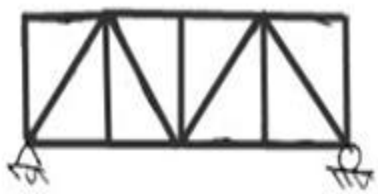
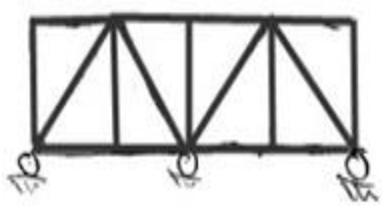
EXAMPLES
2.1: Determinacy & Stability

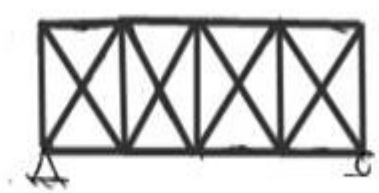
1. Truss determinacy
2. Beam determinacy
3. Frame determinacy
4. Additional examples (method 1 and 2 for beams/frames)

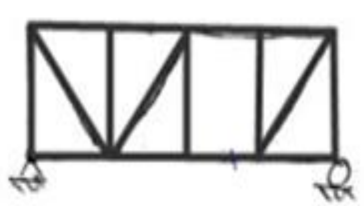
1. Examples: Truss determinacy

Determine the degree of static indeterminacy (SI) of the trusses shown below ...







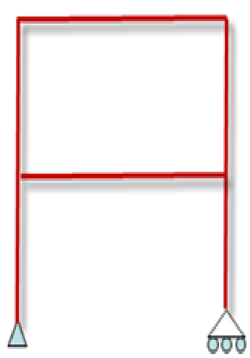


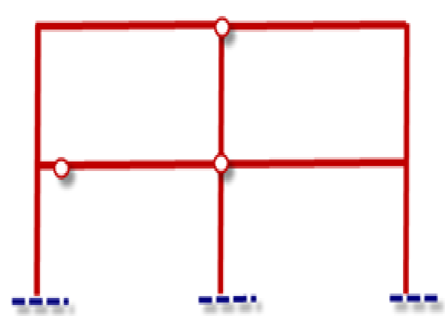
2. Examples: Beam determinacy

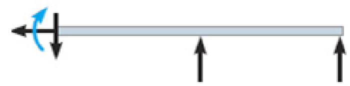
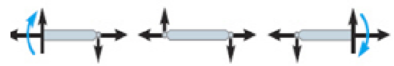
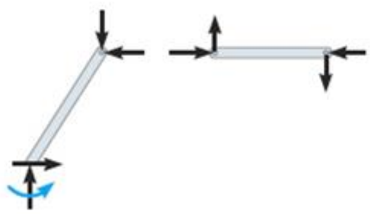
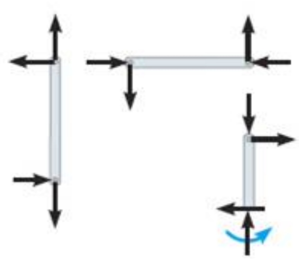
Find SI for the beams shown below...

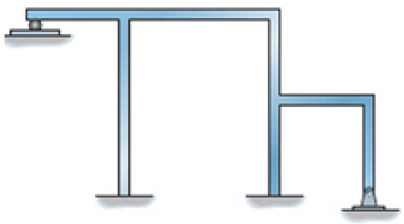
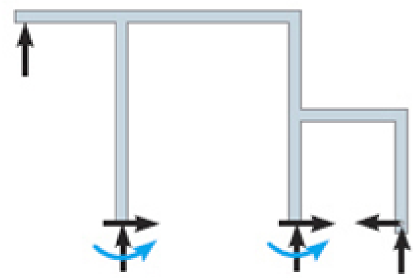
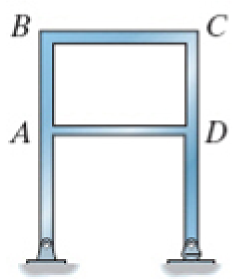
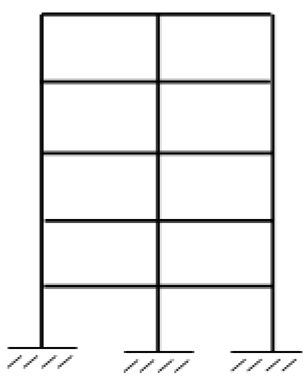
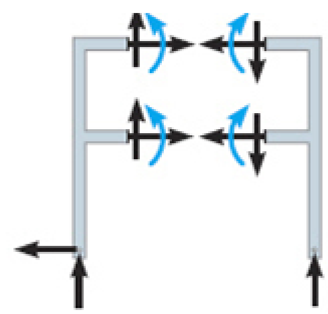
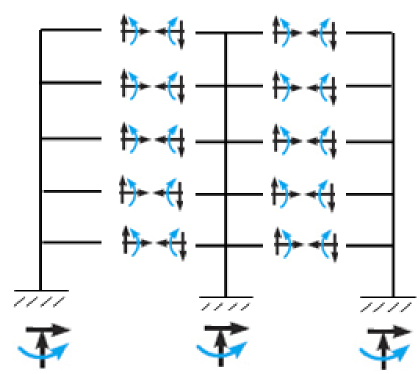
3. Examples: Frame determinacy

Find SI for the frames shown below...





	Method 1	**Method 2**
	SI = (3m +r)- (3j + ec) m = # members r = # reactions j = # joints	*SI = r - 3n* r = # reactions n = # parts
Beams  		 
Pin -Frames  		 

	Method 1	**Method 2**
	$SI = (3m + r) - (3j + ec)$ m = # members r = # reactions j = # joints	$SI = r - 3n$ r = # reactions n = # parts
		
Frames with closed loops  		 

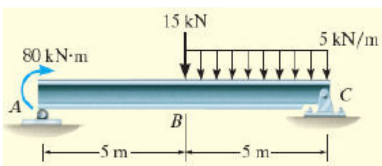
EXAMPLES
Lecture 2.2-2.3: Beams & Frames

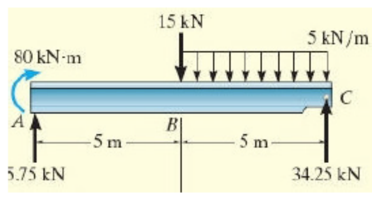
1. Examples: Beams
2. Examples: Frames

1. Beams

Example 1: Find all external reactions

(c)





(Hibbeler, 2007)

