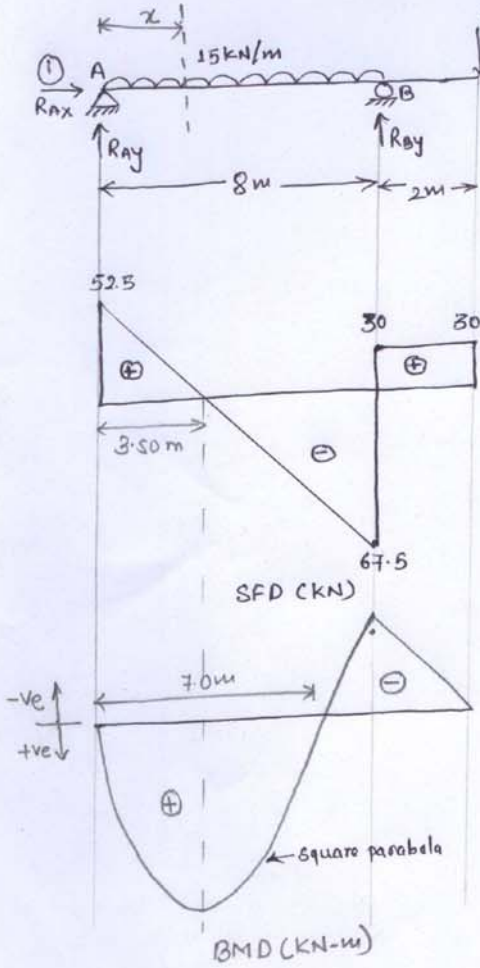
Beam Tutorial



Calculation of support Reaction:

$(\xrightarrow{+}) \Sigma F_x = 0$

$R_{Ax} = 0$

$(+\uparrow) \Sigma F_y = 0$

$R_{Ay} + R_{By} - 15*8 - 30 = 0$

or $R_{Ay} + R_{By} = 150$ ——— (i)

$+\circlearrowleft) \Sigma M_A = 0$

$8R_{By} - 15*8*\frac{8}{2} - 30*10 = 0$

$R_{By} = 97.5\,kN\ (\uparrow)$

$\therefore R_{Ay} = 150 - 97.5 = 52.5\,kN\ (\uparrow)$

Shear Force Calculation (↑ +Vc ↓)

$V_{AL} = 0$

$V_{AR} = 52.5\,kN$

$V_{BL} = V_{AR} - 15*8 = -67.5\,kN$

$V_{BR} = V_{BL} + 97.5 = 30\,kN$

$V_{CL} = V_{BR} = 30\,kN$

$V_{CR} = V_{CL} - 30 = 0$

Bending Moment Calculation (↻ +Vc):

$M_A = 0$

$M_B = 52.5*8 - 15*8*\frac{8}{2} = -60\,kN\text{-}m$

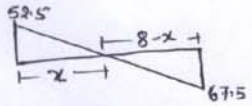
$M_C = 52.8*10 - 15*8*(2+\frac{8}{2}) = 0$

For Point of contraflexure (In portion AB)

$M_x = 52.5x - 15*x*\frac{x}{2} = 0$

$\Rightarrow x = 7.0m$

For SF zero point (In portion AB)



$\frac{52.5}{x} = \frac{67.5}{8-x}$

$\therefore x = 3.50m$

$\therefore$ maximum moment at $x = 3.50m$ is

$M_{max} = 52.5*3.5 - 15*3.5*\frac{3.5}{2}$

$= 91.875\,kN\text{-}m$

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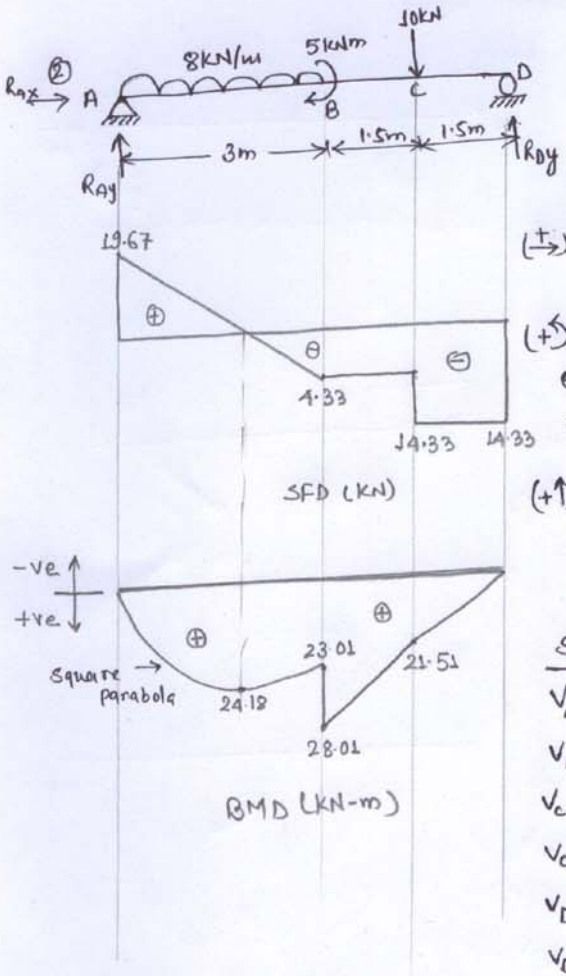


Calculation of support R_x's:

$(\pm\rightarrow) \Sigma F_x = 0$

$R_{Ax} = 0$

$(+\circlearrowleft) \Sigma M_A = 0$

$6R_{Dy} - 5 - 10*4.5 - 8*3*\frac{3}{2} = 0$

$R_{Dy} = 14.33\,KN$

$(+\uparrow) \Sigma F_y = 0$

$R_{Ay} + R_{Dy} - 10 - 8*3 = 0$

$R_{Ay} = 19.67\,KN$

Shear Force Calculation ($\uparrow$ +ve $\downarrow$)

$V_A = R_{Ay} = 19.67\,KN$

$V_B = 19.67 - 8*3 = -4.33\,KN$

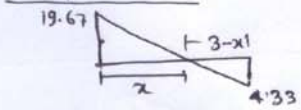
$V_{CL} = V_B = -4.33\,KN$

$V_{CR} = V_{CL} - 10 = -14.33\,KN$

$V_{DL} = V_{CR} = -14.33\,KN$

$V_{DR} = V_{DL} + R_{Dy} = 0$

For shear force zero Point In portion AB:



$\frac{x}{19.67} = \frac{3-x}{4.33}$

$\Rightarrow x = 2.458\,m$

$\therefore$ maximum bending moment in section AB occurs at 2.458 m from A

$M_{max} = 19.67*2.458 - 8*2.458*\frac{2.458}{2}$

$= 24.18\,KN-m$

Bending Moment Calculation (↺ +ve ↻)

$M_A = 0$

$M_{BL} = 19.67*3 - 8*3*\frac{3}{2} = 23.01\,KN-m$

$M_{BR} = 23.01 + 5 = 28.01\,KN-m$

$M_C = 19.67*4.5 - 8*3*3 + 5 = 21.51\,KN-m$

$M_D = 19.67*6 - 8*3*(3+\frac{3}{2}) + 5 - 10*1.5 = 0$

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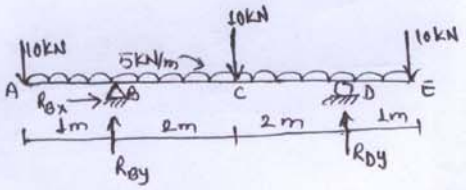


