PEF3200 – Introdução à Mecânica das Estruturas

Aula 13 - 28/06/2023

Estruturas Associadas.

Prof. Martin Paul Schwark

Prof. Osvaldo Shigueru Nakao

Prof. Valério S. Almeida

O que vimos nas aulas 1 a 12:

- Como é a disciplina, materiais de apoio, programação
- Mecânica dos sólidos deformáveis, o que são estruturas, estão em tudo, modelos físicos e matemáticos, classificações das estruturas, ações que atuam sobre elas e alguns tópicos da mecânica
- Deformadas, movimentos em sistemas materiais, vínculos, estaticidade, estruturas hipostáticas, isostáticas e hiperestáticas, grau de hiperestaticidade, as simplificações adotadas nesta disciplina
- Cálculo de reações de apoio, tensões, esforços solicitantes, o Teorema Fundamental da Resistência dos Materiais
- Diagramas de esforços solicitantes em estruturas planas e espaciais
- Linha de Influência
- Treliças
- Pórticos triarticulados
- Arcos triarticulados
- Vigas Gerber

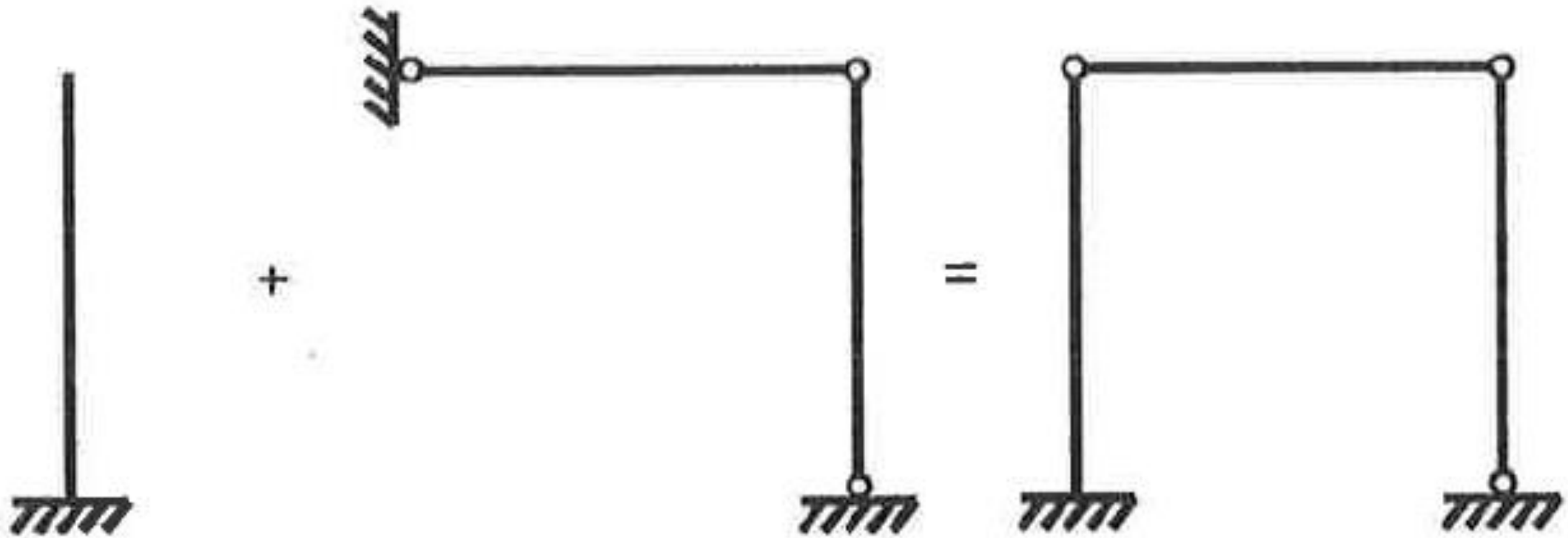
Nesta aula vamos ver: Estruturas Associadas