$\xrightarrow{+} \sum Fx = 0$ . . . . $C_x = 0$

$(+\circlearrowleft) \sum Ma = 0$ . . . $-80 - (15 \times 5) - (25 \times 7.5) + C_y \times 10 = 0$

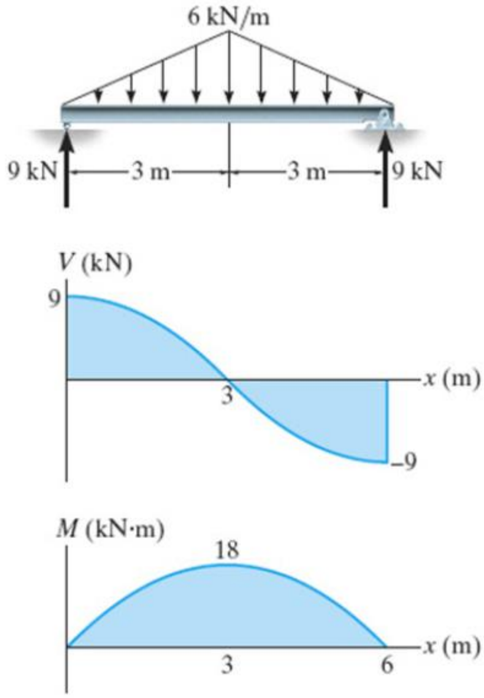
(34.25) ↳ $C_y = +34.25$ kN . . 34.25 ↑

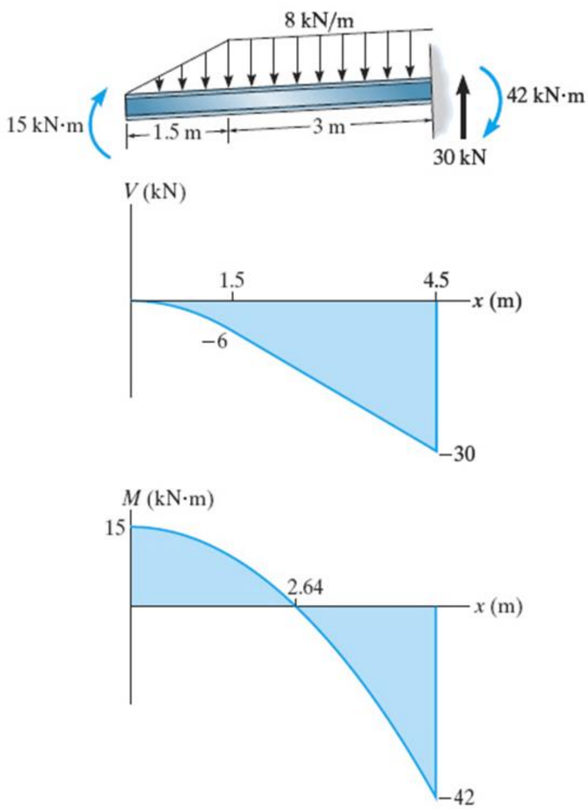
$+\uparrow \sum Fy = 0$

$A_y + C_y - 15 - 25 = 0$

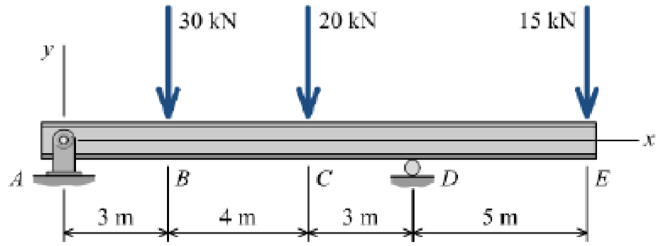
↳ $A_y = 5.75$ kN ↑

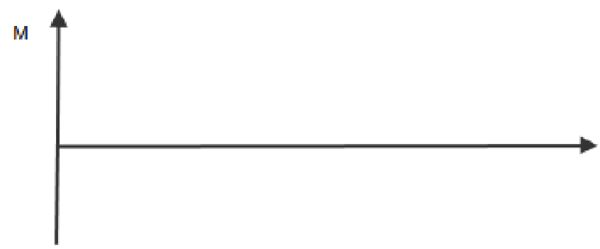
Example #2: For the beams below, draw the shear and moment diagrams …

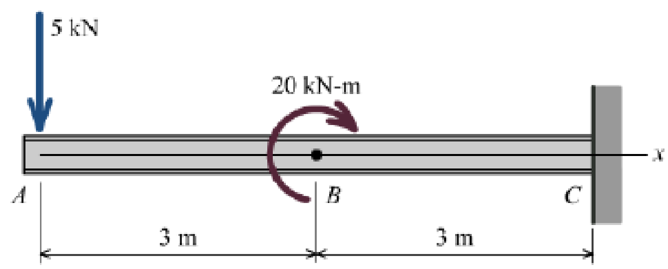


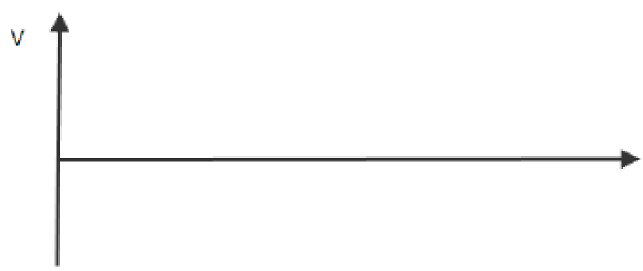


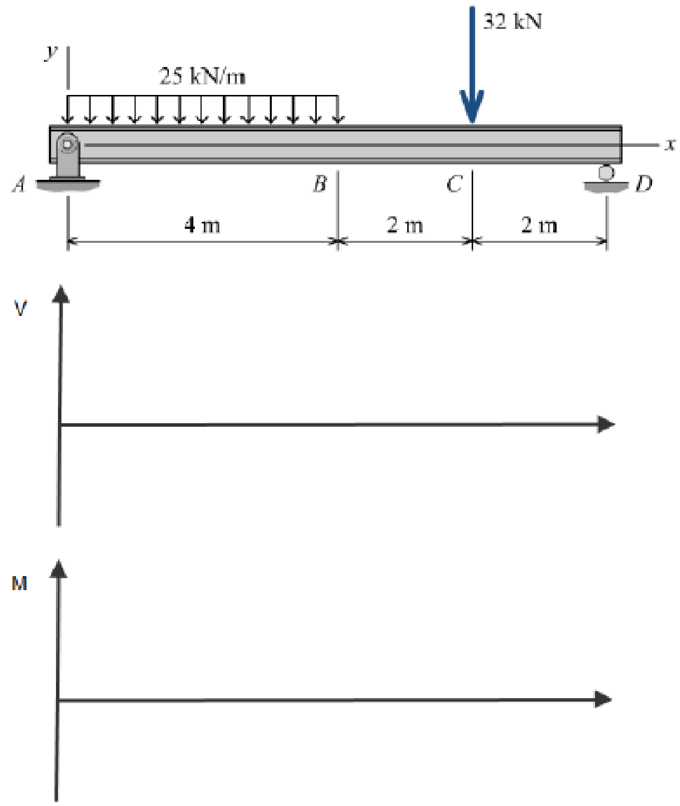
Example #3: For the beams below, draw the shear and moment diagrams :

