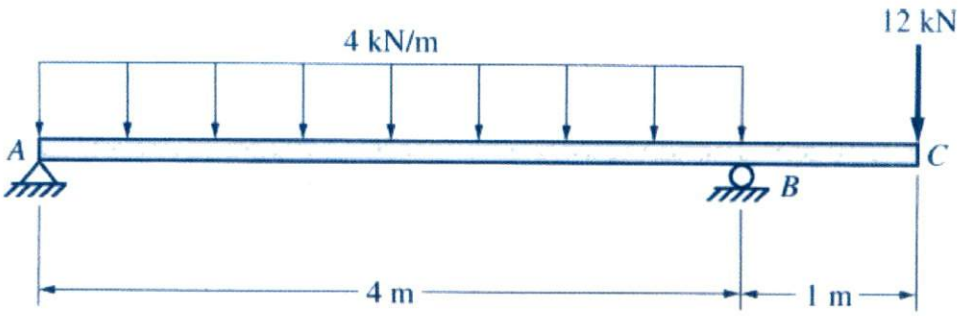
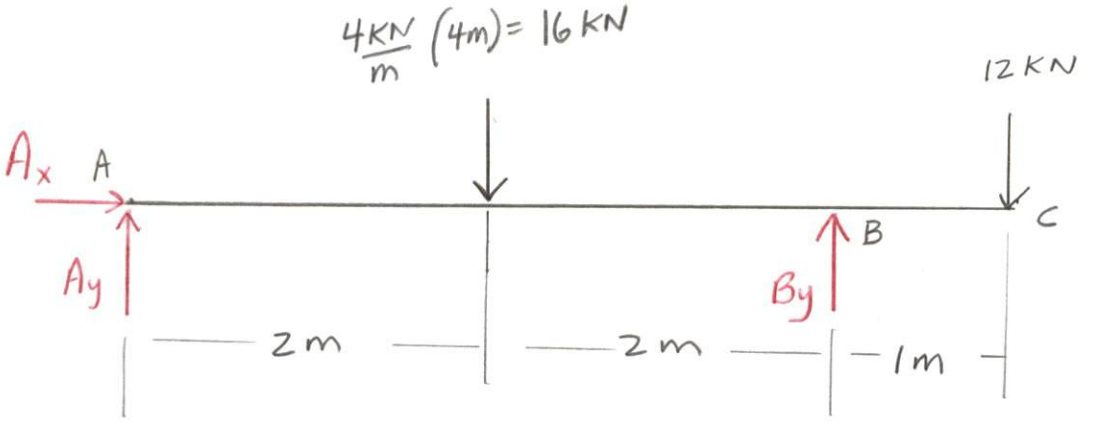
13-17

13-16 to 13-21 Refer to Figs. P13-16 to P13-21. Draw the shear force and bending moment diagrams for each beam. Locate the section with zero shear force (if any) and determine the moment at the section.



Solution.

Step 1 Solve for the reactions at the supports A and B.



FBD

Equilibrium Equations

ccw +M ↺
cw -M ↻

$[\Sigma F_x = 0]$ $A_x = 0$

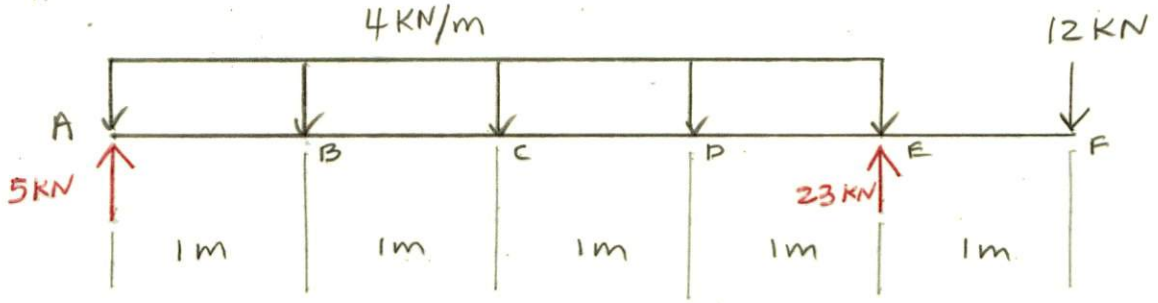
$[\Sigma M_A = 0]$ $-16\,kN(2m) + B_y(4m) - 12\,kN(5m) = 0$