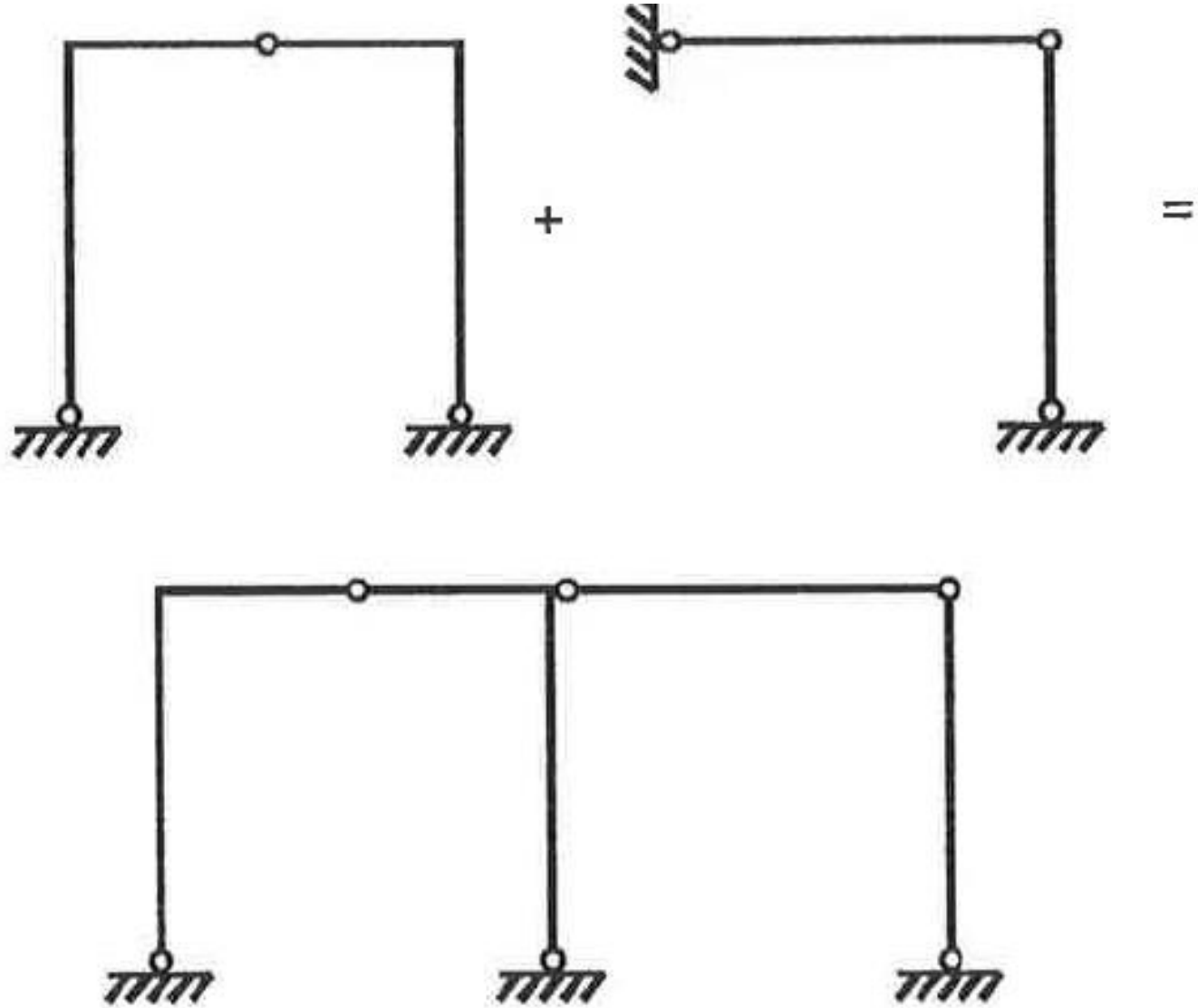

Fortaleza - CE

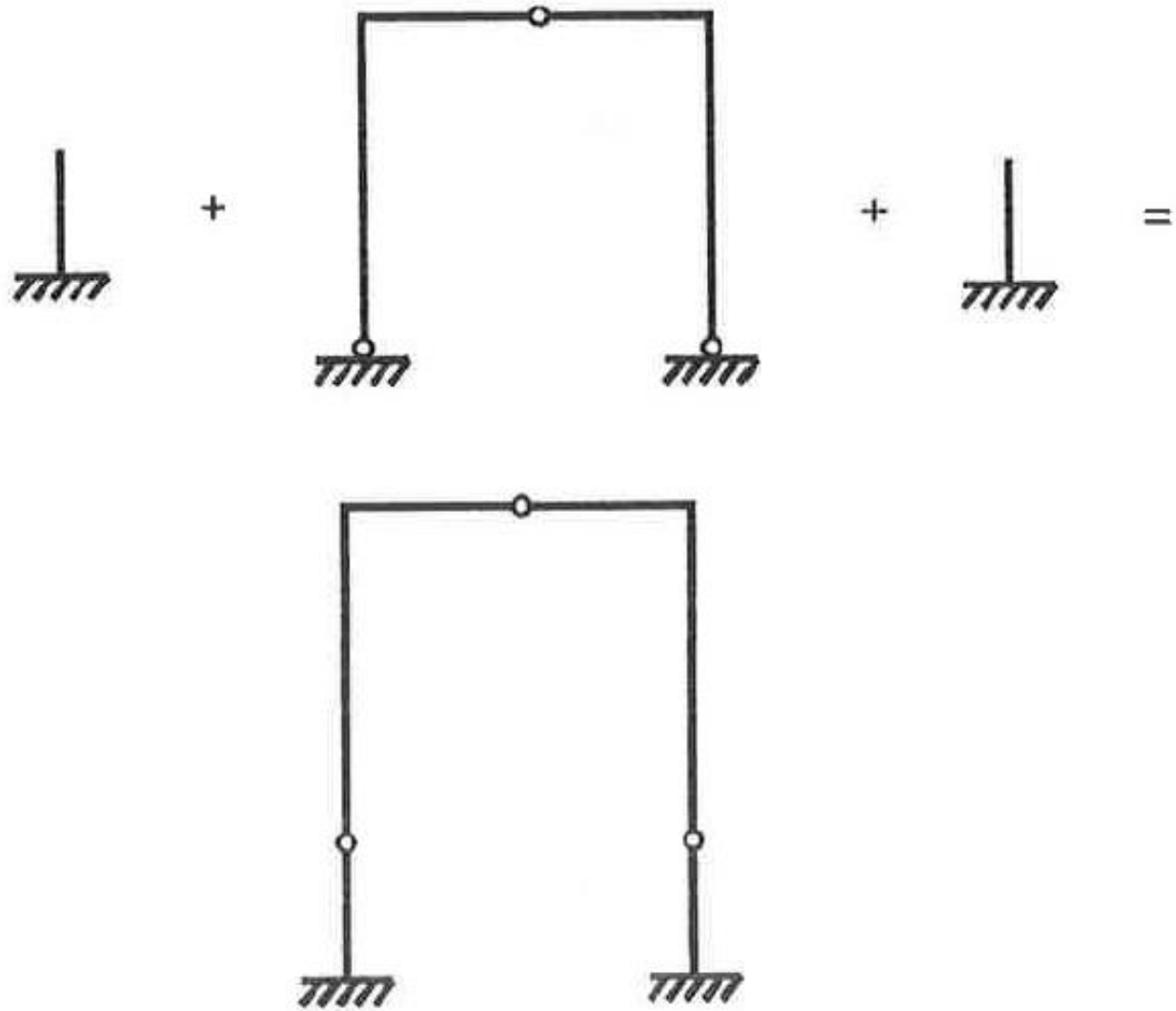

Camboriú - SC

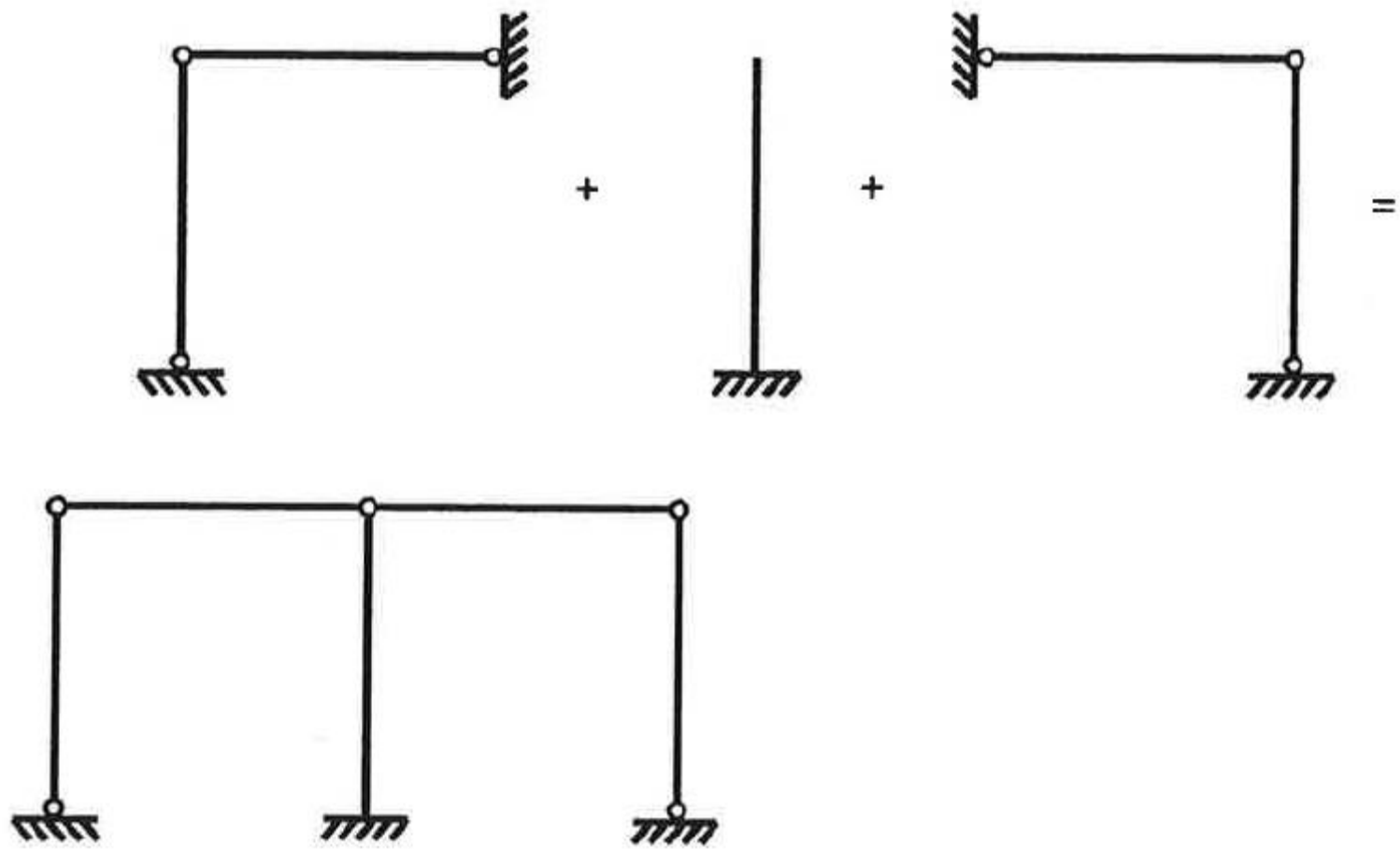

Santiago - Chile

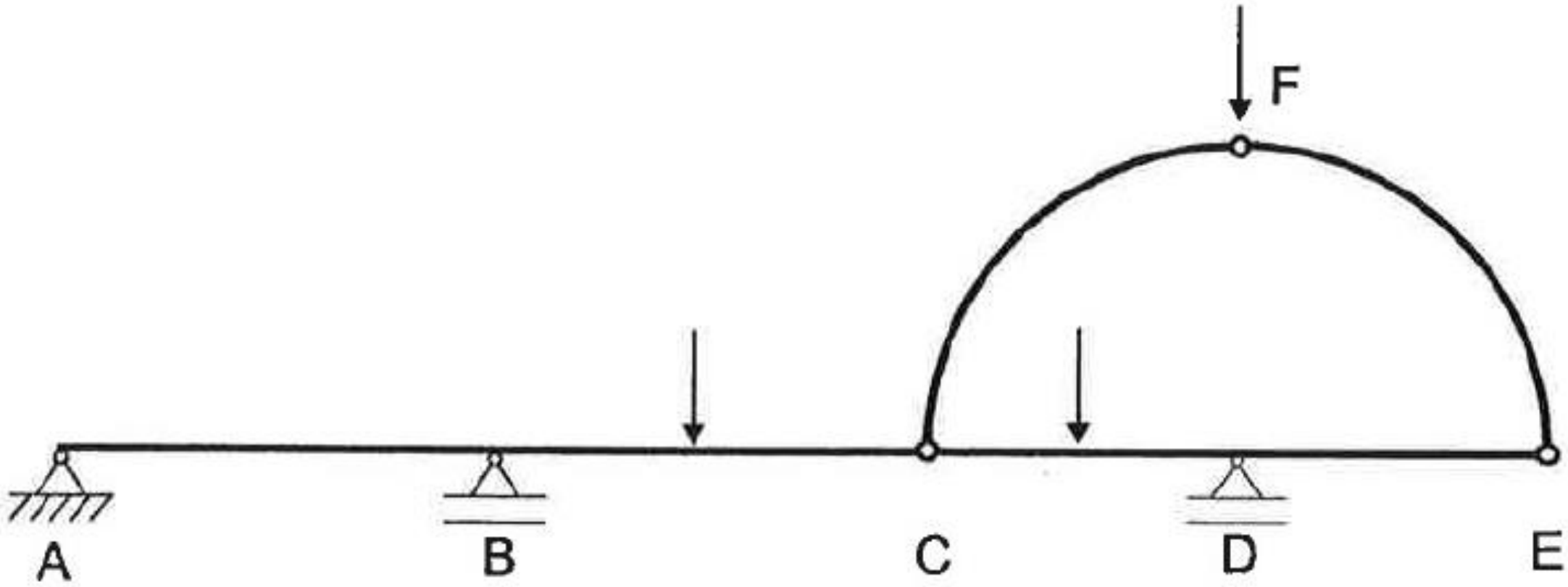

Ford
DHG-1912







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A