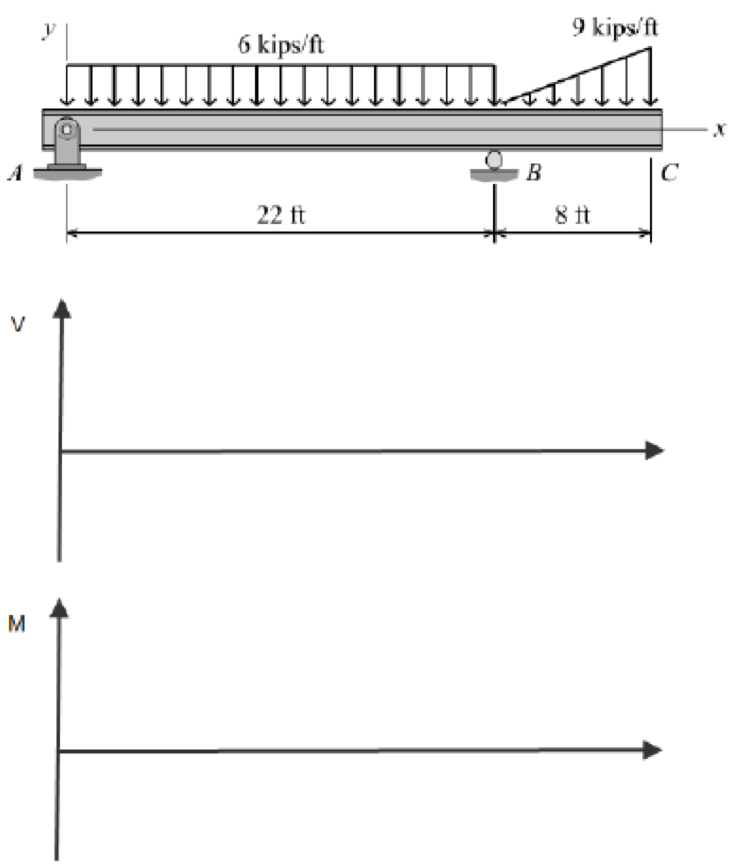


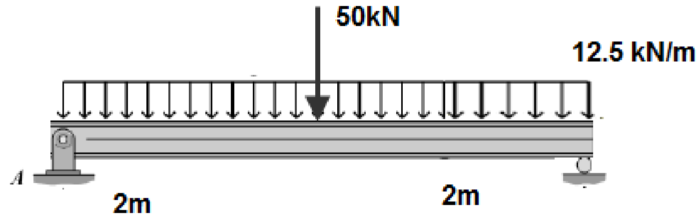




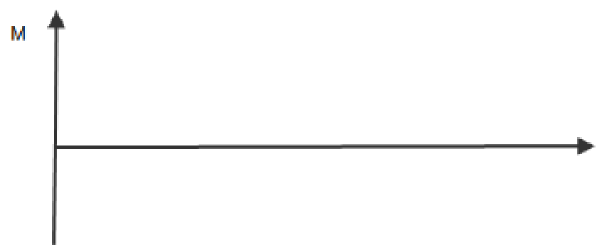


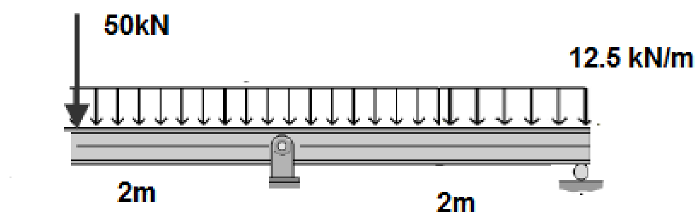

32 kN
y
25 kN/m
x
A
B
C
D
4 m
2 m
2 m
V
M


9 kips/ft
y
6 kips/ft
x
A
B
C
22 ft
8 ft
V
M

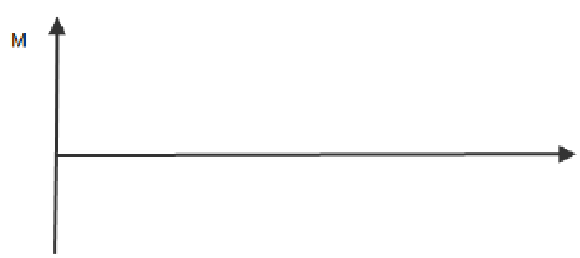

50kN
12.5 kN/m
A
2m
2m


V

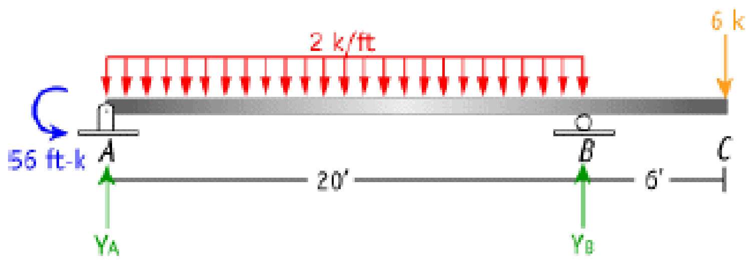

M


50kN
12.5 kN/m
2m
2m


V

