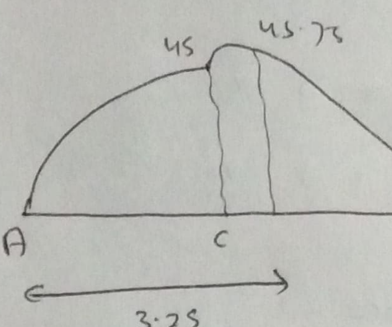
$= 21x - \frac{2x^3}{3}$

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

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

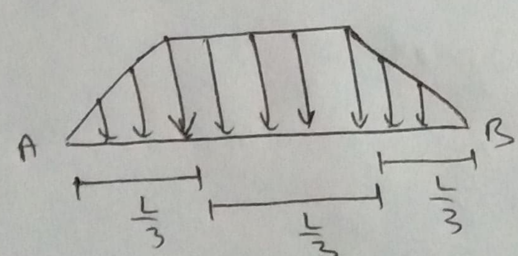


~~BMD~~ SFD

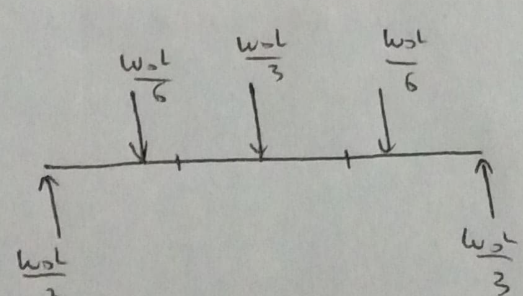


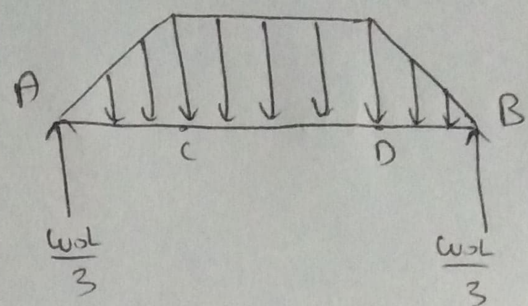
~~SFD~~ BMD

1x)



from symmetry,





a) For shear,

AC -> $V_x = \frac{w_0L}{3} - \frac{1}{2}x \cdot \frac{w_0 \cdot 3x}{L}$

$= \frac{w_0L}{3} - \frac{3w_0x^2}{2L}$

AD -> $V_x = \frac{w_0L}{3} - \frac{w_0L}{6} - w_0\left(x - \frac{L}{3}\right)$

$= \frac{w_0L}{2} - w_0\left(x - \frac{L}{3}\right)$

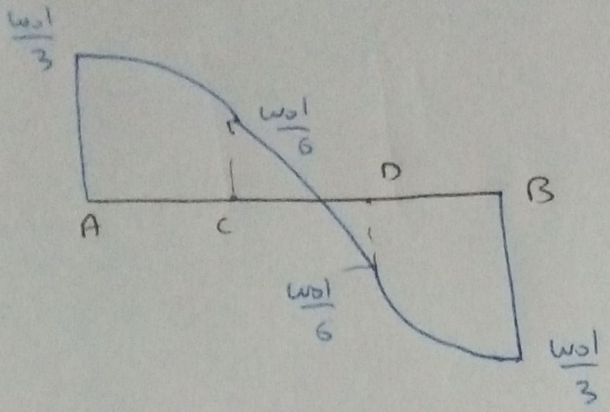
AB -> $V_x = \frac{w_0L}{2} - w_0\left(x - \frac{L}{3}\right) - \frac{w_0L}{3} + \frac{3w_0}{2}\left(x - \frac{2L}{3}\right)^2$

b) For Bending,

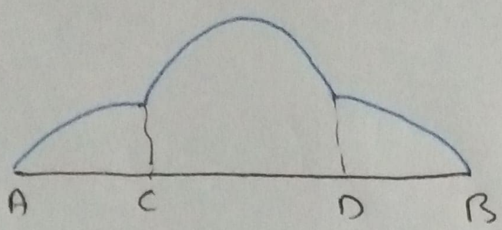
AC -> $M_x = \frac{w_0Lx}{3} - \frac{w_0x^3}{2L}$

AD -> $M_x = \frac{w_0Lx}{3} - \frac{w_0L}{6}\left(x - \frac{2L}{3}\right) - \frac{w_0}{2}\left(x - \frac{L}{3}\right)^2$