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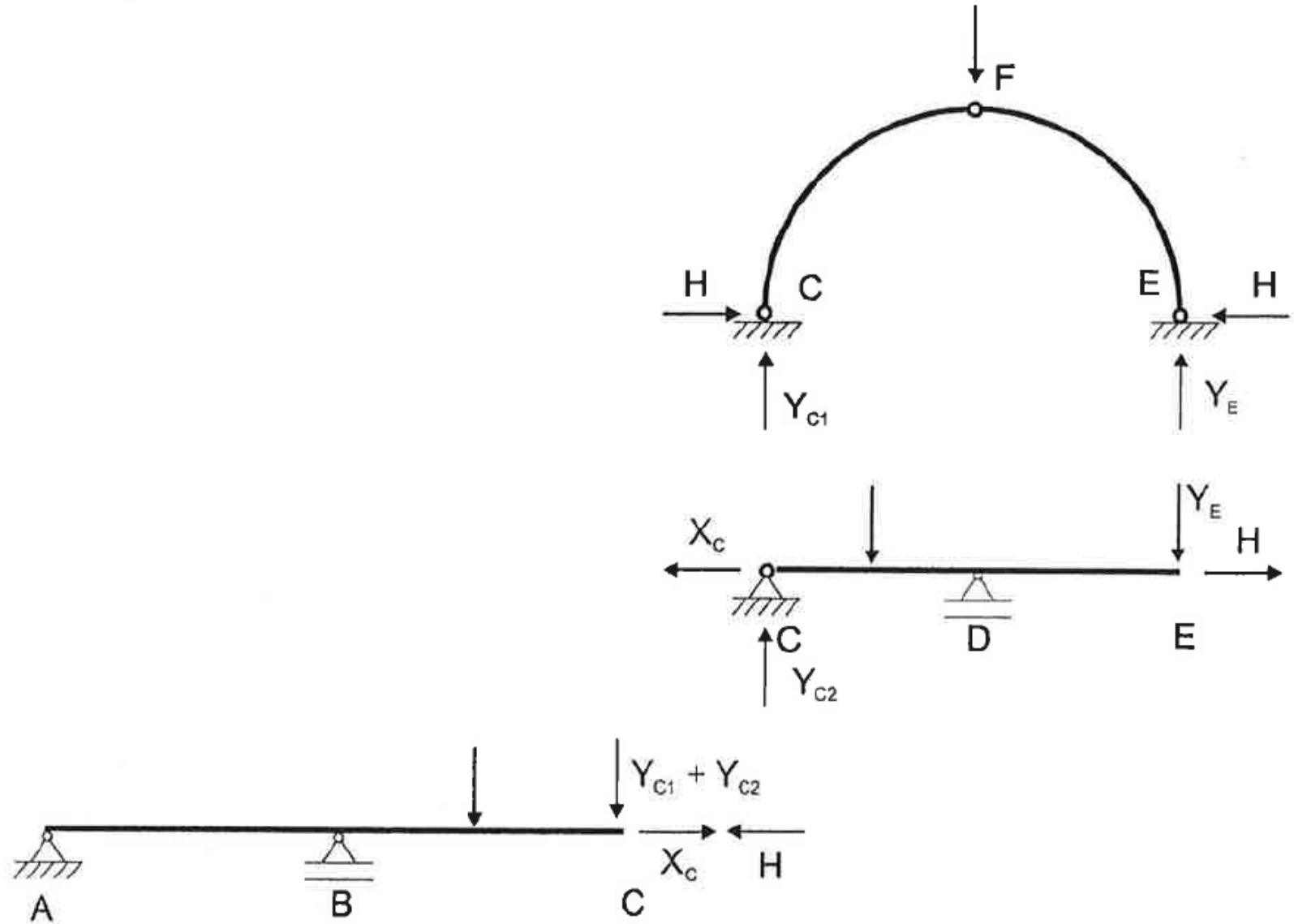
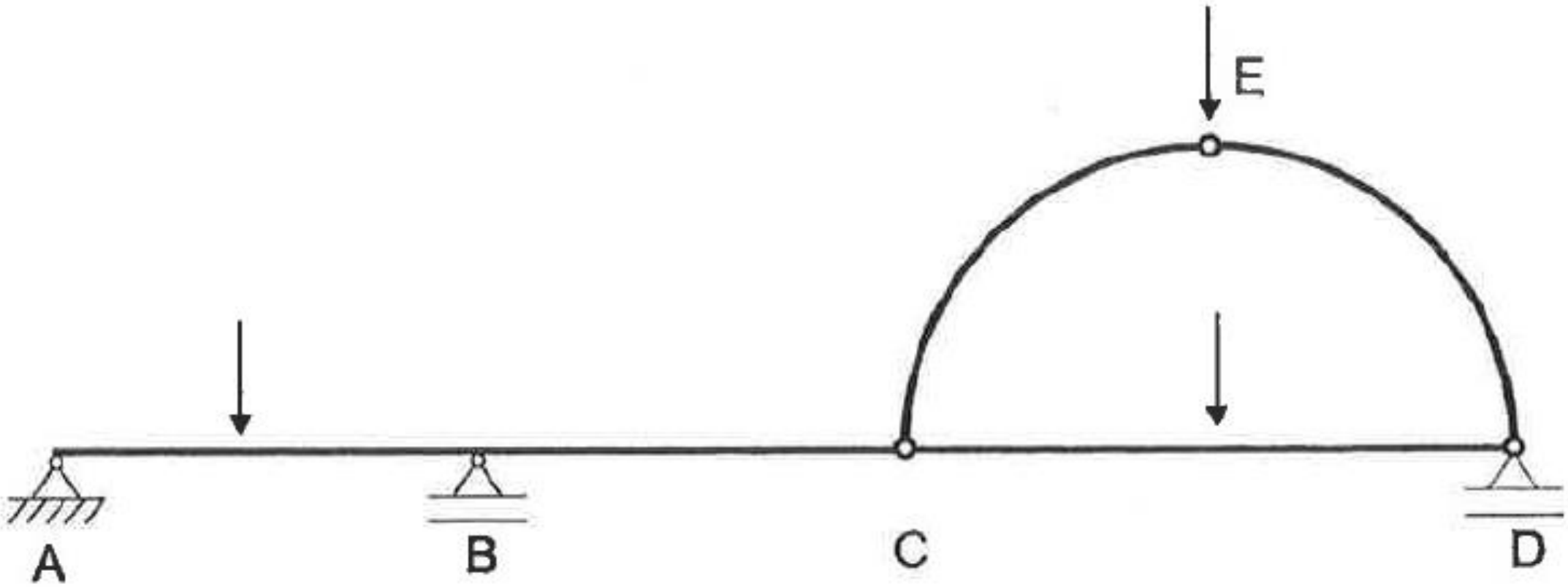

F
H
C
E
H
Y_{C1}
Y_E
Y_E
X_C
H
C
D
E
Y_{C2}
$Y_{C1} + Y_{C2}$
X_C
H
A
B
C


E
A
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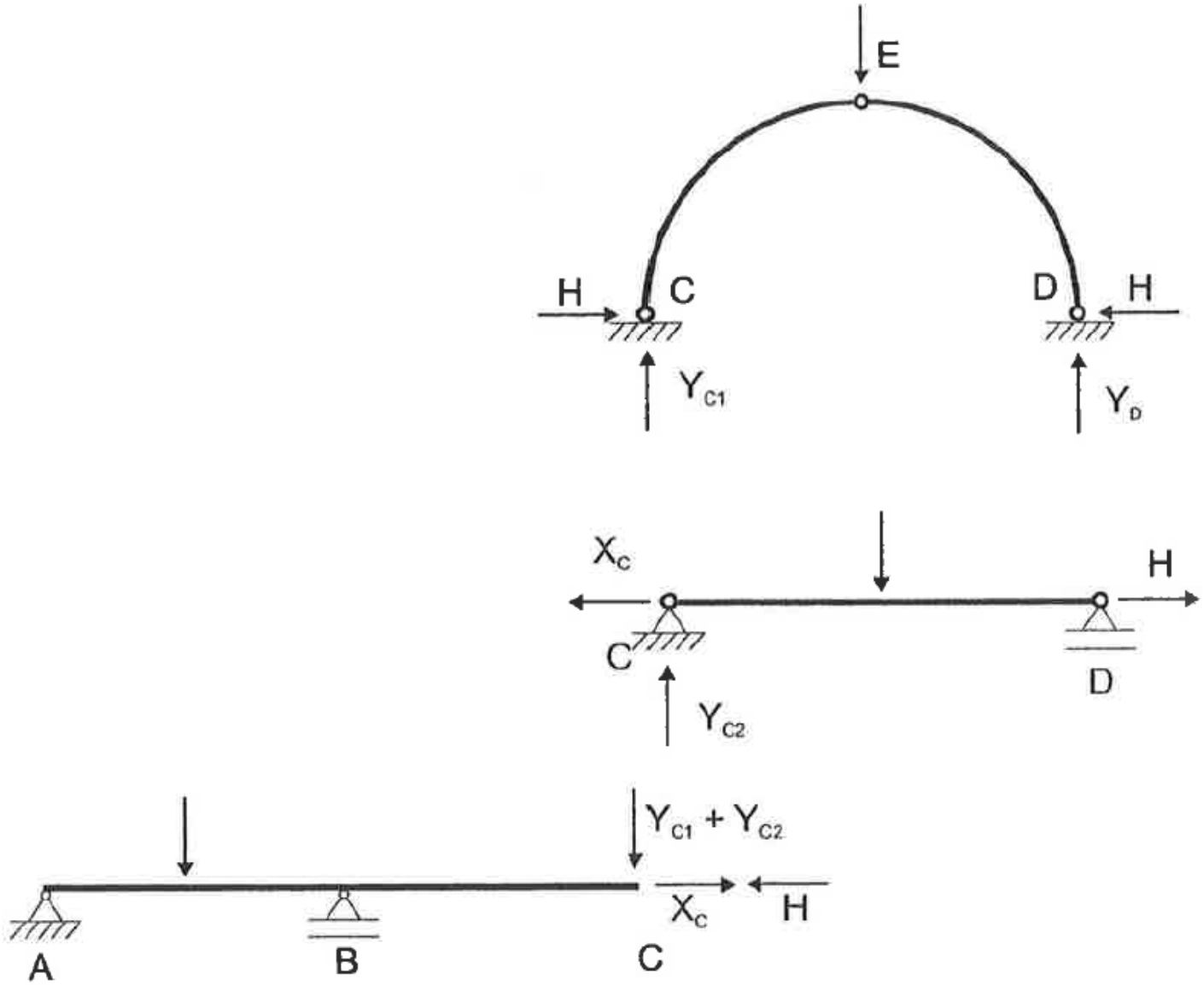
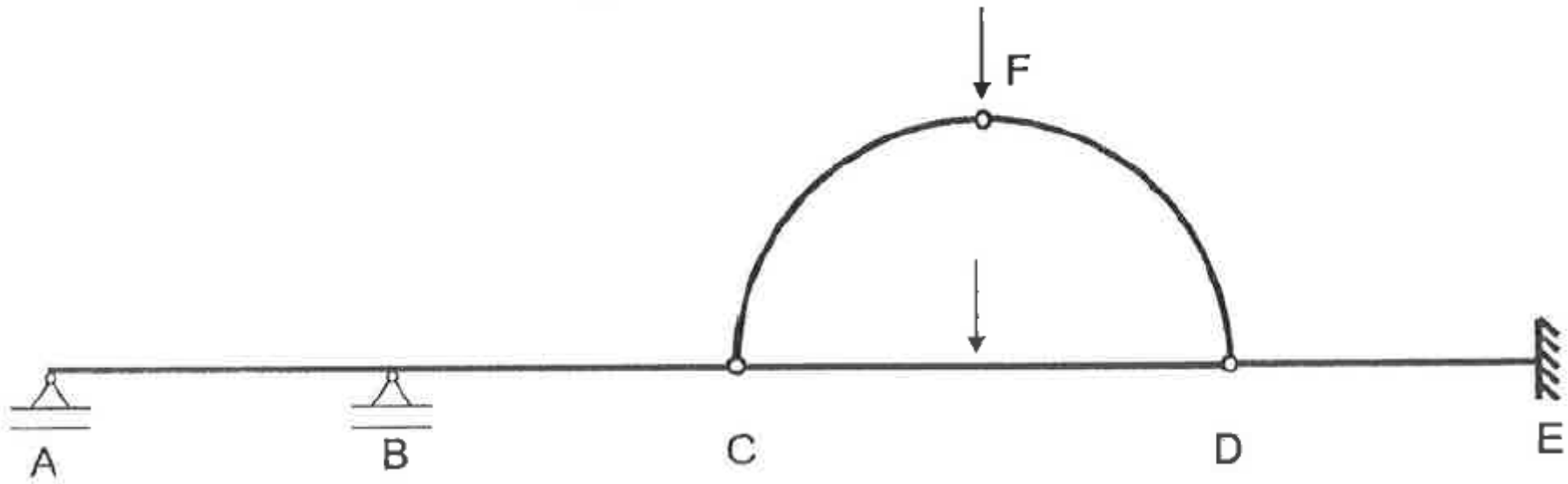