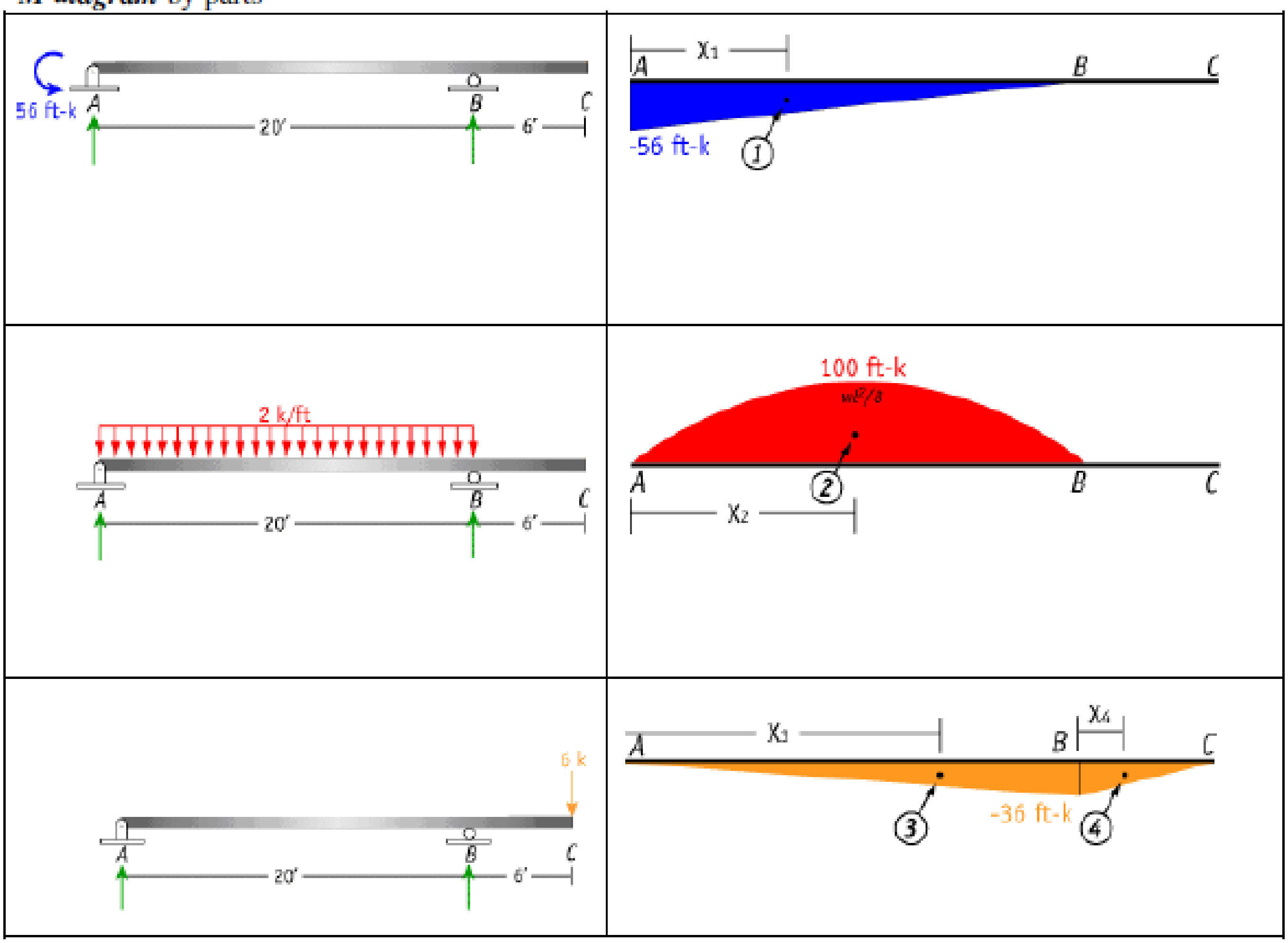

M

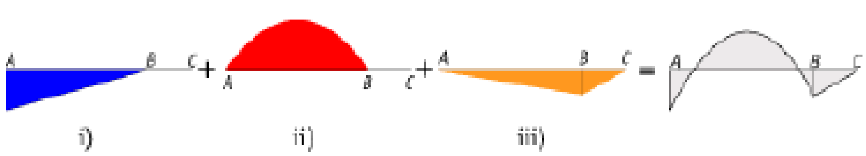
Example #4: For the beam below, draw the shear and moment diagrams by parts.



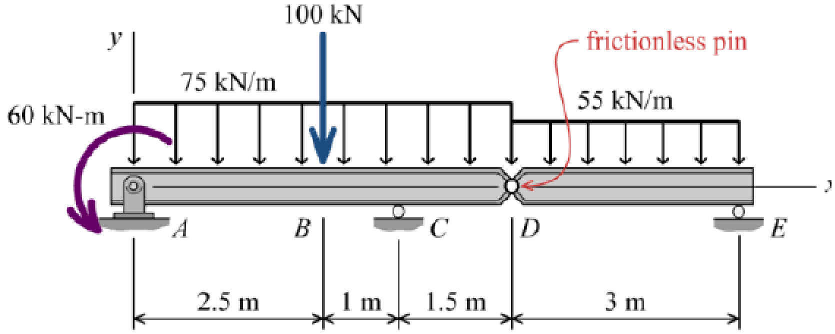
Structure subjected to real forces

M-diagram by parts

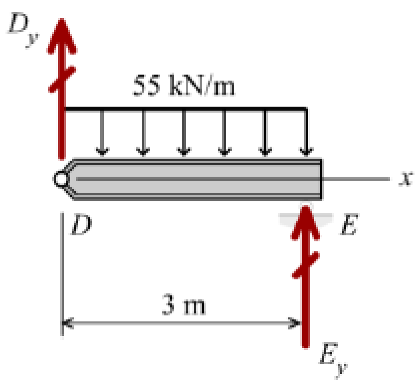




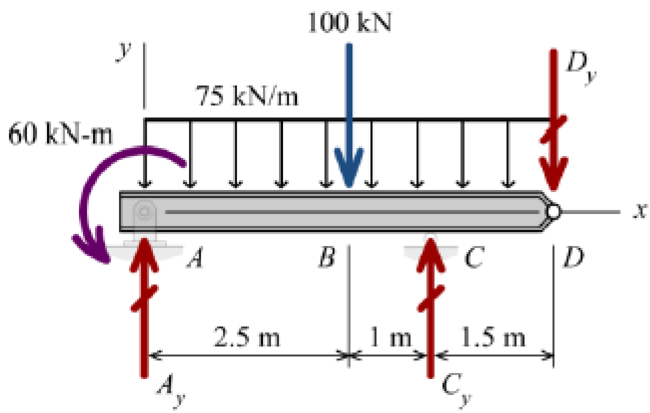
Example #5: Beam with internal moment release (hinge)