Due to symmetry city

$$R_{By} = R_{Dy} = \frac{(10+10+10+5*6)}{2} = 30KN$$

Shear force Calculation (↑ +ve ↓)

$V_{AL} = 0$

$V_{AR} = -10KN$

$V_{BL} = V_{AR} - 5*1 = -15KN$

$V_{BR} = V_{BL} + 30 = 15KN$

$V_{CL} = V_{BR} - 5*2 = 5KN$

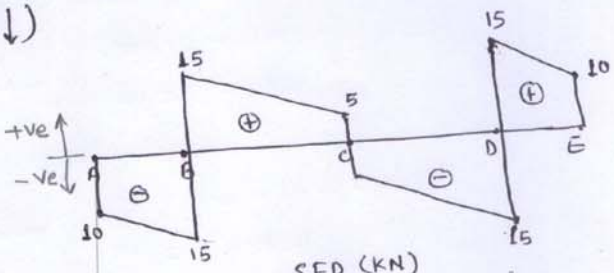
$V_{CR} = V_{CL} - 10 = -5KN$

$V_{DL} = V_{CR} - 5*2 = -15KN$

$V_{DR} = V_{DL} + R_{Dy} = 15KN$

$V_{EL} = V_{DR} - 5*1 = 10KN$

$V_{ER} = V_{EL} - 10 = 0$



SFD (KN)

Bending Moment Calculation [↻ +ve]

$M_A = 0$

$M_B = -10*1 - 5*1*\frac{1}{2} = -12.5KN-m$

$M_C = -10*3 - 5*3*\frac{3}{2} + 30*2$

$= 7.5KN-m$

$M_D = M_B = -12.5KN-m$

$M_E = 0$

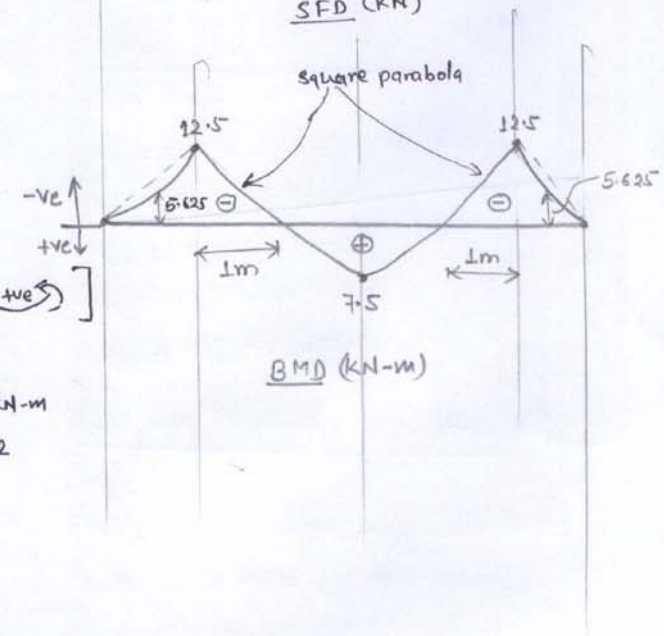
$M_{AB,mid} = -10*\frac{1}{2} - 5*\frac{1}{2}*\frac{1}{2}*0.5$

$= 5.625KN-m$

$M_{DE,mid} = 5.625KN-m$

$M_{BC,mid} = -10*2 - 5*2*\frac{2}{2} + 30*1$

$= 0$



BMD (KN-m)

For point of contraflexure in portion BC (Origin at B)

$$M_x = -10(x+1) - 5*(1+x)*\frac{(1+x)}{2} + 30*x = 0$$

$\therefore x = 1m$

Similarly for portion $x = 1m$ from point D.

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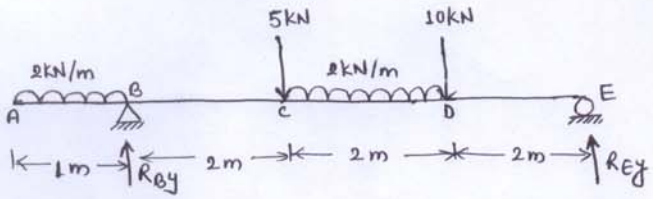


Calculation of Support Rx^n:

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

$$6R_{EY} + 2*1*\frac{1}{2} - 5*2 - 10*4 - 2*2*(2+2/2) = 0$$

$$R_{EY} = 10.16 \text{ KN}$$

$(+\uparrow) \sum F_y = 0$

$$R_{BY} + R_{EY} - 5 - 10 - 2*2 - 2*1 = 0$$

$$R_{BY} = 10.83 \text{ kN}$$

Shear Force calculation ($\uparrow$ +ve $\downarrow$)

$V_A = 0$

$V_{BL} = V_A - 2*1 = -2\text{KN}$

$V_{BR} = V_{BL} + 10.83 = 8.83\text{KN}$

$V_{CL} = V_{BR} = 8.83\text{KN}$

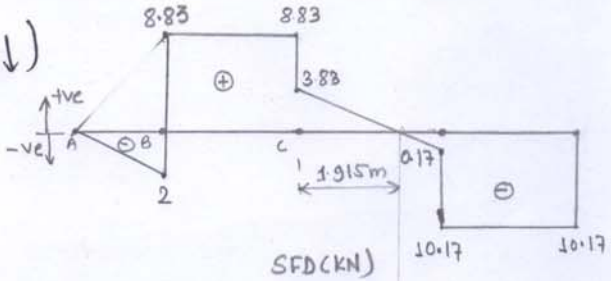
$V_{CR} = V_{CL} - 5 = 3.83\text{KN}$

$V_{DL} = V_{CR} - 2*2 = -0.17\text{KN}$

$V_{DR} = V_{DL} - 10 = -10.17\text{KN}$

$V_{EL} = V_{DR} = -10.17\text{KN}$

$V_{ER} = V_{EL} + R_{EY} = 0$



SFD(KN)

Bending Moment Calculation (↻ +ve ↺)

$M_A = 0$

$M_B = -2*1*\frac{1}{2} = -1\text{KN-m}$

$M_C = -2*1*(2+\frac{1}{2}) + 10.83*2$

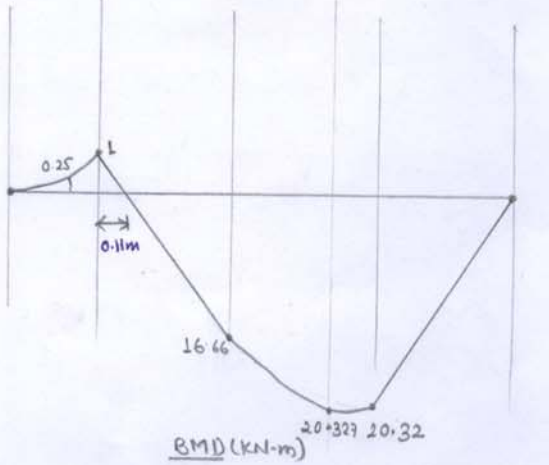
$= 16.66\text{KN-m}$

$M_D = -2*1*(4+\frac{1}{2}) + 10.83*4 - 5*2 - 2*2*\frac{2}{2}$

$= 20.32\text{ KN-M}$

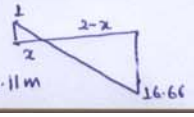
$M_E = 0$

$M_{AB,mid} = -2*0.5*\frac{0.5}{2} = -0.25\text{KN-m}$



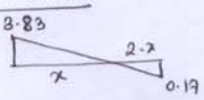
BMD (KN-m)