AB -> $M_x = \frac{w_0Lx}{3} - \frac{w_0L}{6}\left(x - \frac{2L}{3}\right) - \frac{w_0L}{3}\left(x - \frac{L}{3}\right) - \frac{w_0}{2L}\left(x - \frac{2L}{3}\right)^3$

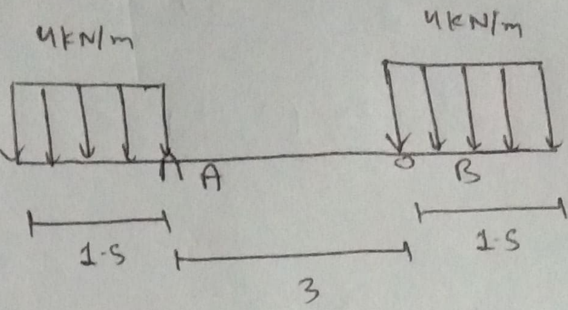


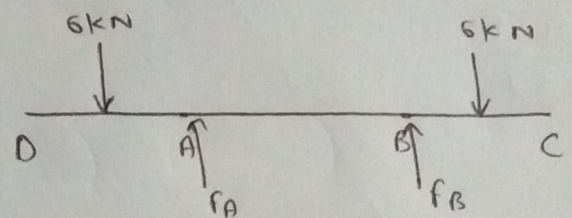
SFD



Ans

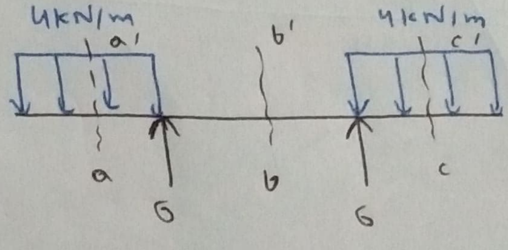
x)





By symmetry,

$F_A = F_B = 6$



a) For shear force,

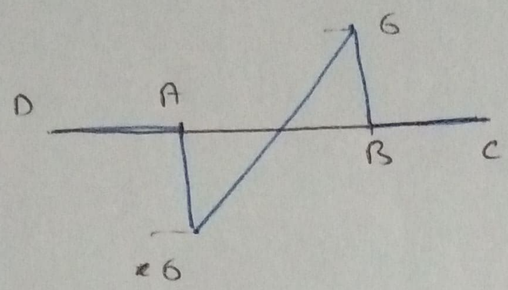
$aa' \Rightarrow -4x$ — $x = 0$, $V_x = 0$; $x = 1.5$, $V_x = -6$

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

~~$x = 4.5$~~

~~$cc' \Rightarrow 6 = 4x$~~

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



b) For Moment diagram,

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

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

$= -6(x - 0.75) + 6(x - 1.5)$

$\Rightarrow 6[\cancel{x} - 1.5 - \cancel{x} + 0.75]$

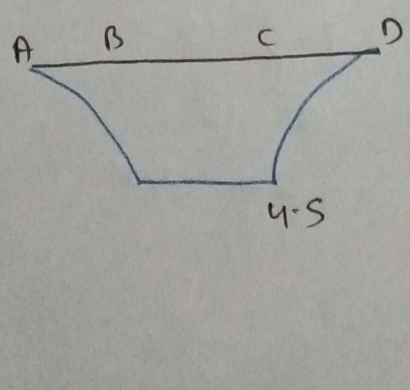
$\Rightarrow -4.5$

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

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

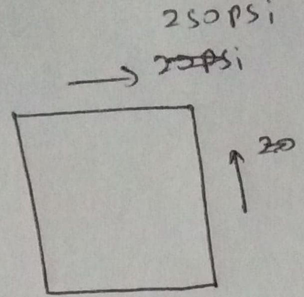
$M_x = -4.5 - \frac{4 \times 2.25}{2}$

$= -9$



2)

a)



$\sigma_x = \sigma_y = 0$

$\tau_{xy} = 250$ psi

$\theta = -15^\circ$

$2\theta = -30^\circ$

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

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

$= 250\sin(-30^\circ)$

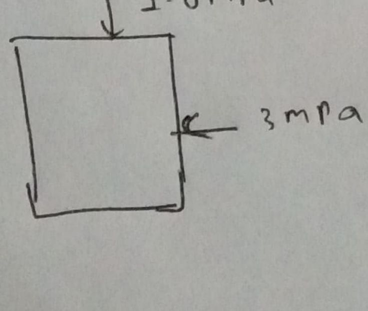
$= -125$ psi (compression)

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

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

$= 216.5$ psi

b)