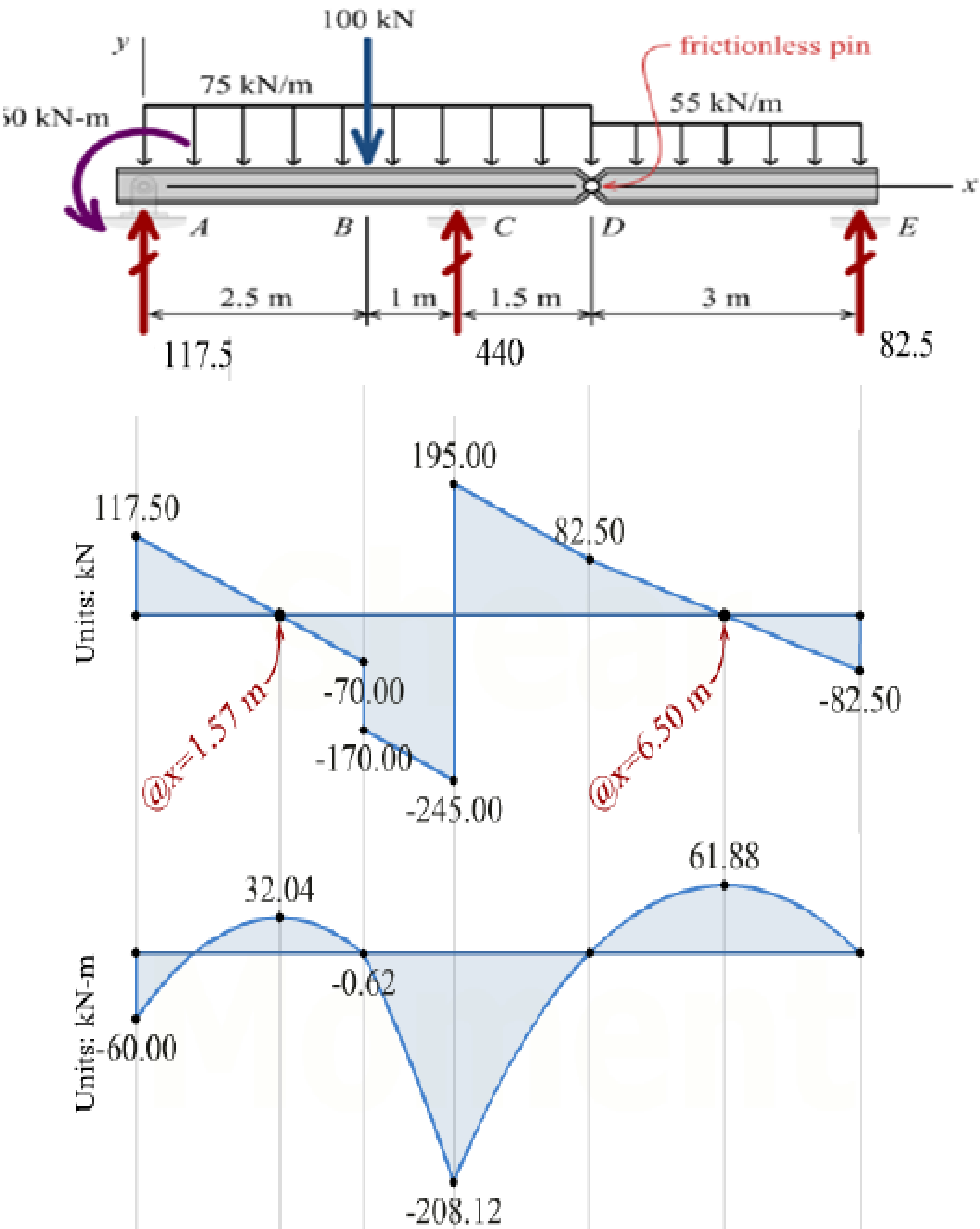
Consider free-body diagram of *DE*:



Consider free-body diagram of *ABCD*:

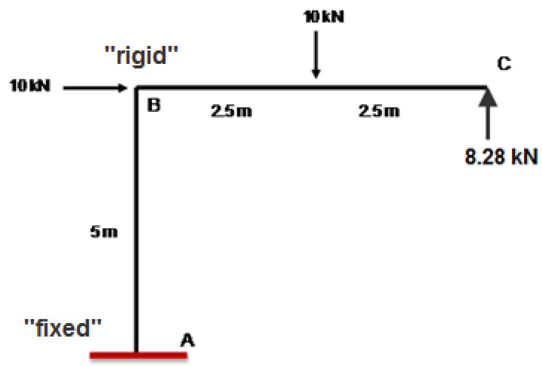


Shear-force and bending-moment diagrams



2. Examples: Frames

Example #1: Draw the shear and moment diagrams for the frame shown below

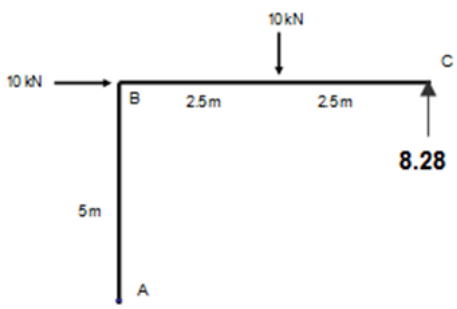


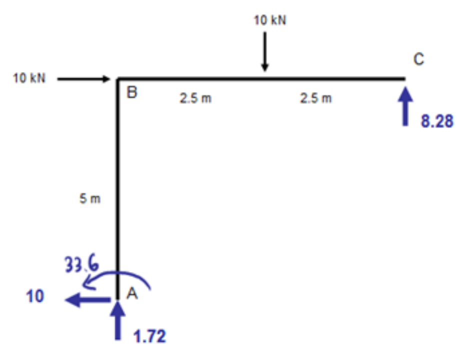
$\overset{+}{\rightarrow} \sum F_x = 0 \ldots \quad A_x + 10 = 0 \quad \hookrightarrow A_x = -10\,kN$

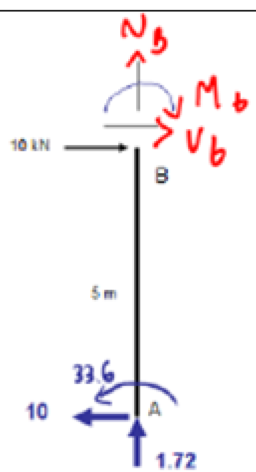
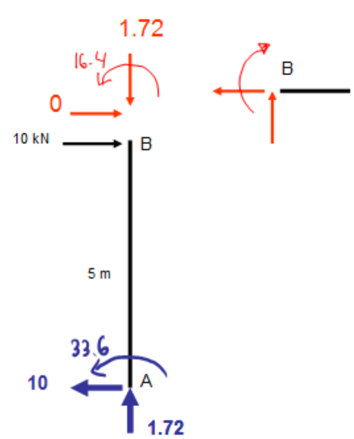
$+\uparrow \sum F_y = 0 \quad A_y - 10 + 8.28 = 0 \quad \hookrightarrow A_y = +1.72\,kN$