For Point of contraflexure in BC



$\frac{1}{x} = \frac{16.66}{2-x} \Rightarrow x = 0.11\text{m}$

For SF zero point in portion CD



$\frac{x}{3.83} = \frac{2-x}{0.17}$

$\Rightarrow x = 1.915\text{ m}$

$\therefore$ max^m BM (M_{max}) $= -2*1*(3.915+\frac{1}{2})$

$+ 10.83*3.915 - 5*1.915 - 2*1.915*\frac{1.915}{2}$

$= 20.327\text{KN-m}$

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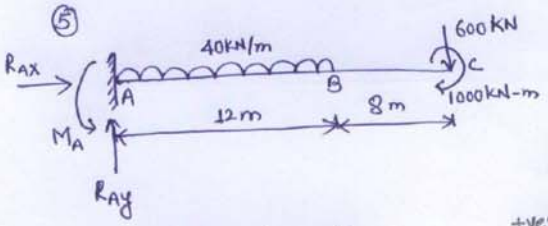

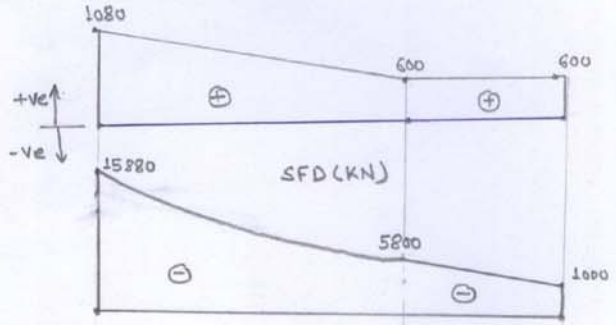

Calculation of reaction:

$(\pm\rightarrow) \leq F_x = 0$

$R_{AX} = 0$

$(+\uparrow) \leq F_y = 0$

$R_{AY} - 40*12 - 600 = 0$

$R_{AY} = 1080\ KN$

$(+\circlearrowleft) \leq M_A = 0$

$M_A - 40*12*\frac{12}{2} - 1000 - 600*20 = 0$

$M_A = 15880\ KN\text{-}m$

Shear force calculation ($\uparrow$ +ve $\downarrow$)

$V_{AL} = 0$

$V_{AR} = 1080\ KN$

$V_B = V_{AR} - 40*12 = 600\ KN$

$V_{CL} = V_B = 600\ KN$

$V_{CR} = V_{CL} - 600 = 0$

Bending Moment Calculation ($\circlearrowright$ +ve)

$M_{AL} = 0$

$M_{AR} = -15880\ KN\text{-}m$

$M_B = -15880 + 1080*12 - 40*12*6$

$= -5800\ KN\text{-}m$

$M_{AB,mid} = -15880 + 1080*6 - 40*6*\frac{6}{2}$

$= -10120\ KN\text{-}m$

$M_{CL} = -15880 + 1080*20 - 40*12*(8+\frac{12}{2})$

$= -1000\ KN\text{-}m$

$M_{CR} = M_{CL} + 1000 = 0$

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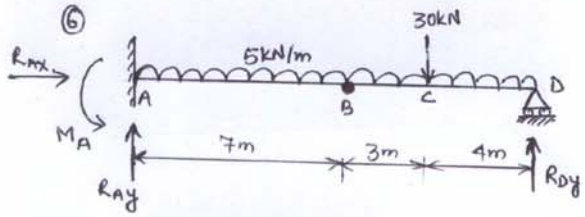


Calculation of Support Reaction:

$+\circlearrowleft \sum M_{B,right} = 0$

$7R_{Dy} - 30*3 - 5*7*\frac{7}{2} = 0$

$R_{Dy} = 30.36\ kN$

$(+\uparrow) \sum F_y = 0$

$R_{Ay} + R_{Dy} - 30 - 5*14 = 0$

$R_{Ay} = 69.64\ kN$

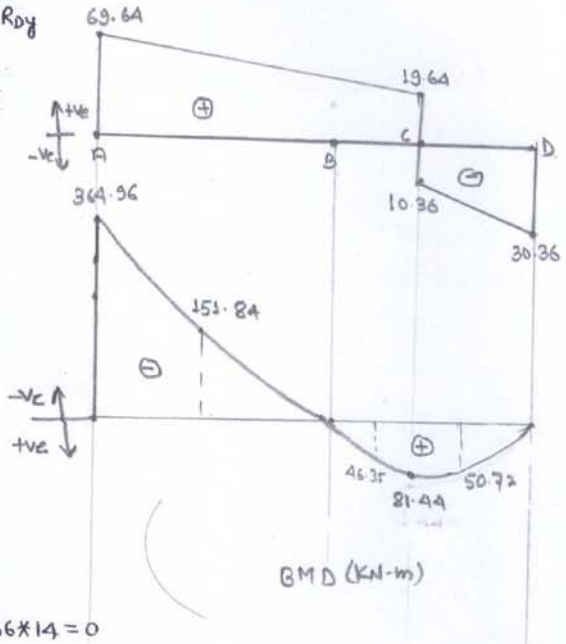
$(\pm\rightarrow) \sum F_x = 0$

$R_{Ax} = 0$

$(+\circlearrowleft) \sum M_A = 0$

$M_A - 5*14*7 - 30*10 + 30.36*14 = 0$

$M_A = 364.96\ kN\text{-}m$



BMD (KN-m)

Shear Force Calculation ($\uparrow$ +ve $\downarrow$)

$V_{AL} = 0$

$V_{AR} = 69.64\ kN$

$V_{CL} = V_{AR} - 5*10 = 19.64\ kN$

$V_{CR} = V_{CL} - 30 = -10.36\ kN$

$V_{DL} = V_{CR} - 5*4 = -30.36\ kN$

$V_{DR} = V_{DL} + R_{Dy} = 0$

Bending moment calculation ($\circlearrowleft$ +ve $\circlearrowright$)

$M_{AL} = 0$

$M_{AR} = -364.96\ kN\text{-}m$

$M_B = -364.96 + 69.64*7 - 5*7*\frac{7}{2} = 0$

$M_C = -364.96 + 69.64*10 - 5*10*\frac{10}{2}$

$= 81.44\ kN\text{-}m$

$M_D = -364.96 + 69.64*14 - 5*14*\frac{14}{2} - 30*4$

$= 0$

$M_{AB,mid} = -364.96 + 69.64*3.5 - 5*3.5*\frac{3.5}{2}$

$= -151.84\ kN\text{-}m$

$M_{CD,mid} = 30.36*2 - 5*2*\frac{2}{2}$ (from right side)

$= 50.72\ kN\text{-}m$

$M_{BC,mid} = -364.96 + 69.64*(7+3/2) - 5*(7+1.5)*\frac{(7+1.5)}{2}$

$= 46.35\ kN\text{-}m$

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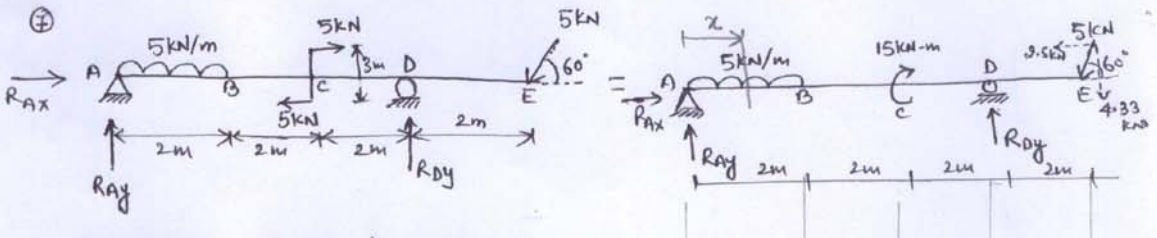