E
H
C
D
H
Y_{C1}
Y_D
X_C
H
C
D
Y_{C2}
$Y_{C1} + Y_{C2}$
X_C
H
A
B
C


F
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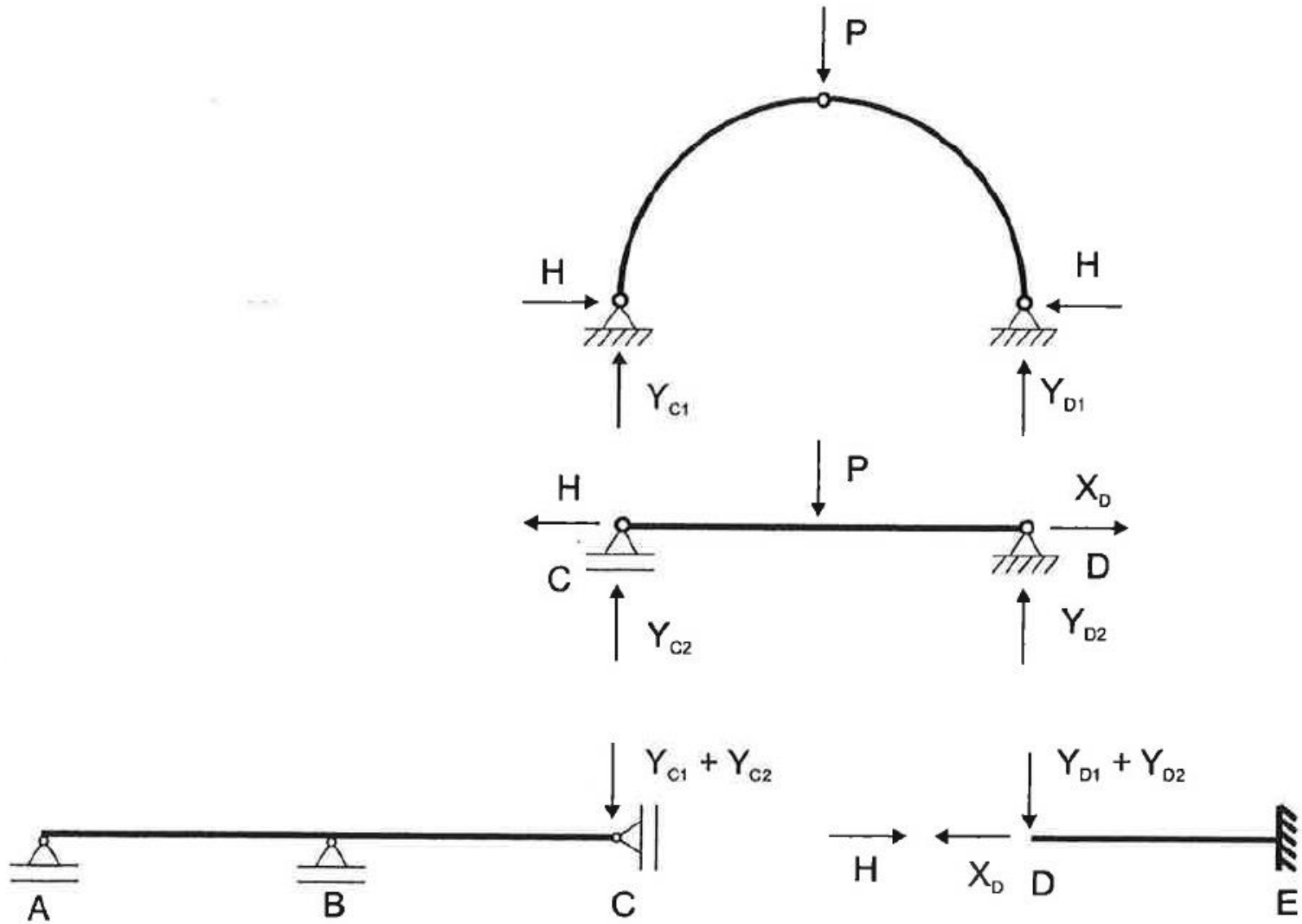
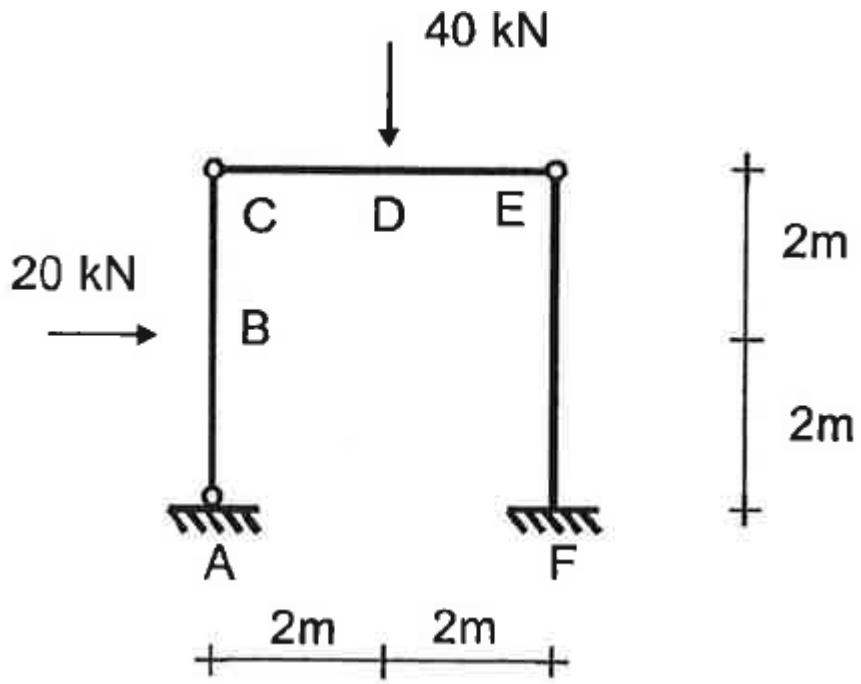
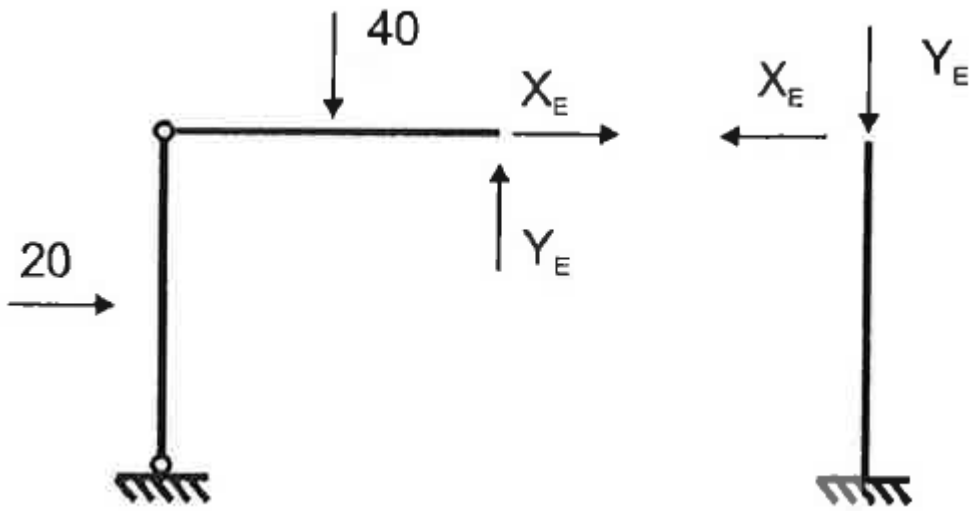
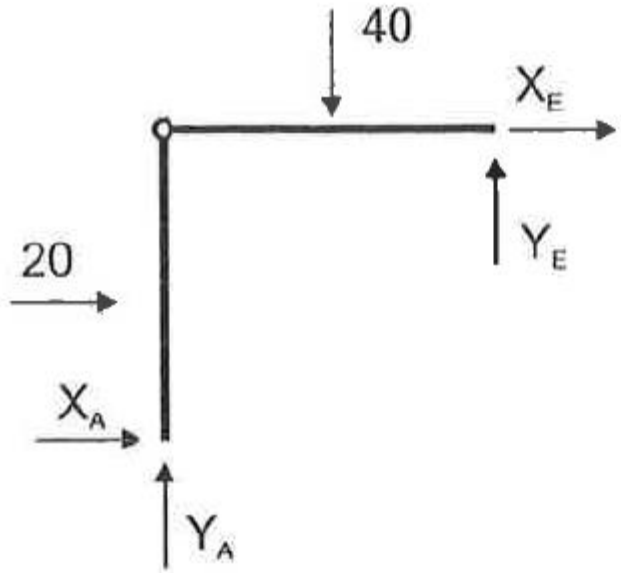
B
C
D
E