$\circlearrowleft^{+} \sum M_A = 0 \quad M_A - 10\times5 - 10\times2.5 + 8.28\times5 = 0 \quad \hookrightarrow M_A = +33.6\,kNm$

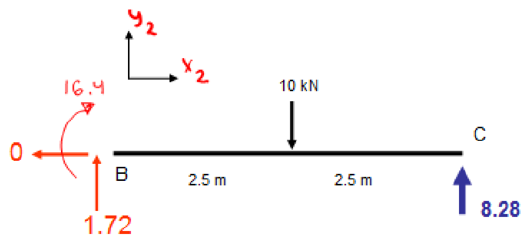
Find reactions:



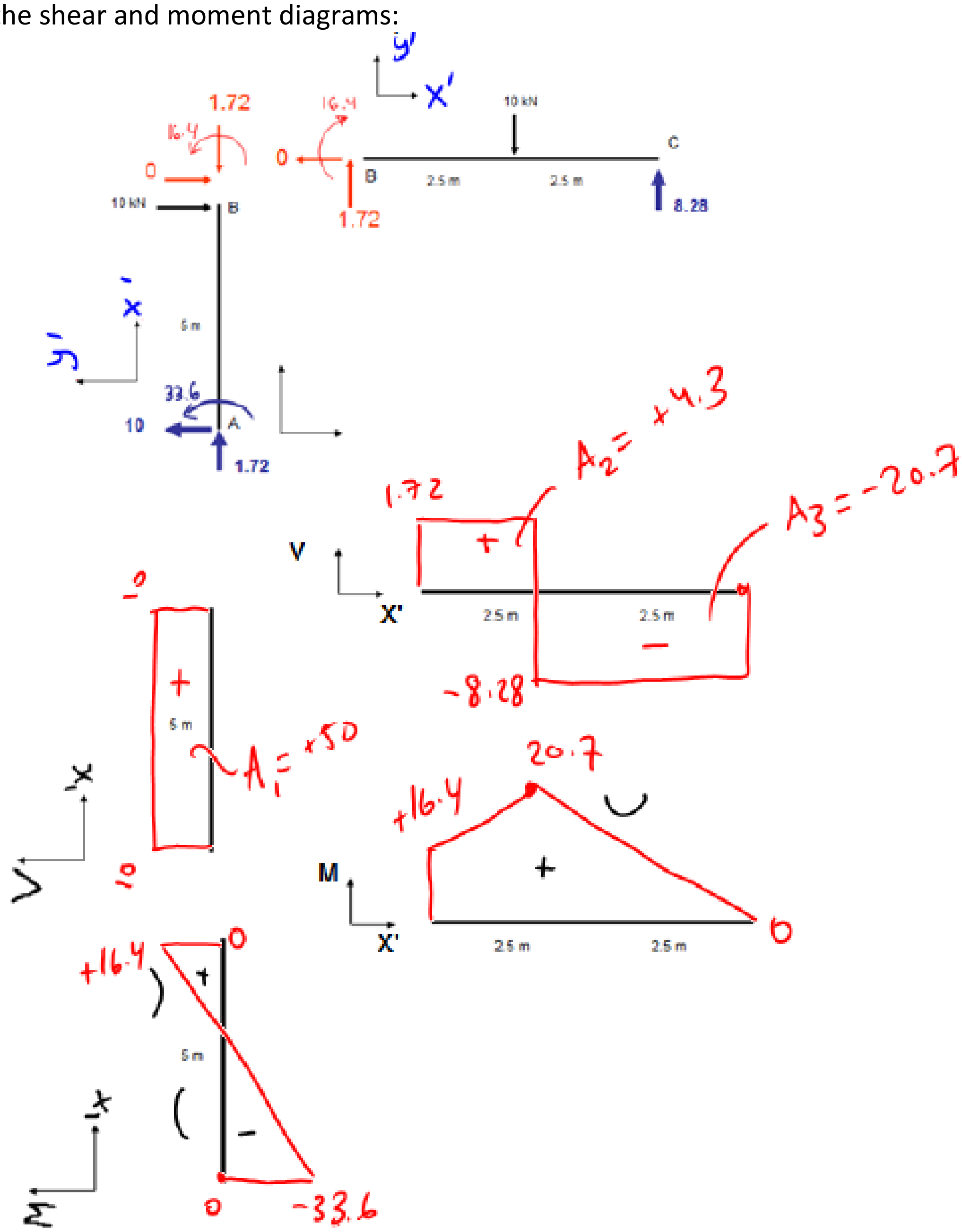


FBD of member AB	Correct directions and « transfer » forces
 $+\uparrow \sum F = 0 \quad 1.72 + N_B = 0 \ldots N_B = -1.72$ $\overset{+}{\rightarrow} \sum F = 0 \quad -10 + 10 + V_b = 0 \ldots V_b = 0$ $\circlearrowleft^{+} \sum M_A = 0 \quad 33.6 - 10\times5 - M_b = 0 \quad \hookrightarrow M_b = -16.4$	

Member BC .... verification (for this example)

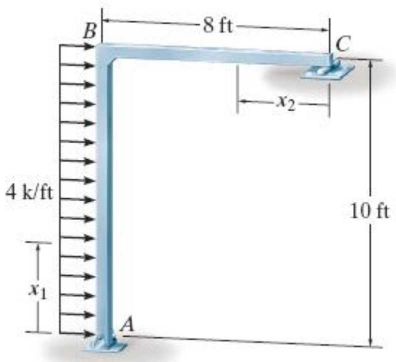


Draw the shear and moment diagrams:



Example #2:

Find reactions

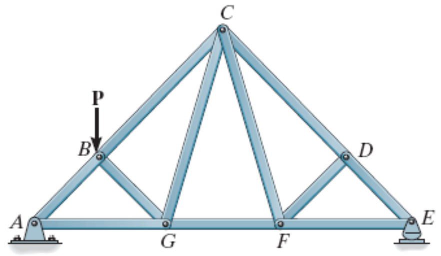


EXAMPLES
2.4: Trusses

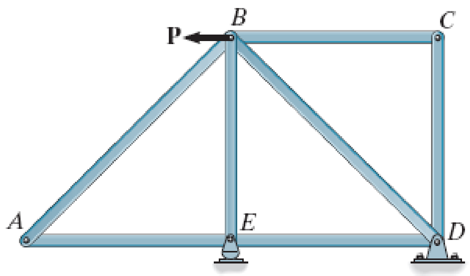
1. Example: Zero-force members
2. Example: Method of joints
3. Example: Method of sections
4. Visual analysis examples

1. Examples: Zero-force members

Identify the zero-force members ...