Calculation of support reaction:-

$(\pm\rightarrow) \leq F_x = 0$

$R_{Ax} - 5\cos 60 = 0$

$R_{Ax} = 2.5\,kN$

$(+\circlearrowleft) \leq M_A = 0$

$-5*2*\frac{2}{2} - 15 + 6R_{Dy} - 8*5\sin 60 = 0$

$R_{Dy} = 9.94\,kN$

$(+\uparrow) \leq F_y = 0$

$R_{Ay} + R_{Dy} - 5*2 - 4.33 = 0$

$R_{Ay} = 4.40\,kN$

Calculation of Axial Force (+ve →)

$AF_{AB} = -2.5\,kN$

Calculation of shear Force (+ve ↑ ↓)

$V_{AL} = 0$

$V_{AR} = 4.40\,kN$

$V_B = V_{AR} - 5*2 = -5.60\,kN$

$V_{DL} = V_B = -5.6\,kN$

$V_{DR} = V_{DL} + 9.94 = 4.34\,kN$

$V_{EL} = V_{DR} = 4.34\,kN$

$V_{ER} = V_{EL} - 4.33 = 0$

Calculation of Bending Moment (+ve ↻)

$M_A = 0$

$M_B = 4.4*2 - 5*2*1 = -1.20\,kN\text{-}m$

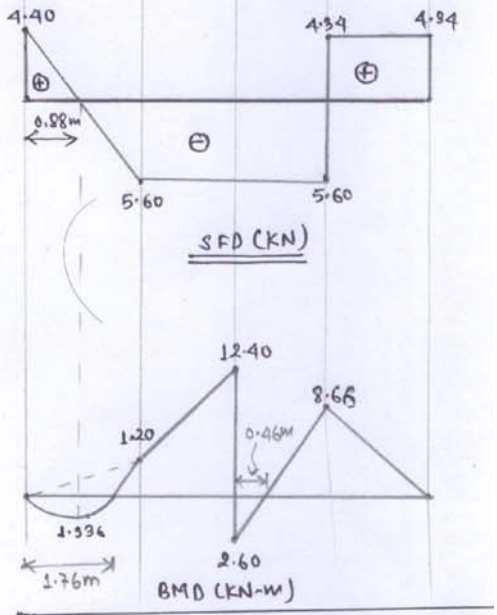
$M_{CL} = 4.4*4 - 5*2*(2+1) = -12.4\,kN\text{-}m$

$M_{CR} = M_{CL} + 15 = 2.60\,kN\text{-}m$

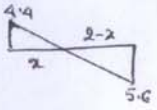
$M_D = -4.33*2 = -8.66\,kN\text{-}m$ (from right side)

$M_E = 0$

$M_{AB,mid} = 4.4*1 - 5*1*0.5 = 1.90\,kN\text{-}m$



For SF zero point in AB



$\frac{x}{4.4} = \frac{2-x}{5.6}$

$\Rightarrow x = 0.88\,m$

$\therefore$ max^m BM at $x = 0.88$ is

$M_{max} = 4.40*0.88 - 5*0.88*\frac{0.88}{2}$

$= 1.936\,kN\text{-}m$

For point of contraflexure

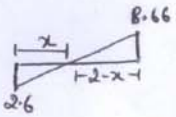
a) In portion AB

$M_x = 4.40x - 5*x*\frac{x}{2} = 0$

$\Rightarrow x = 0, 1.76$

i.e. $x = 1.76\,m$

b) In portion CD



$\frac{x}{2.6} = \frac{2-x}{8.66}$

$\Rightarrow x = 0.46\,m$

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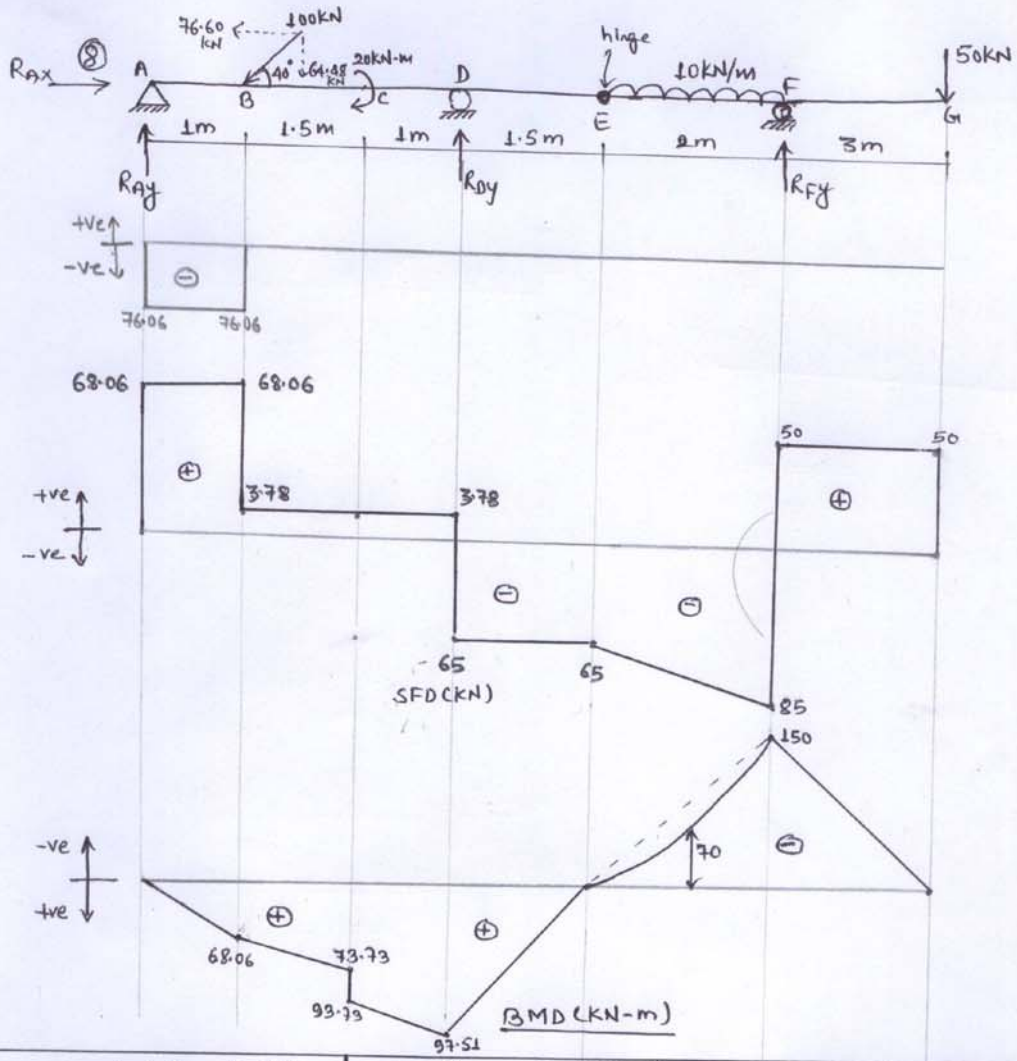