$B_y = \frac{92\,kN \cdot m}{4m} = 23\,kN \uparrow$

$[\Sigma F_y = 0]$ $A_y - 16\,kN + B_y - 12\,kN = 0$

$A_y = 28\,kN - 23\,kN = 5\,kN \uparrow$

Step 2 13-17



Loading Diagram

Shear Force (V)

$V_{A-} = 0$

$V_{A+} = 5\,KN$

$V_B = 5\,KN - \frac{4\,KN}{m}(1m) = 5\,KN - 4\,KN = 1\,KN$

$V_C = 5\,KN - \frac{4\,KN}{m}(2m) = 5\,KN - 8\,KN = -3\,KN$

$V_D = 5\,KN - \frac{4\,KN}{m}(3m) = 5\,KN - 12\,KN = -7\,KN$

$V_{E-} = 5\,KN - \frac{4\,KN}{m}(4m) = 5\,KN - 16\,KN = -11\,KN$

$V_{E+} = 5\,KN - \frac{4\,KN}{m}(4m) + 23\,KN = -11\,KN + 23\,KN = +12\,KN$

$V_{F-} = +12\,KN$

$V_{F+} = +12\,KN - 12\,KN = 0$

Bending Moment (M)

$M_A = 0$

$M_B = 5\,KN(1m) - \frac{4\,KN}{m}(1m)(0.5m) = +3\,KN\cdot m$

$M_C = 5\,KN(2m) - \frac{4\,KN}{m}(2m)(1m) = +2\,KN\cdot m$

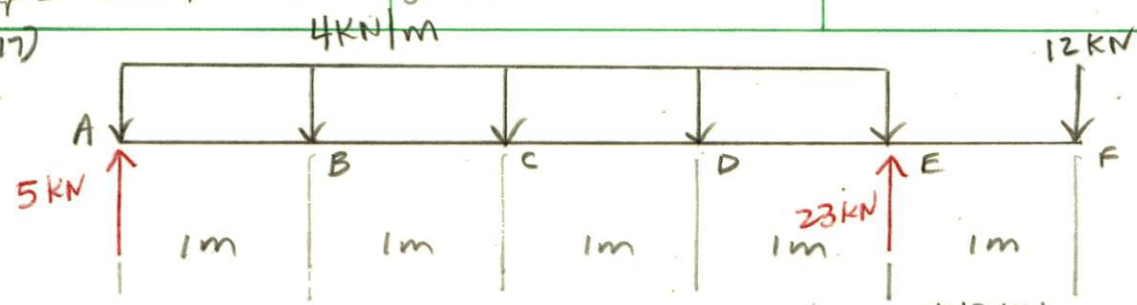
$M_D = 5\,KN(3m) - \frac{4\,KN}{m}(3m)(1.5m) = -3\,KN\cdot m$