$\sigma_x = -1.8$ mPa

$\sigma_y = -3$ mPa

$\tau_{xy} = 0$

$\theta = -15^\circ$

$2\theta = -30^\circ$

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

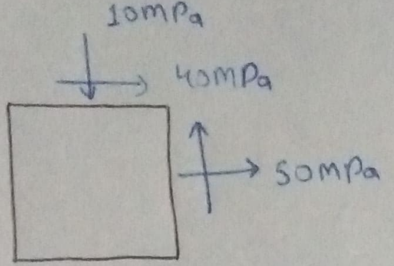
$$= \left(\frac{-1.6-3}{2}\right) + \left(\frac{-1.8+3}{2}\right)\cos(-30^\circ)$$

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

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

$$= 0.3 \text{ MPa}$$

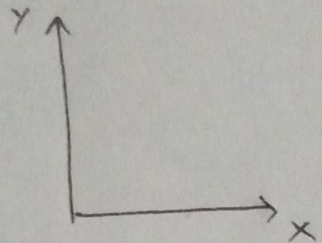
3)



Sign conventions,

Tensile stress (+ve)

Shear stress producing anti-clockwise rotation (+ve)



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

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

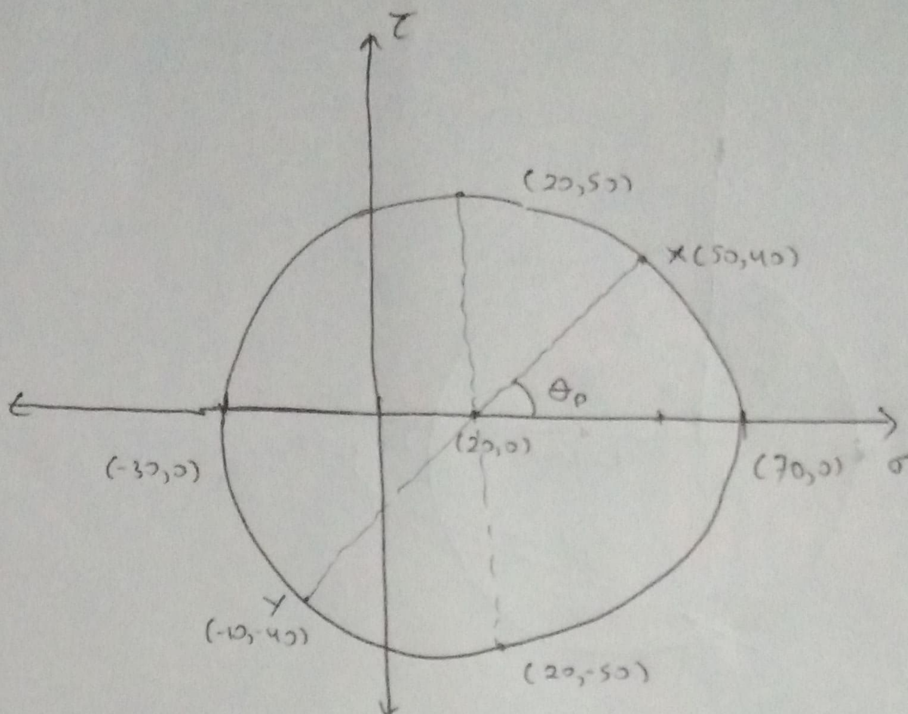
~~Using~~ we will use Mohr's circle,

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

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

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

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



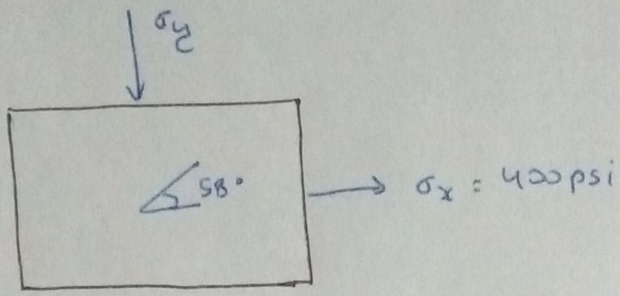
a) $\tan\theta_p = \frac{40}{50} \Rightarrow \theta_p = \tan^{-1}\left(\frac{4}{5}\right)$

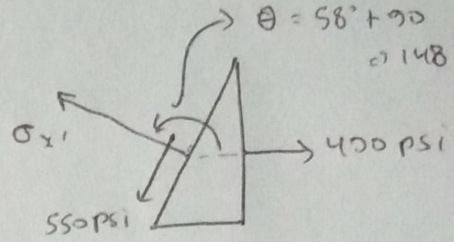
$= 38.66°$

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

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

4)





we know that,

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

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

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

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

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

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