Calculation of R_x's

$(\rightarrow) \Sigma F_x = 0$

$R_{Ax} - 100\cos 40 = 0$

$R_{Ax} = 76.60\,kN\ (\rightarrow)$

$(+\circlearrowleft) \Sigma M_{E,right} = 0$

$-10*2*1 + 2R_{Fy} - 50*5 = 0$

$R_{Fy} = 135\,kN\ (\uparrow)$

$(+\circlearrowleft) \Sigma M_A = 0$

$-64.28*1 - 20 + 3.5R_{Dy} - 10*2*6 + 135*7 - 50*10 = 0$

$R_{Dy} = -68.78\,kN$

$= 68.78\,kN\ (\downarrow)$

AF Calculation

$AF_{AB} = -76.60\,N$

$(+\uparrow) \Sigma F_y = 0$

$R_{Ay} - 64.28 - 68.78 - 10*2 + 135 - 50 = 0$

$\Rightarrow R_{Ay} = 68.06\,kN\ (\uparrow)$

Shear force cal^n ($\uparrow$ +ve, $\downarrow$ −ve)

$V_{AL} = 0$, $V_{AR} = R_{Ay} = 68.06\,kN$

$V_{BL} = V_{AR} = 68.06\,kN$

$V_{BR} = V_{AR} - 64.28 = 3.78\,kN$

$V_{DL} = 3.78\,kN$

$V_{DR} = 3.78 - 68.78 = -65\,kN$

$V_E = -65\,kN$

$V_{FL} = V_E - 10*2 = -85\,kN$

$V_{FR} = V_{FL} + 135 = 50\,kN$

$V_{GL} = V_{FR} = 50\,kN$

$V_{GR} = V_{GL} - 50 = 0$

BM calculation ($\circlearrowright$ +ve)

$M_A = 0$

$M_B = 68.06*1 = 68.06\,kN\text{-}m$

$M_{CL} = 68.06*2.5 - 64.28*1.5 = 73.73\,kN\text{-}m$

$M_{CR} = 73.73 + 20 = 93.73\,kN\text{-}m$

$M_D = 68.06*3.5 - 64.28*2.5 + 20 = 97.51\,kN\text{-}m$

$M_E = 68.06*5 - 64.28*4 + 20 - 68.78*1.50 = 0$

$M_F = -50*3 = -150\,kN\text{-}m$

$M_G = 0$

$M_{EF,mid} = -50*(3+1) + 135*1 - 10*1*1/2$

$= -70\,kN\text{-}m$

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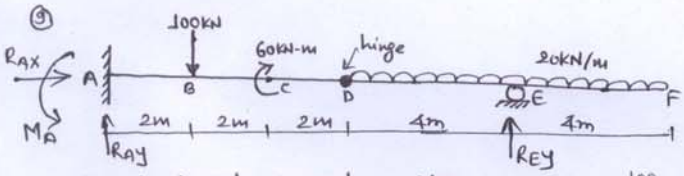


Calculation of support reaction

$(\pm\rightarrow)\leq F_x = 0$

$R_{AX} = 0$

$(+\circlearrowleft)\leq M_{D,right} = 0$

$4R_{EY} - 20\times8\times\frac{8}{2} = 0$

$R_{EY} = 160KN$

$(+\uparrow)\leq F_y = 0$

$R_{AY} + R_{EY} - 100 - 20*8 = 0$

$R_{AY} = 100KN$

$+\circlearrowleft\leq M_A = 0$

$M_A - 100*2 + 60 - 20\times8*(6+4) + 10R_{EY} = 0$

$M_A = 260KN-m$

Shear force calculation ($\uparrow$ +ve $\downarrow$)

$V_{AL} = 0$, $V_{AR} = 100KN$

$V_{BL} = V_{AR} = 100KN$

$V_{BR} = V_{BL} - 100 = 0$

$V_D = V_{BR} = 0$

$V_{EL} = V_D - 20\times4 = -80KN$

$V_{ER} = V_{EL} + 160 = 80KN$

$V_F = V_{ER} - 20\times4 = 0$

Bending Moment calculation ($\circlearrowright$ +ve $\circlearrowleft$)

$M_{AL} = 0$

$M_{AR} = -260KN-m$

$M_B = -260 + 100*2 = -60KN-m$

$M_{CL} = -260 + 100\times4 - 100\times2 = -60KN-m$

$M_{CR} = M_{CL} + 60 = 0$

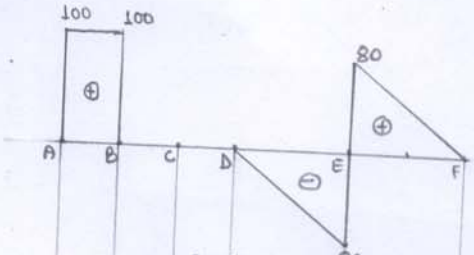
$M_D = -260 + 100*6 - 100*4 + 60 = 0$

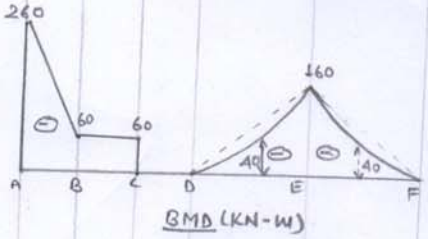
$M_E = -20\times4\times2 = -160KN-m$ (from right side cal^n)

$M_F = 0$

$M_{DE,mid} = -260 + 100\times8 - 100\times6 + 60 - 20\times2\times1$
$= -40KN-m$

$M_{EF,mid} = -20\times2\times1 = -40KN-m$





BMD (KN-m)

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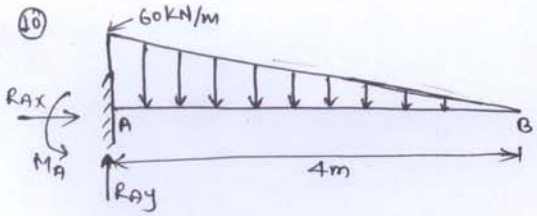


Calculation of Support reaction

$(\overset{+}{\rightarrow}) \leq F_x = 0$

$R_{Ax} = 0$

$(+\uparrow) \leq F_y = 0$

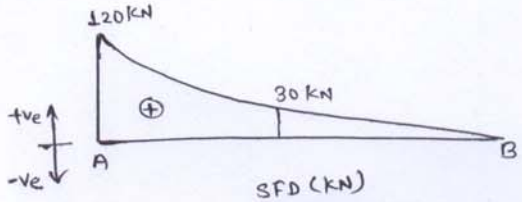
$R_{Ay} - \frac{1}{2} \times 60 \times 4 = 0$

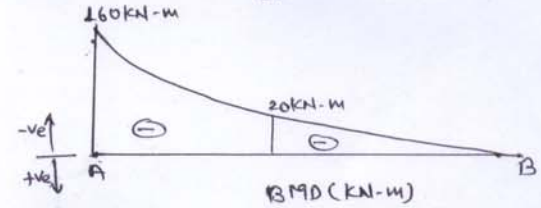
$R_{Ay} = 120\,KN$

$(+\circlearrowleft) \leq M_A = 0$

$M_A - \frac{1}{2} \times 60 \times 4 \times \frac{1}{3} \times 4 = 0$

$M_A = 160\,KN\text{-}m$





Shear Force Calculation ($\uparrow$ +ve $\downarrow$)