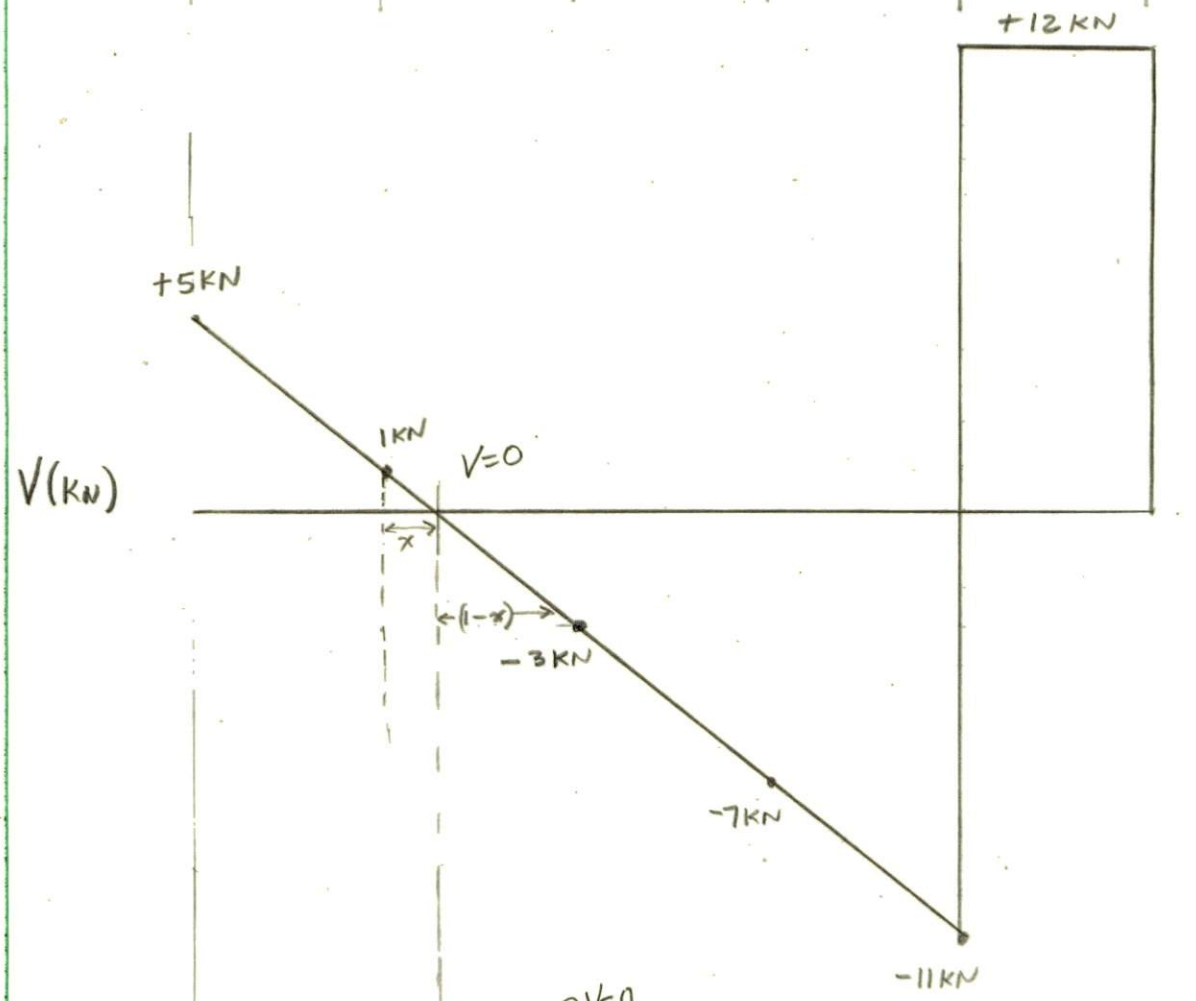
$M_E = 5\,KN(4m) - \frac{4\,KN}{m}(4m)(2m) = -12\,KN\cdot m$