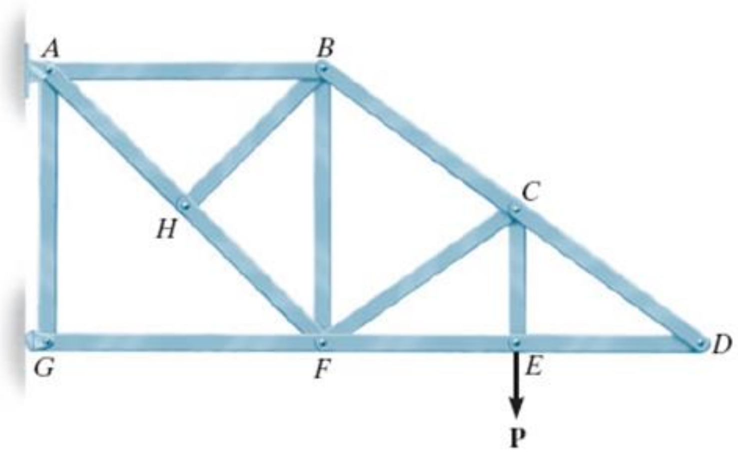
Identify the zero-force members ...



(a)

Identify the zero-force members ...

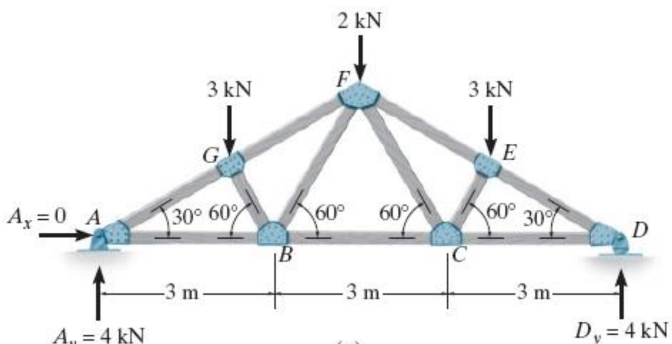
Roller



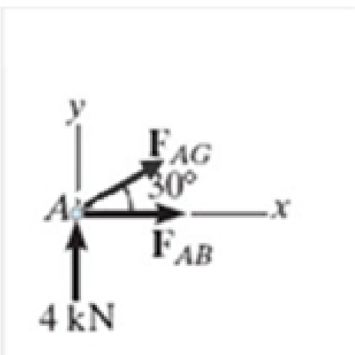
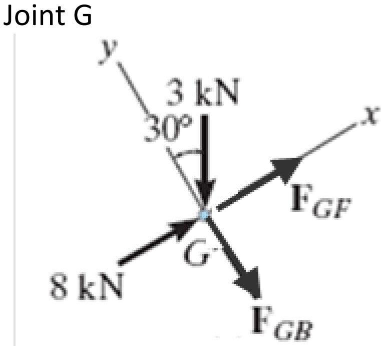
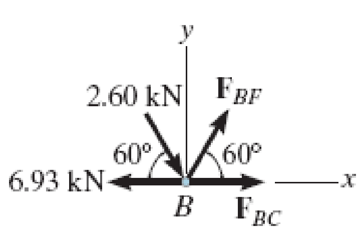
2. Example: Method of joints

Example #1

Find the forces in members AG, AB, GF, GB using the method of joints ...



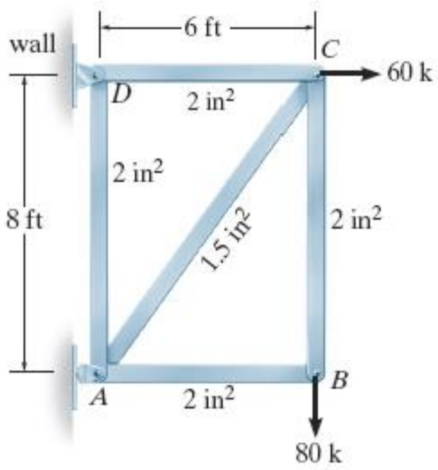
(a)

Joint A: 	Joint A, $+\uparrow \sum F_y = 0;\quad 4 + F_{AG}\sin 30^0 = 0$ $F_{AG} = -8 = 8kN(C)$ $\xrightarrow{+}\sum F_x = 0;\quad F_{AB} - 8\cos 30^0 = 0$ $F_{AB} = 6.93kN(T)$
Joint G 	Joint G, $+\uparrow \sum F_y = 0;\ -F_{GB} - 3\cos 30^0 = 0$ $F_{GB} = -2.60 = 2.60kN(C)$ $\xrightarrow{+}\sum F_x = 0;\quad 8 - 3\sin 30^0 + F_{GF} = 0$ $F_{GF} = -6.5 = 6.50kN(C)$
Joint B  (d)	Joint B, $+\uparrow \sum F_y = 0;\quad F_{BF}\sin 60^0 - 2.60\sin 60^0 = 0$ $F_{BF} = 2.60kN(T)$ $\xrightarrow{+}\sum F_x = 0;\quad F_{BC} + 2.60\cos 60^0 + 2.60\cos 60^0 - 6.93 = 0$ $F_{BC} = 4.33kN(T)$

Note: Only the forces in half the members have to be determined as the truss is symmetric wrt both loading & geometry.

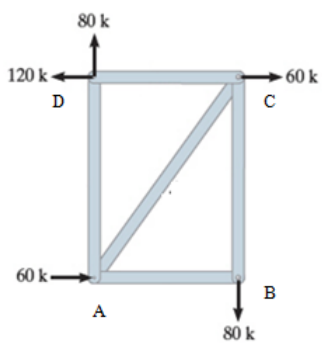
Example #2

Find the force in all members...

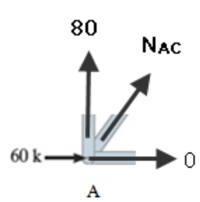


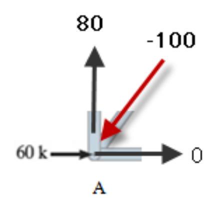
After find reactions can you determine which members are in compression and which are in tension ?