$V_{AL} = 0,\ V_{AR} = 120\,KN$

$V_B = 0$

$V_{AB,mid} = \frac{1}{2} * 30 * 2 = 30\,KN$

Bending moment calculation [$\circlearrowright$ +ve]

$M_{AL} = 0$

$M_{AR} = -160\,KN\text{-}m$

$M_B = -160 + 120 \times 4 - \frac{1}{2} \times 60 \times 4 \times \frac{2}{3} \times 4$

$= 0$

$M_{AB,mid} = -\frac{1}{2} \times 30 \times 2 \times \frac{1}{3} \times 2$

$= -20\,KN\text{-}M$

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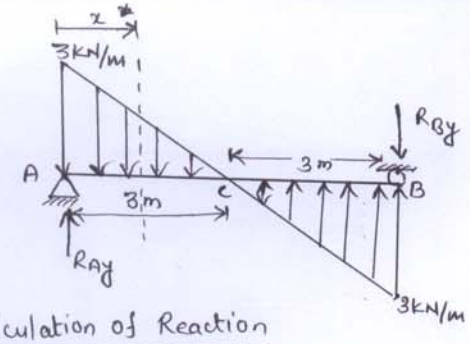


Calculation of Reaction

$+\circlearrowleft \Sigma M_A = 0$

$-\frac{1}{2}*3*3*\frac{1}{3}*3 + \frac{1}{2}*3*3*(3+\frac{2}{3}*3) - 6R_{By} = 0$

$R_{By} = 3kN$

$(+\uparrow)\ \Sigma F_y = 0$

$R_{Ay} - \frac{1}{2}*3*3 - R_{By} + \frac{1}{2}*3*3 = 0$

$\therefore R_{Ay} = 3kN$

Shear force calculation ($\uparrow$ +ve $\downarrow$)

$V_{AL} = 0$

$V_{AR} = 3kN$

$V_C = 3 - \frac{1}{2}*3*3 = -1.50kN$

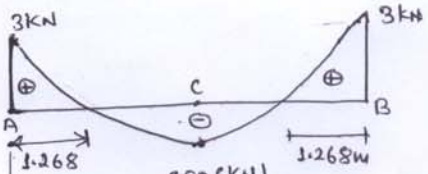
$V_{BL} = V_C + \frac{1}{2}*3*3 = 3kN$

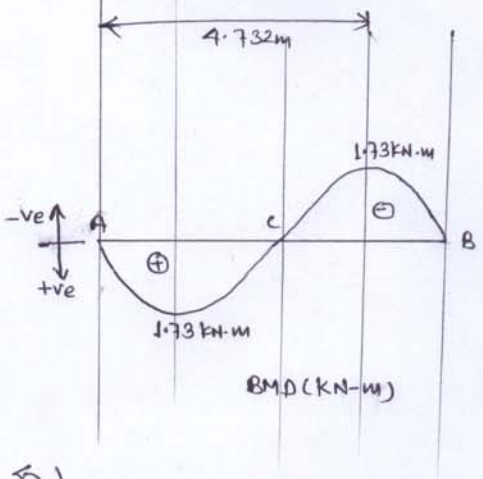
$V_{BR} = V_{BL} - 3 = 0$

$V_{AC,mid} = V_{AR} - 1.5*1.5 - \frac{1}{2}*1.5*1.5$

$= -0.375$

$V_{CB,mid} = V_C + \frac{1}{2}*1.5*1.5 = -0.375\ kN$





Bending Moment Calculation (↻ +ve ↺)

$M_A = 0$

$M_{AC,mid} = 3*1.5 - 1.5*1.5*\frac{1.5}{2} - \frac{1}{2}*1.5*1.5*\frac{2}{3}*1.5$

$= 1.687\ kN-m$

$M_C = 3*3 - \frac{1}{2}*3*3*\frac{2}{3}*3 = 0$

$M_{CB,mid} = 3*4.5 - \frac{1}{2}*3*3*(1.5+\frac{2}{3}*3) + \frac{1}{2}*1.5*1.5*\frac{1}{3}*1.5$

$= -1.687\ kN-m$

$M_B = 3*6 - \frac{1}{2}*3*3*(3+\frac{2}{3}*3) + \frac{1}{2}*3*3*\frac{1}{3}*3 = 0$

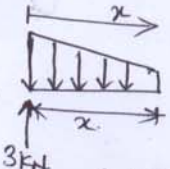
Similarly max. BM in portion BC is

$M_{max} = -1.73kN-m$

For SF zero point in portion AC:

$V_x = 3 - \frac{1}{2}*x*x - (3-x)*x = 0$

$\Rightarrow x = 4.732m, 1.268m$



$M_{max} = 3*1.268 - 3*1.268^2/2 + 1.268^3/6 = 1.73kN-m$

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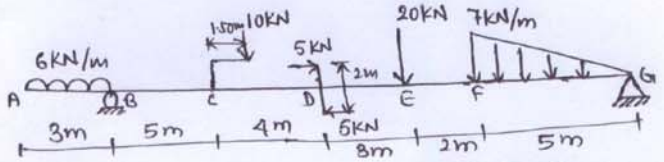
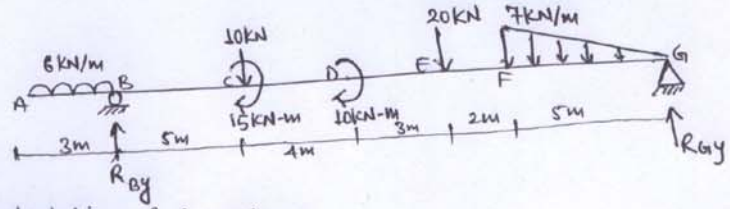




Calculation of Reaction:-

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

$$6*3*\frac{3}{2} - 10*5m - 15 - 10 - 20*12 - \frac{1}{2}*5*7*\left(14+\frac{1}{3}*5\right) + 19R_{Gy} = 0$$

$$R_{Gy} = 29.58\,KN$$

$(+\uparrow) \sum F_y = 0$

$$R_{By} + R_{Gy} - 6*3 - 10 - 20 - \frac{1}{2}*7*5 = 0$$

$$R_{By} = 35.92\,KN$$

Shear Force Calculation ($\uparrow$ +ve $\downarrow$)

$V_A = 0$

$V_{BL} = V_A - 6*3 = -18\,KN$

$V_{BR} = V_{BL} + 35.92 = 17.92\,KN$

$V_{CL} = V_{BR} = 17.92\,KN$

$V_{CR} = V_{CL} - 10 = 7.92\,KN$

$V_{EL} = V_{CR} = 7.92\,KN$

$V_{ER} = V_{EL} - 20 = -12.08\,KN$

$V_F = V_{ER} = -12.08\,KN$

$V_{GL} = V_F - \frac{1}{2}*7*5 = -29.58\,KN$

$V_{GR} = V_{GL} + R_{Gy} = 0$

$V_{FG,mid} = -29.58 + \frac{1}{2}*3.5*2.5$
$= -25.20\,KN$ (from right side cal^n)

$M_{AB,mid} = -6*1.5*\frac{1.5}{2} = -6.75\,KN\text{-}m$

$M_{FG,mid} = 29.58*2.5 - \frac{1}{2}*3.5*2.5*\frac{1}{3}*2.5$
$= 70.3\,KN\text{-}m$

Bending Moment Calculation ($\circlearrowright$ +ve $\circlearrowleft$)