P
H
H
Y_{C1}
Y_{D1}
P
H
X_D
C
D
Y_{C2}
Y_{D2}
$Y_{C1} + Y_{C2}$
$Y_{D1} + Y_{D2}$
A
B
C
H
X_D
D
E

Exemplo 1





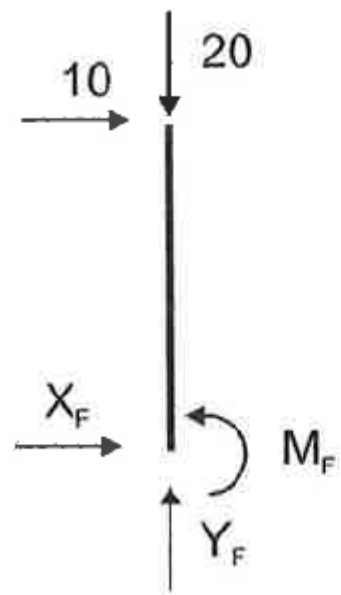


$\Sigma X = 0 \quad X_A + X_E + 20 = 0 \Rightarrow X_E = -10$

$\Sigma Y = 0 \quad Y_A + Y_E = 40 \Rightarrow Y_A = 20$

$\Sigma M_A = 0 \quad -20.2 - 40.2 - X_E.1 + Y_E.1 = 0 \Rightarrow Y_E = 20$

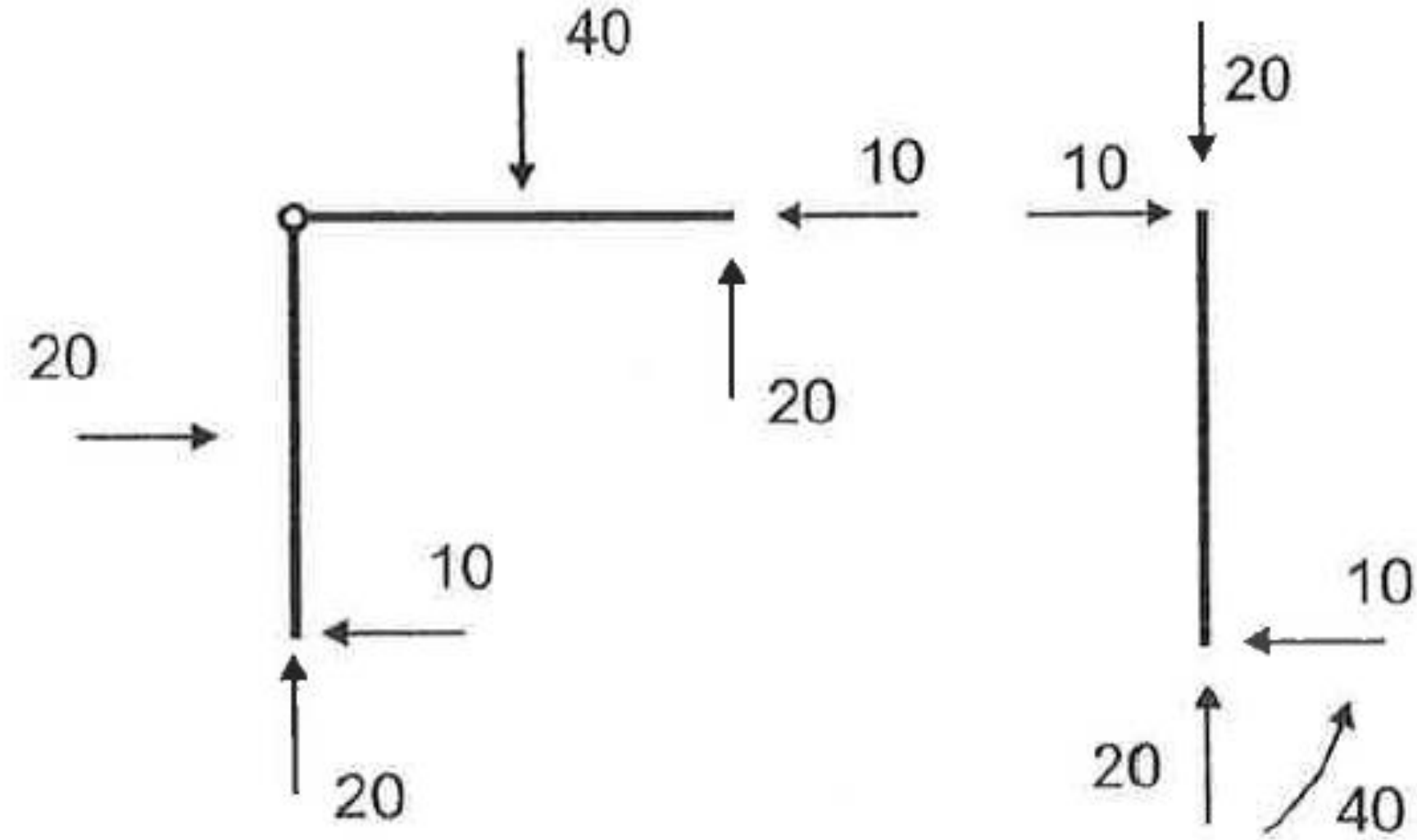
$M_C = 0 \quad X_A.4 + 20.2 = 0 \Rightarrow X_A = -10$

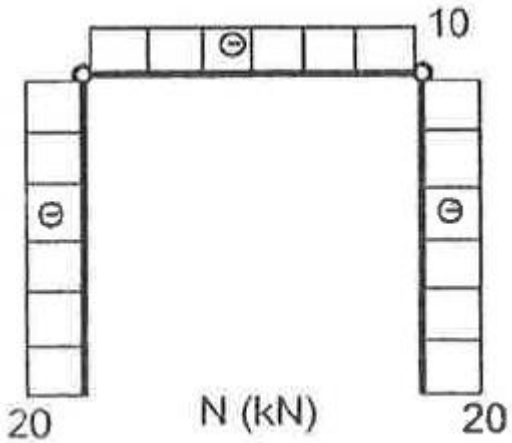


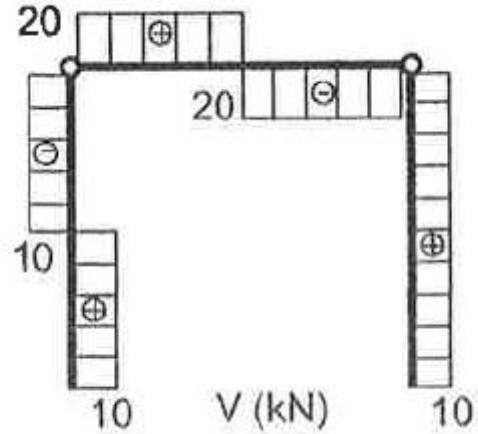
$\Sigma X = 0 \quad X_F + 10 = 0 \Rightarrow X_F = -10$

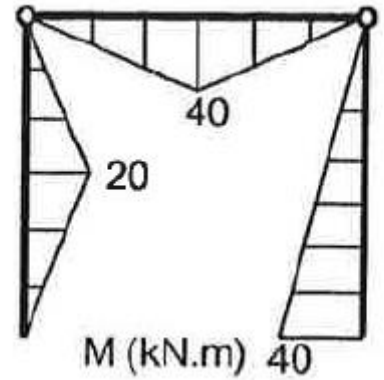
$\Sigma Y = 0 \quad Y_F - 20 = 0 \Rightarrow Y_F = 20$