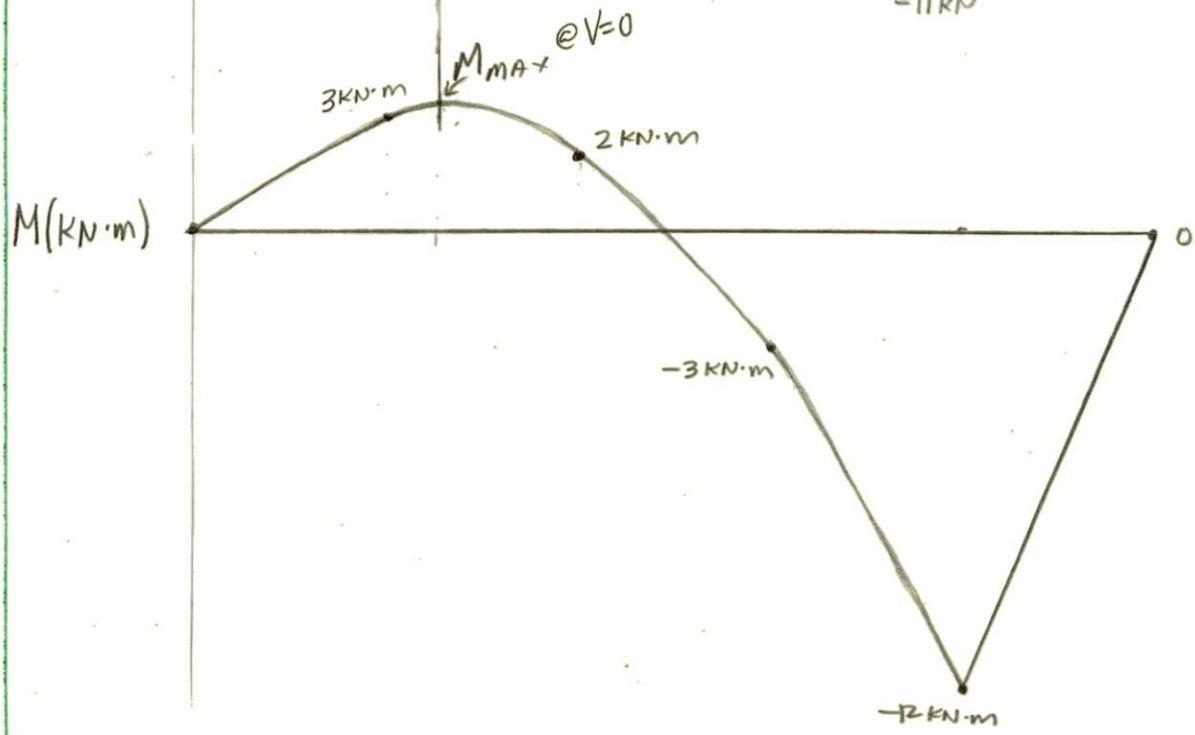
$M_F = 5\,KN(5m) - \frac{4\,KN}{m}(4m)(3m) + 23\,KN(1m) = 0$

Step 3 Shear / Moment Diagrams

(13-17)







The maximum bending moment occurs when $V=0$

Find M_{MAX}

Method 1

Equation of a straight Line

$$y = mx + b$$

$$b = 5\ KN$$

$$m = -\frac{16\ KN}{4m} = -4\frac{KN}{m}$$

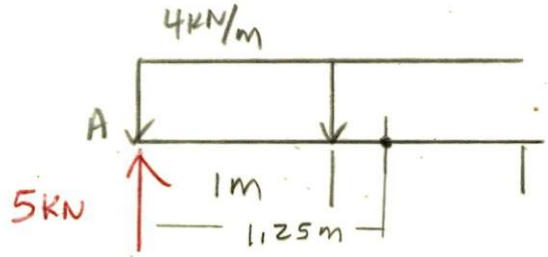
$$y = -4\frac{KN}{m}x + 5KN$$

$y=0$ $$0 = -4\frac{KN}{m}x + 5KN$$

$$-5KN = -4\frac{KN}{m}x$$

$$x = \frac{5\ KN\cdot m}{4KN} = 1.25\ m$$

Determine $M_{@\ x=1.25m}$



$$M_{MAX} = 5KN(1.25m) - \frac{4KN}{m}(1.25m)\left(\frac{1.25m}{2}\right)$$

$$= 6.25\ KN\cdot m - 3.125\ KN\cdot m$$

$$= \underline{3.125\ KN\cdot m}$$

Method 2

By Similar triangles (Shear Diagram)

$$\frac{x}{1-x} = \frac{1}{3}$$

$$3x = 1-x$$

$$4x = 1$$

$$x = \frac{1}{4} = 0,25\ m$$

M_{MAX} occurs @ $x = 1.25\ m$

$$M_{MAX} = 5\,KN(1.25m) - \frac{4KN}{m}(1.25m)\left(\frac{1.25m}{2}\right)$$

$$= \underline{\underline{3.125\ KN.m}}$$