$M_A = 0$

$M_B = -6*3*\frac{3}{2} = -27\,KN\text{-}m$

$M_{CL} = -6*3*(1.5+3/2) + 35.92*5 = 62.6\,KN\text{-}m$

$M_{CR} = M_{CL} + 15 = 77.60\,KN\text{-}m$

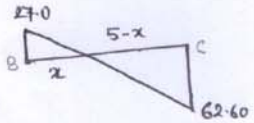
$M_{DL} = -6*3*(9+3/2) + 35.92*9 - 10*4 + 15 = 109.28\,KN\text{-}m$, $M_{DR} = M_{DL} + 10 = 119.28\,KN\text{-}m$

$M_E = -6*3*(12+3/2) + 35.92*12 - 10*7 + 15 + 10 = 143.04\,KN\text{-}m$

$M_F = -6*3*(14+3/2) + 35.92*14 - 10*9 + 15 + 10 - 20*2 = 118.88\,KN\text{-}m$ (It's better to calculate from right)

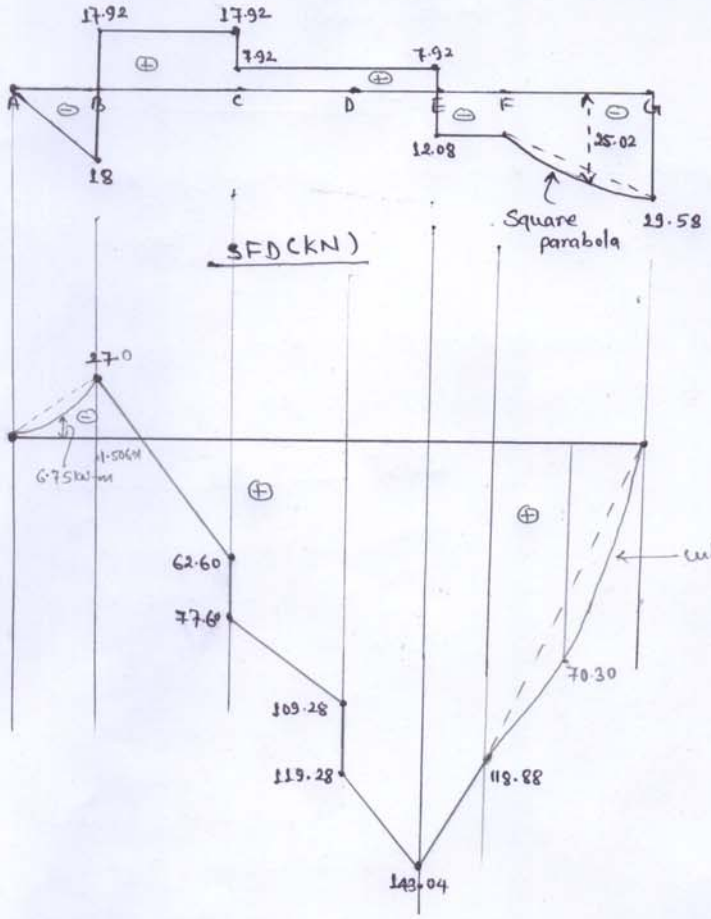
$M_G = -6*3*(19+3/2) + 35.92*19 - 10*14 + 15 + 10 - 20*7 - \frac{1}{2}*7*5*\frac{2}{3}*5 = 0$

For Point of contraflexure in BC



$\frac{x}{27} = \frac{5-x}{62.6}$

$\Rightarrow x = 1.506m$



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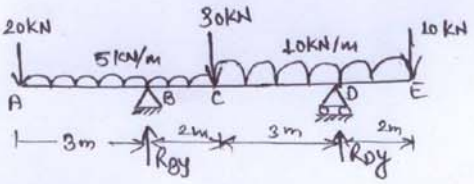


Calculation of reactions:-

$+\circlearrowleft \Sigma M_B = 0$

$20*3 + 5*5*0.5 - 30*2 - 10*5*(2+2.5) - 10*7 + R_{Dy}*5 = 0$

$R_{Dy} = 56.50 \text{ kN}$

$(+\uparrow) \Sigma F_y = 0$

$R_{By} + R_{Dy} - 20 - 30 - 10 - 5*5 - 10*5 = 0$

$R_{By} = 78.50 \text{ kN}$

SF calculation ($\uparrow$ +ve $\downarrow$)

$V_{AL} = 0$

$V_{AR} = -20 \text{ kN}$

$V_{BL} = V_{AR} - 5*3 = -35 \text{ kN}$

$V_{BR} = V_{BL} + 78.5 = 43.5 \text{ kN}$

$V_{CL} = V_{BR} - 5*2 = 33.50 \text{ kN}$

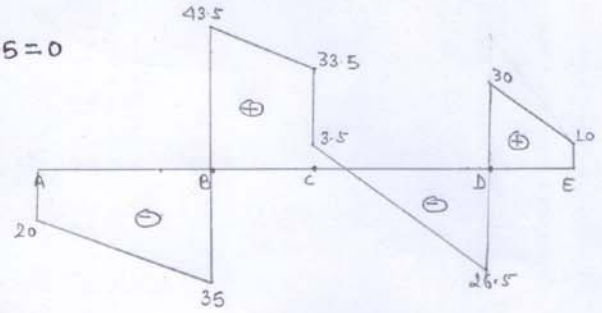
$V_{CR} = V_{CL} - 30 = 3.50 \text{ kN}$

$V_{DL} = V_{CR} - 10*3 = -26.50 \text{ kN}$

$V_{DR} = V_{DL} + 56.5 = 30 \text{ kN}$

$V_{EL} = V_{DR} - 10*2 = 10 \text{ kN}$

$V_{ER} = V_{EL} - 10 = 0$



SFD (KN)

BM calculation [$\circlearrowright$ +ve $\circlearrowleft$]

$M_A = 0$

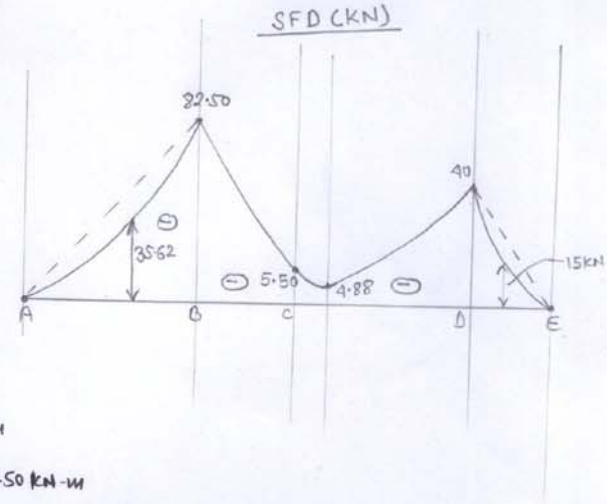
$M_B = -20*3 - 5*3*\frac{3}{2} = -82.50 \text{ kN-m}$

$M_C = -20*5 - 5*5*\frac{5}{2} + 78.5*2 = -5.50 \text{ kN-m}$

$M_D = -10*2 - 10*2*1 = -40 \text{ kN-m}$ (from right)

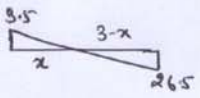
$M_E = 0$, $M_{AB,mid} = -20*1.5 - 5*1.5*\frac{1.5}{2} = -35.62 \text{ kN-m}$

$M_{DE,mid} = -10*1 - (10*1*\frac{1}{2}) = -15 \text{ kN-m}$



SF zero point in portion CD:

$\frac{x}{3.5} = \frac{3-x}{26.50}$



$x = 0.35 \text{ m}$

$\therefore$ max. BM (M_{max}) $= -20*5.35 + 78.5*2.35 - 30*0.35 - 5*5*(2.5+0.35) - 10*0.35*\frac{0.35}{2}$

$= -4.88 \text{ kN-m}$

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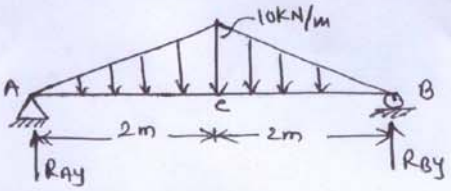


Calculation of reaction

$R_{Ay} = R_{By} = \frac{1}{2}\left[\frac{1}{2}*2*10 + \frac{1}{2}*2*10\right]$

$= 10KN$

Calculation of SF ($\uparrow$ +ve $\downarrow$)

$V_{AL} = 0$, $V_{AR} = 10KN$

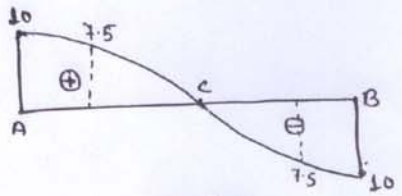
$V_C = V_{AR} - \frac{1}{2}*2*10 = 0$

$V_{BL} = V_C - \frac{1}{2}*2*10 = -10KN$

$V_{BR} = V_{BL} + 10 = 0$

$V_{AC,mid} = 10 - \frac{1}{2}*1*5 = 7.5KN$

$V_{BC,mid} = -10 + \frac{1}{2}*1*5 = -7.5KN$



SFD (KN)

Calculation of Bending Moment (↻ +ve)

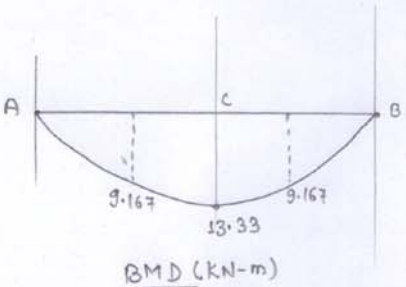
$M_A = 0$

$M_C = 10X2 - \frac{1}{2}*2*10*\frac{1}{3}*2 = 13.33KN-m$

$M_B = 0$

$M_{AC,mid} = 10X1 - \frac{1}{2}X1X5X\frac{1}{3}X1 = 9.167KN-m$

$M_{BC,mid} = 10X1 - \frac{1}{2}X1X5X\frac{1}{3}X1 = 9.167KN-m$



BMD (KN-m)

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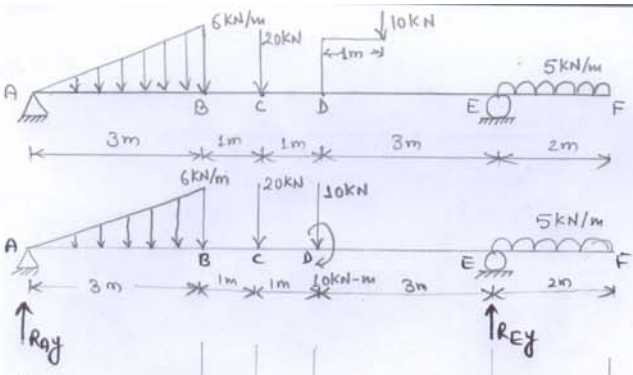
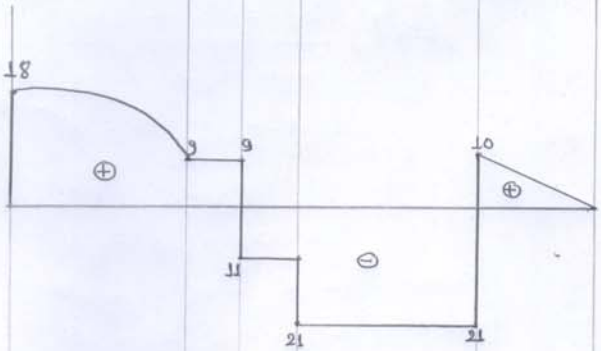
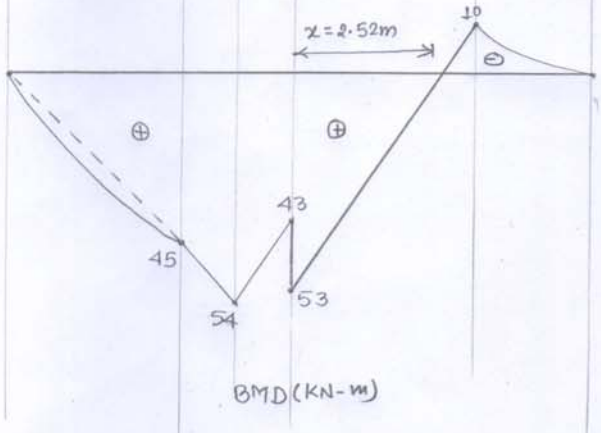




SFD(KN)



BMD(KN-m)

Calculation of Reaction

$+\circlearrowleft \Sigma M_A = 0$

$8R_{Ey} - \frac{1}{2}*3*6*\frac{2}{3}*8 - 20*4 - 10 - 10*5 - 5*2*9 = 0$

$R_{Ey} = 31KN$

$(+\uparrow)\ \Sigma F_y = 0$

$R_{Ay} + R_{Ey} - \frac{1}{2}*3*6 - 20 - 10 - 5*2 = 0$

$R_{Ay} = 18\,KN$

Shear Force Calculation ($\uparrow$ +ve $\downarrow$)

$V_{AL} = 0$, $V_{AR} = 18KN$

$V_B = V_{AR} - \frac{1}{2}*3*6 = 9KN$

$V_{AB,mid} = 18 - \frac{1}{2}*1.5*3 = 15.75KN$

$V_{CL} = V_B = 9KN$

$V_{CR} = V_{CL} - 20 = -11KN$

$V_{DL} = V_{CR} = -11KN$

$V_{DR} = V_{DL} - 10 = -21KN$

$V_{EL} = V_{DR} = -21KN$

$V_{ER} = V_{EL} + 31 = 10KN$

$V_F = V_{ER} - 5*2 = 0$

Bending Moment calculation [$\circlearrowright$ +ve]

$M_A = 0$

$M_B = 18*3 - 9*\frac{1}{3}*3 = 45\,KN-m$

$M_{AB,mid} = 18*1.5 - \frac{1}{2}*1.5*3*\frac{1}{3}*1.5 = 25.87\,KN-m$

$M_C = 18*4 - \frac{1}{2}*3*6*(1+\frac{1}{3}*3) = 54\,KN-m$

$M_{DL} = 18*5 - \frac{1}{2}*3*6*(2+\frac{1}{3}*3) - 20*1$

$= 43\,KN-m$

$M_{DR} = 43 + 10 = 53\,KN-m$

$M_E = -5*2*1 = -10\,KN-m$

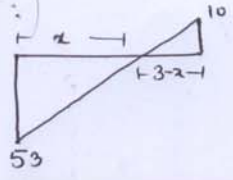
$M_F = 0$

$M_{EF,mid} = -5*1*\frac{1}{2} = -2.5\,KN-m$

For point of contraflexure in DE

$\frac{x}{53} = \frac{3-x}{10}$:

$\Rightarrow x = 2.52m$



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