$\Sigma M_F = 0 \quad M_F - 10.4 = 0 \Rightarrow M_F = 40$

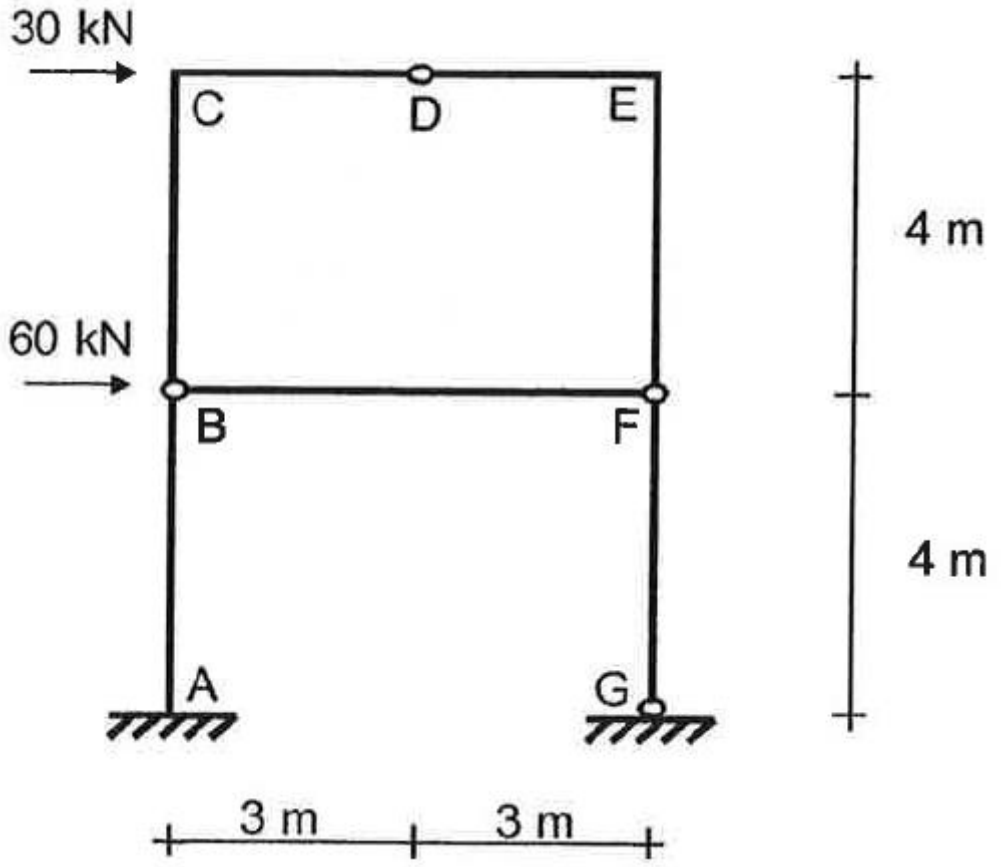

40
10
20
20
10
20
10
20
20
10
20
40

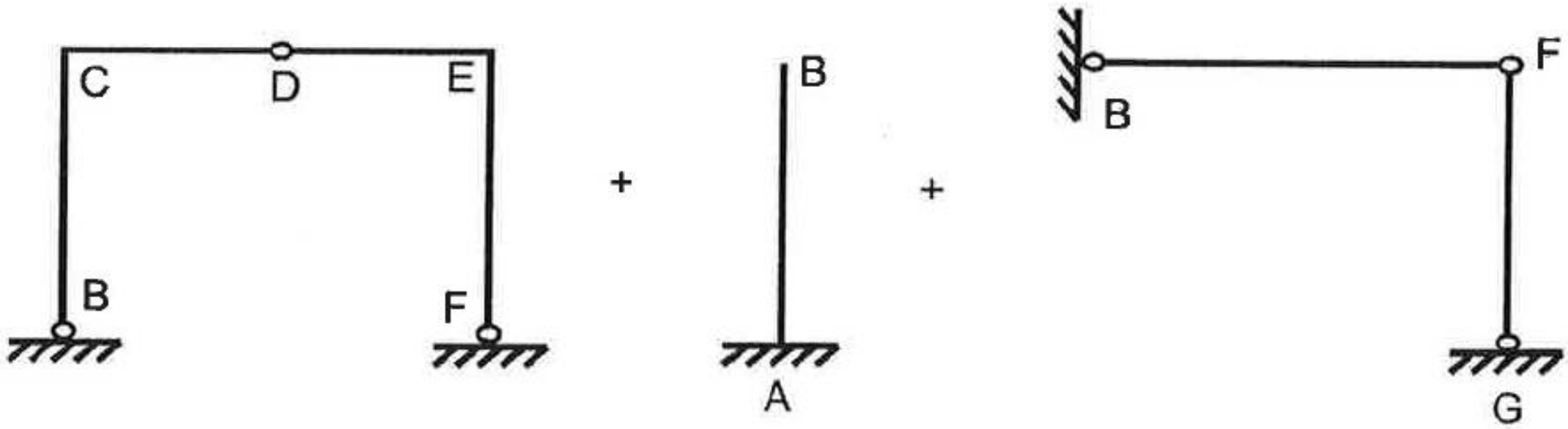

10
20
N (kN)
20

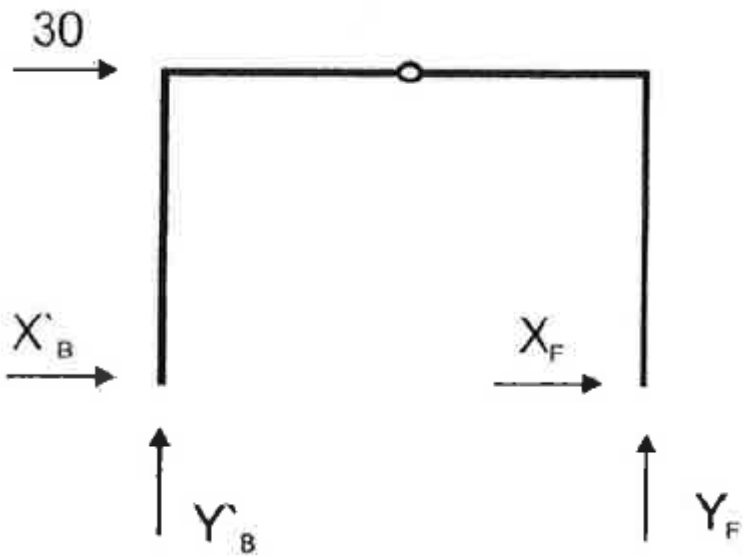

20
20
10
10
V (kN)
10

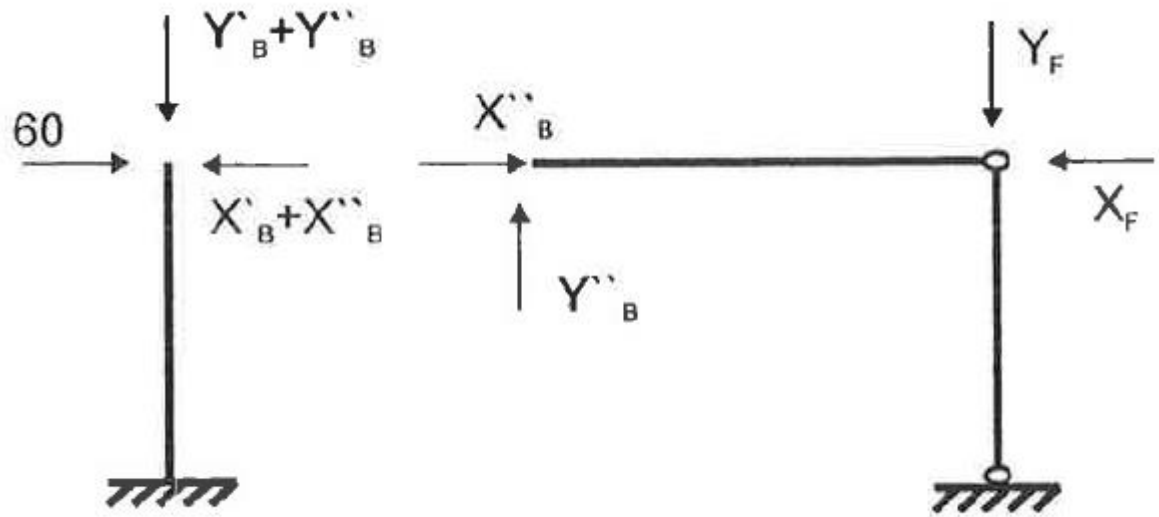

40
20
M (kN.m)
40

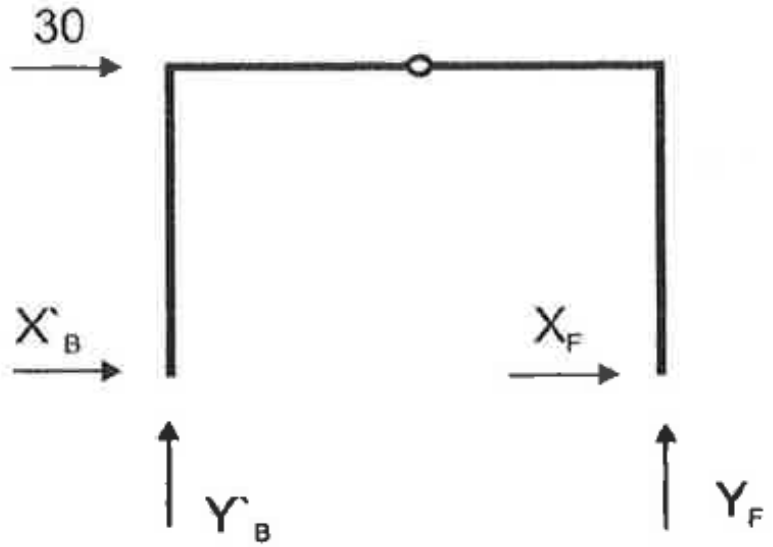
Exemplo 2




C
D
E
B
F
+
B
A
+
B
F
G


30
X`B
XF
Y`B
YF


Y`B+Y``B
60
X`B+X``B
X``B
YF
XF
Y``B

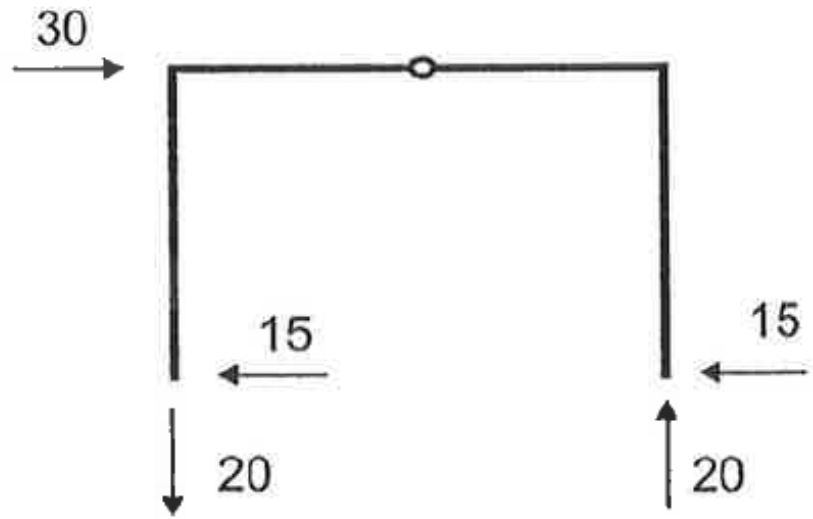


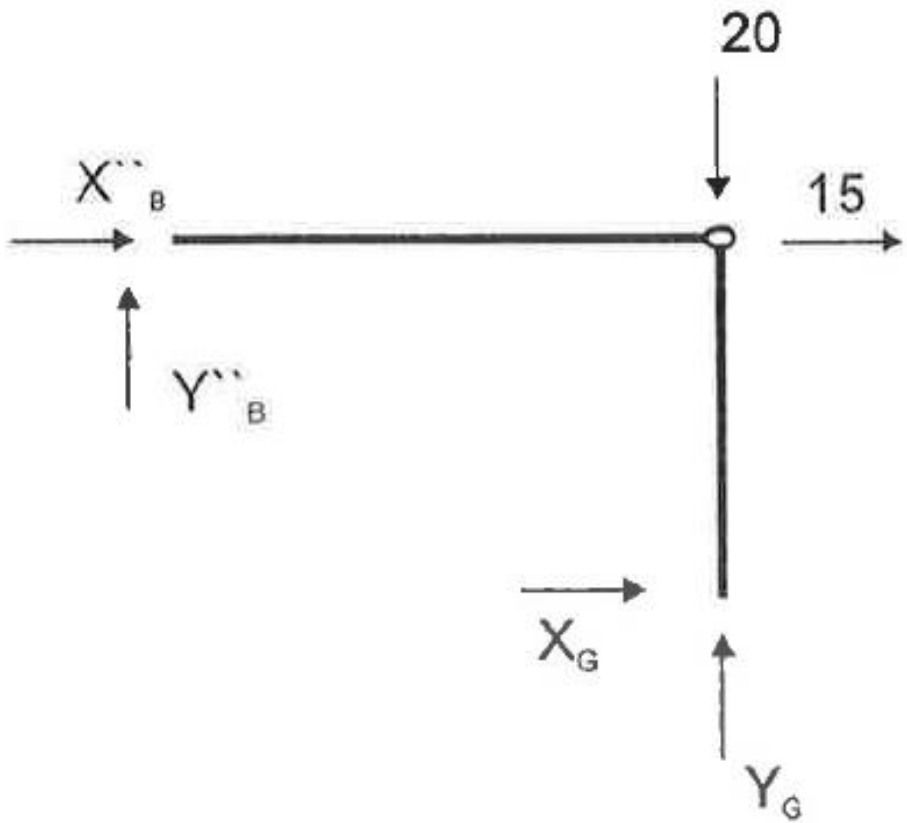
$\Sigma X = 0 \quad X`_B + X_F + 30 = 0 \Rightarrow X`_B = -15$