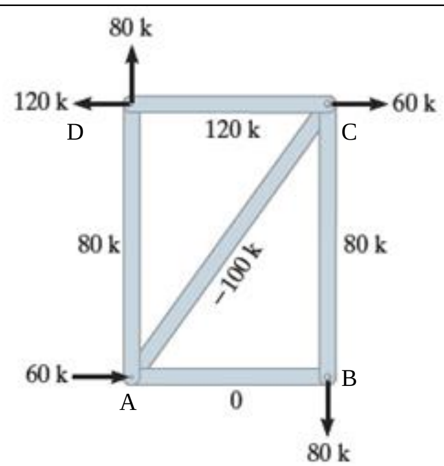
Next can find forces either using method of joints ....



Joint A





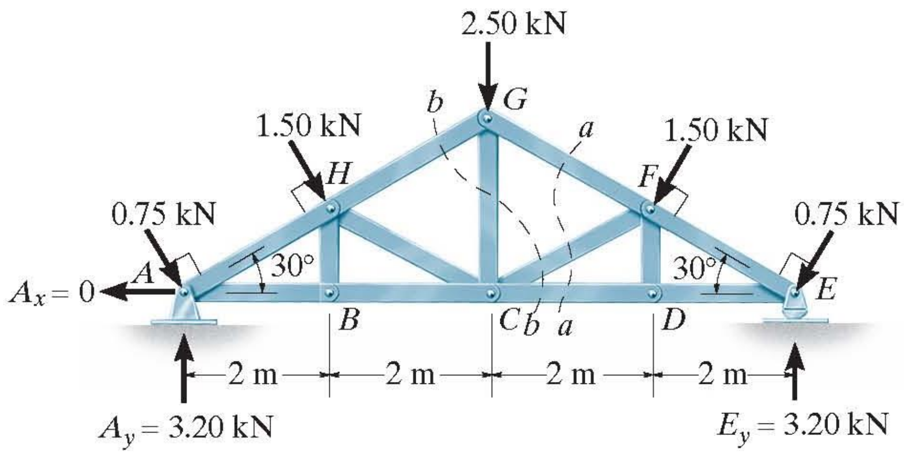


Member	Force (kips)
AB	0
AC	-100 (C)
AD	+80 (T)
BC	+80 (T)
CD	+120 (T)

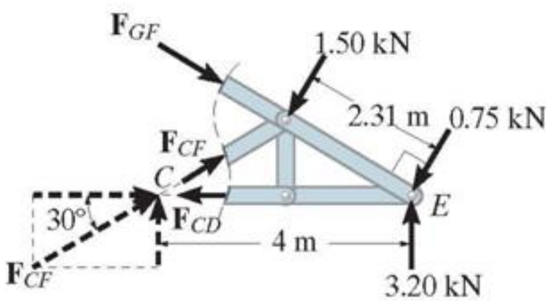
Example: Truss method of sections

Example #1:

Use the method of sections to find the force in members CF and GC



The free-body diagram of member CF can be obtained by considering the section aa,



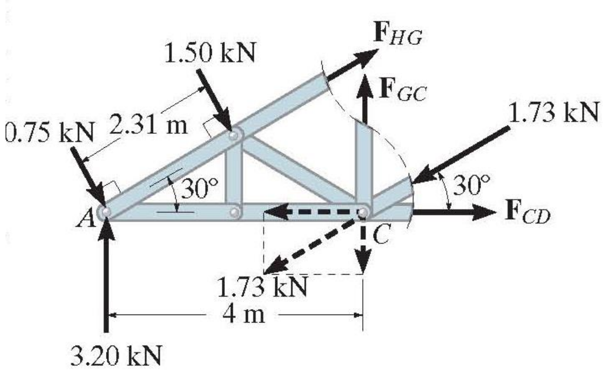
A direct solution for F_{CF} can be obtained by applying $\sum M_E = 0$

$$\sum M_E = 0$$

$$-F_{CF} \sin 30^o (4) + 1.50(2.31) = 0$$

$$F_{CF} = 1.73 kN(C)$$

The free-body diagram of member GC can be obtained by considering the section bb,



Moments will be summed about point A in order to eliminate the unknowns F_{HG} and F_{CD}.

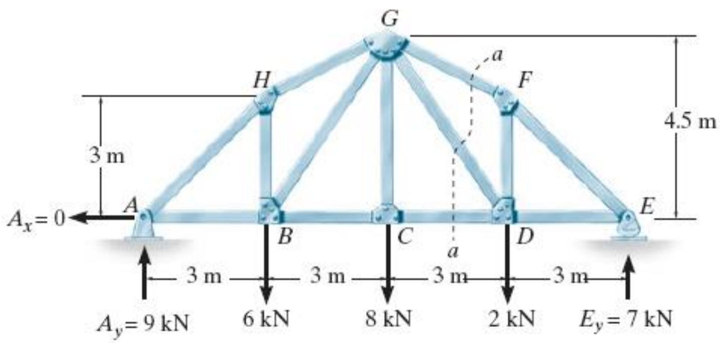
$$\sum M_A = 0$$

$$-1.50(2.31) + F_{GC}(4) - 1.73 \sin 30^o (4) = 0$$

$$F_{GC} = 1.73 kN(T)$$

Example #2

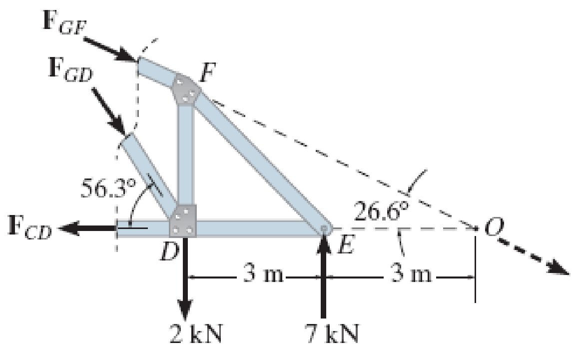
Use the method of sections to find the force in members GF and GD.



The distance EO can be determined by proportional triangles.

1.5 drop : 3 m horizontal

4.5 m drop : ?? m … To drop 4.5m from G the distance from C to O must be 9m



The angles F_{GD} and F_{GF} make with the horizontal are

$\tan^{-1}(4.5/3) = 56.3°$

$\tan^{-1}(4.5/9) = 26.6°$

The force in GF can be determined directly by applying $\sum M_D = 0$

$$\sum M_D = 0$$

$$-F_{GF} \sin 26.6^o (6) + 7(3) = 0$$

$$F_{GF} = 7.83 kN (C)$$

The force in GD can be determined directly by applying $\sum M_O = 0$

$$\sum M_O = 0$$

$$-7(3) + 2(6) + F_{GD} \sin 56.3^o (6) = 0$$

$$F_{GD} = 1.80 kN (C)$$