$\Sigma Y = 0 \quad Y`_B + Y_F = 0 \Rightarrow Y`_B = -20$

$\Sigma M_B = 0 \quad -30.4 + Y_F.6 = 0 \Rightarrow Y_F = 20$

$M_D = 0 \quad Y_F.3 + X_F.4 = 0 \Rightarrow X_F = -15$



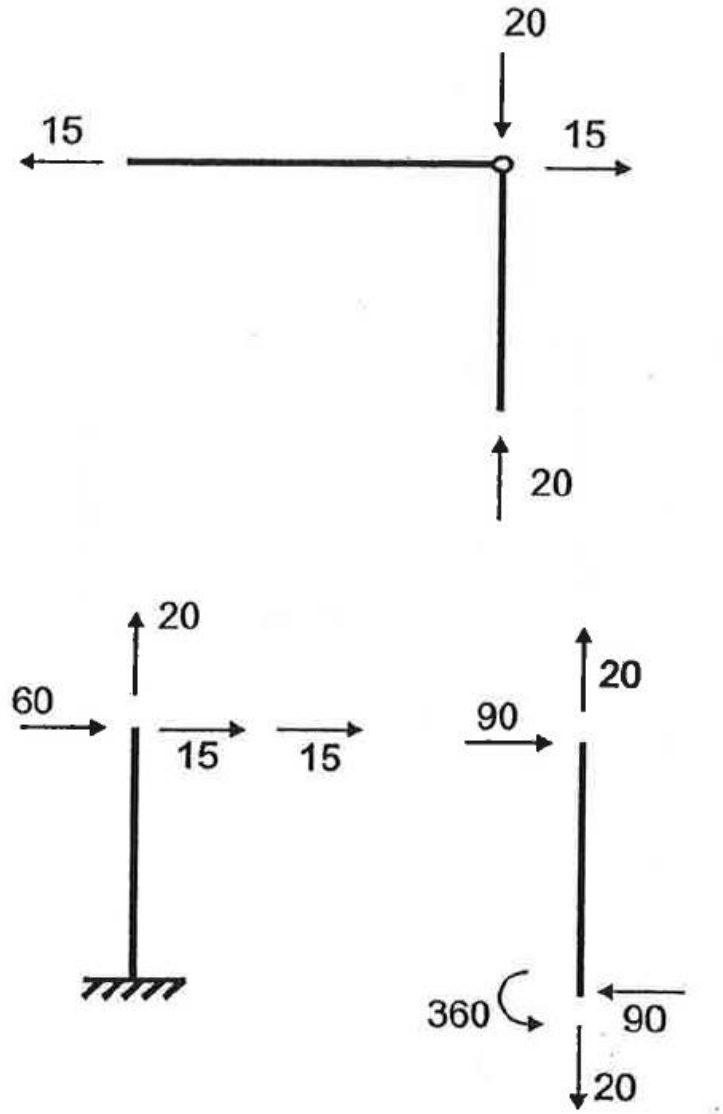


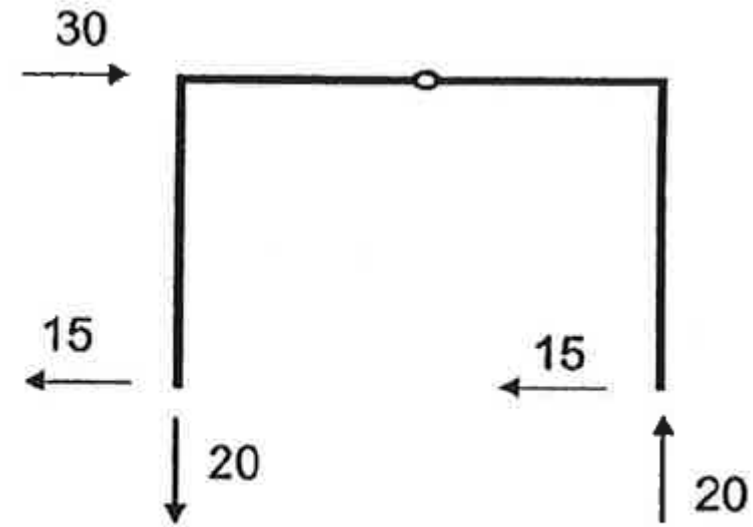
$\Sigma X = 0 \quad X``_B + X_G + 15 = 0 \Rightarrow X``_B = -15$

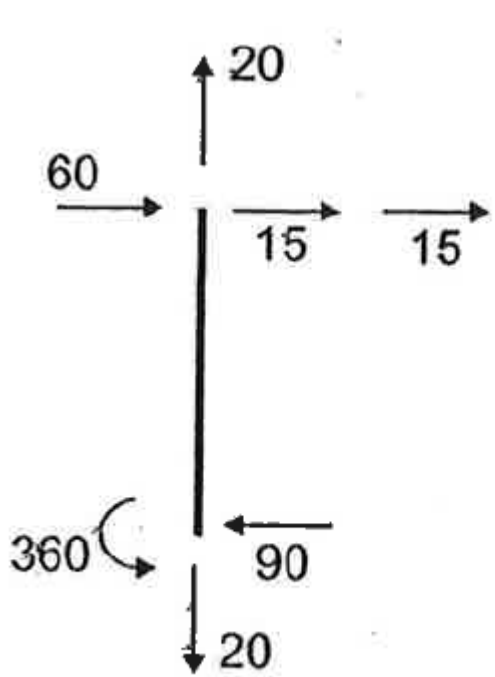
$\Sigma Y = 0 \quad Y``_B + Y_G = 20 \Rightarrow Y``_B = 0$

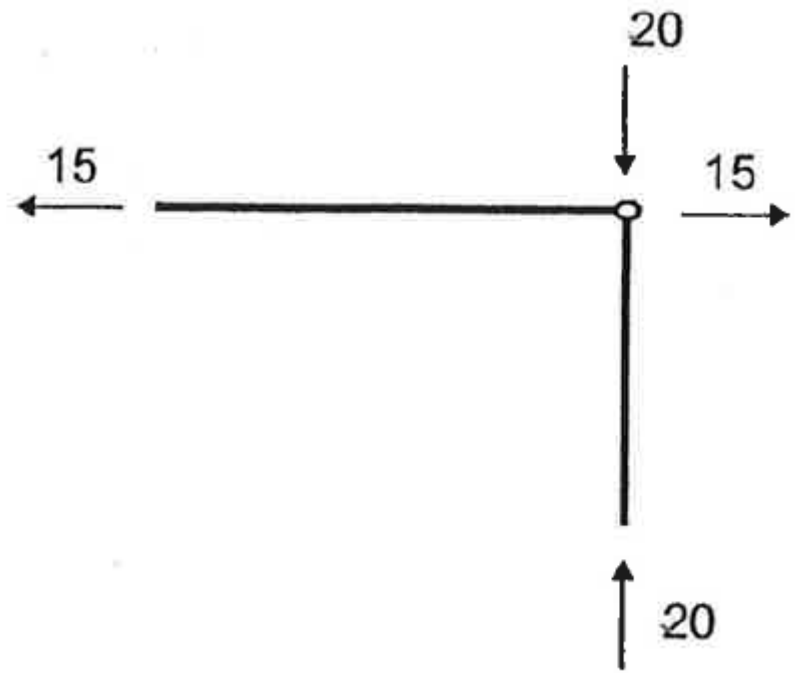
$\Sigma M_B = 0 \quad X_G \cdot 4 + Y_G \cdot 6 - 20 \cdot 6 = 0 \Rightarrow Y_G = 20$

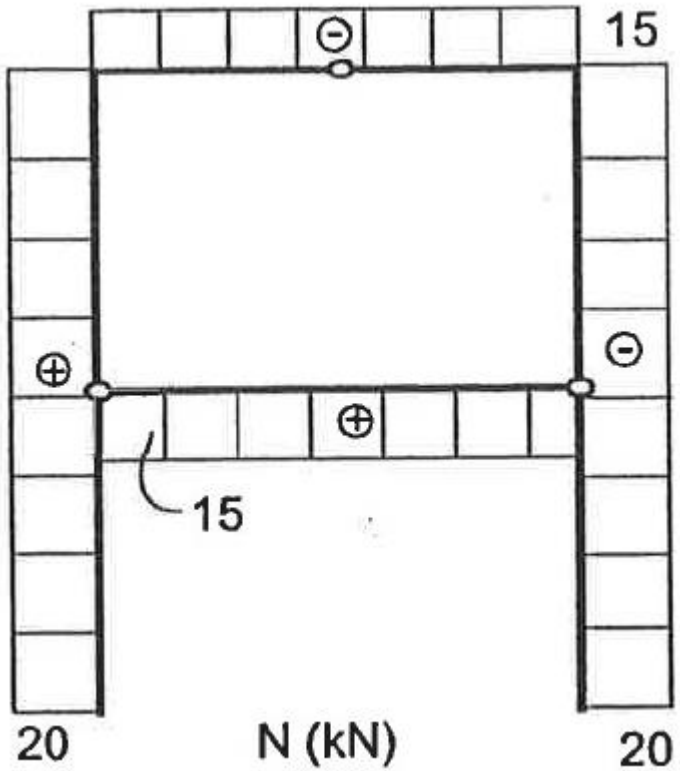
$M_F = 0 \quad X_G \cdot 4 = 0 \Rightarrow X_G = 0$


20
15
15
20
20
60
15
15
20
90
360
90
20

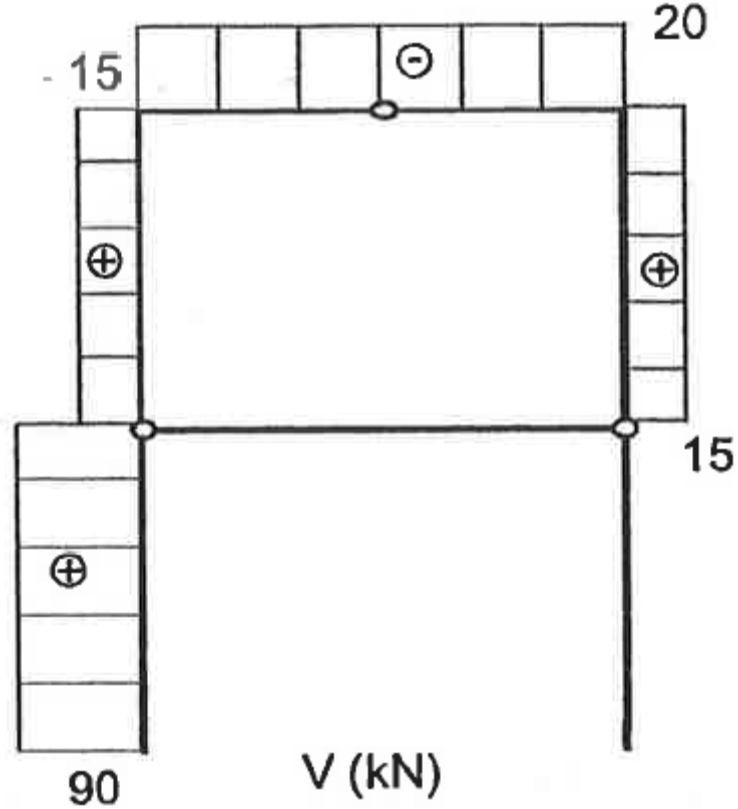

30
15
15
20
20


20
60
15
15
360
90
20

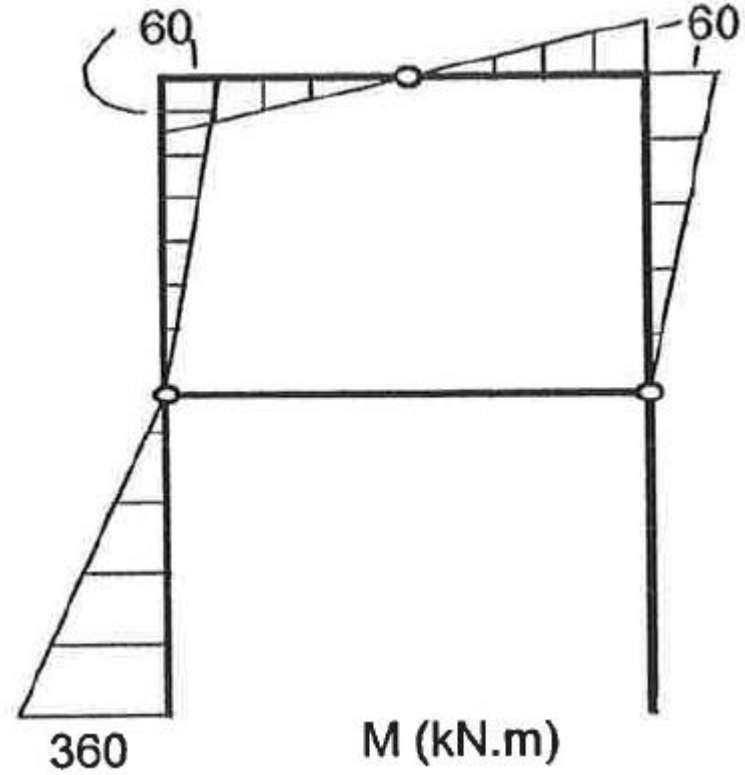

20
15
15
20



N (kN)



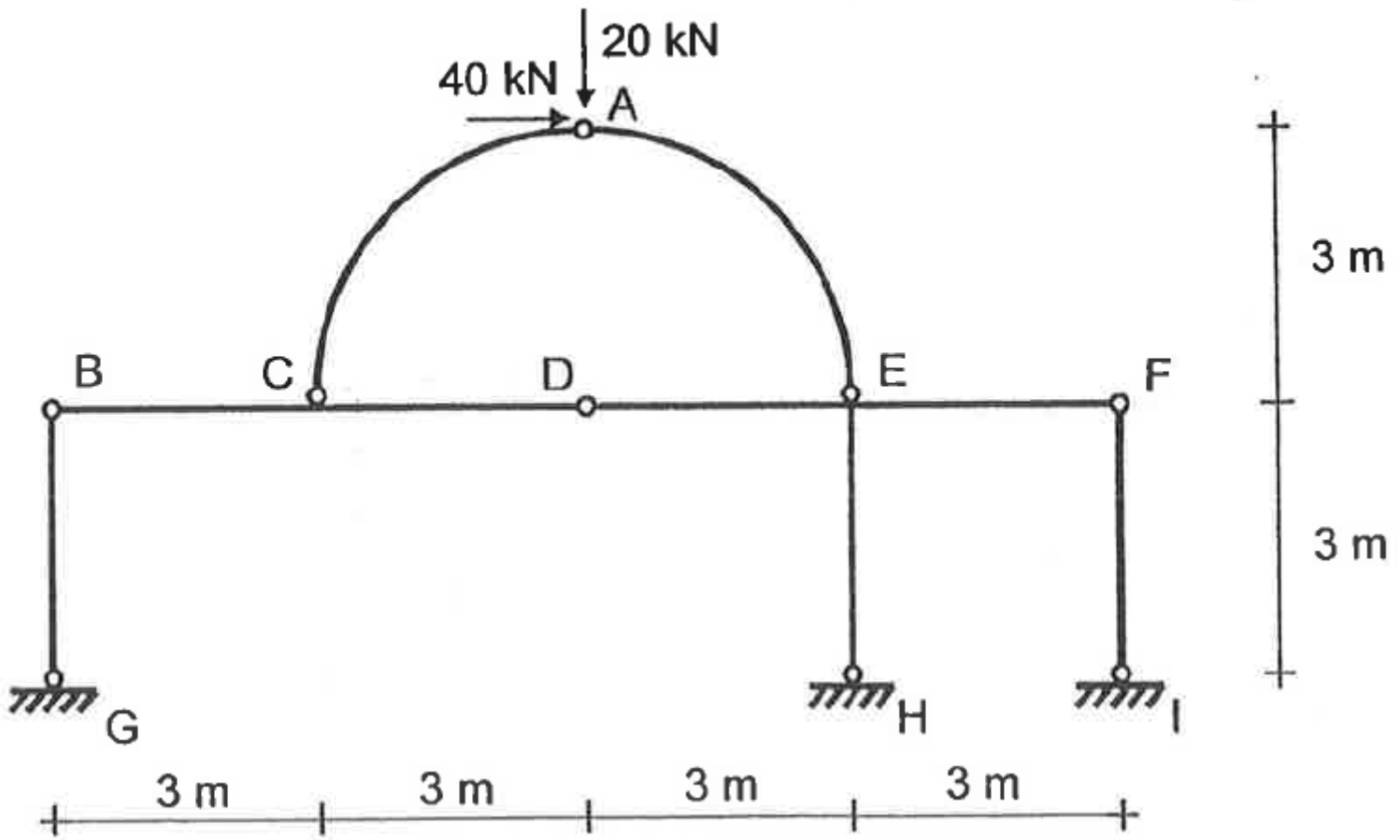
V (kN)

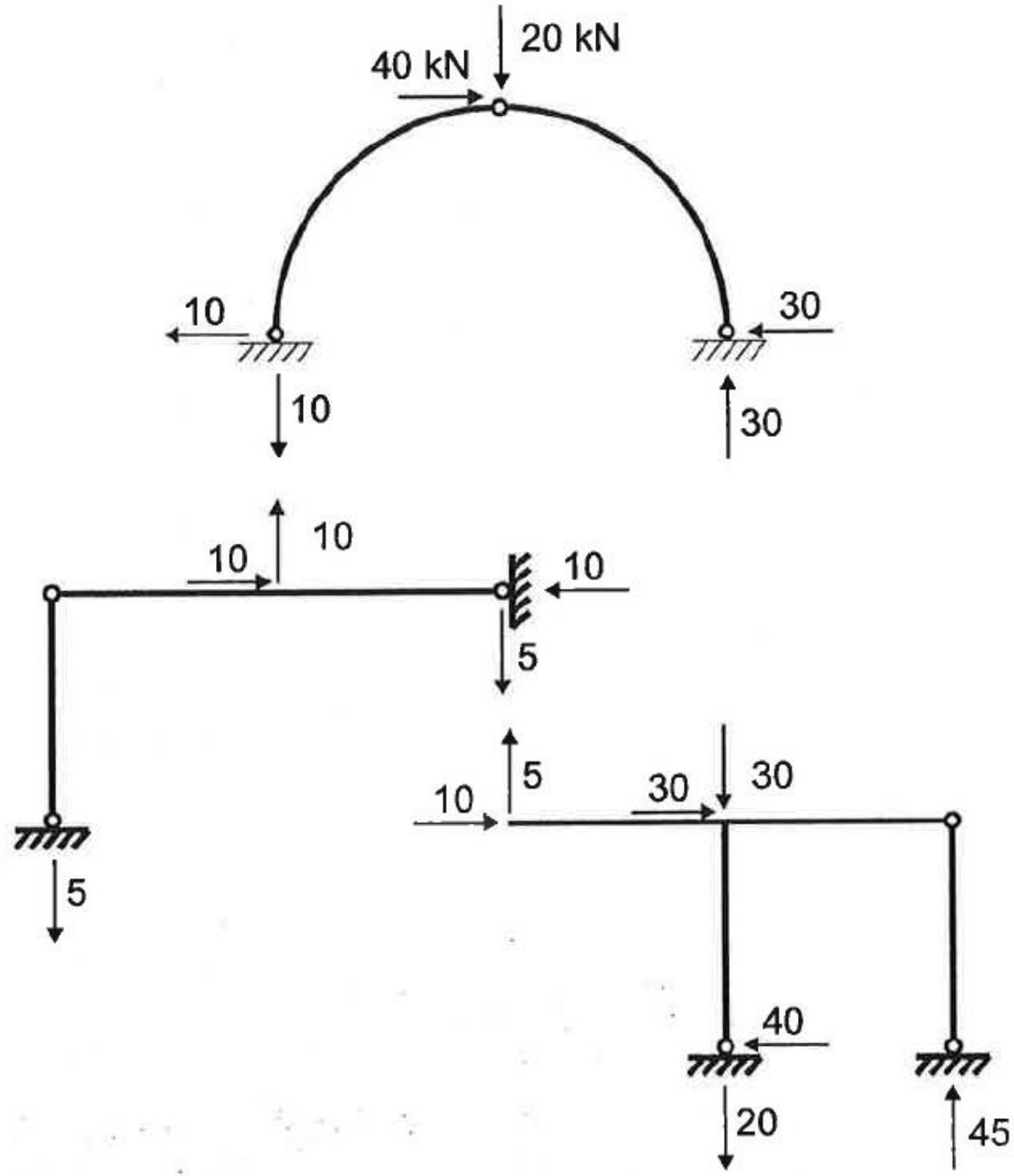


M (kN.m)

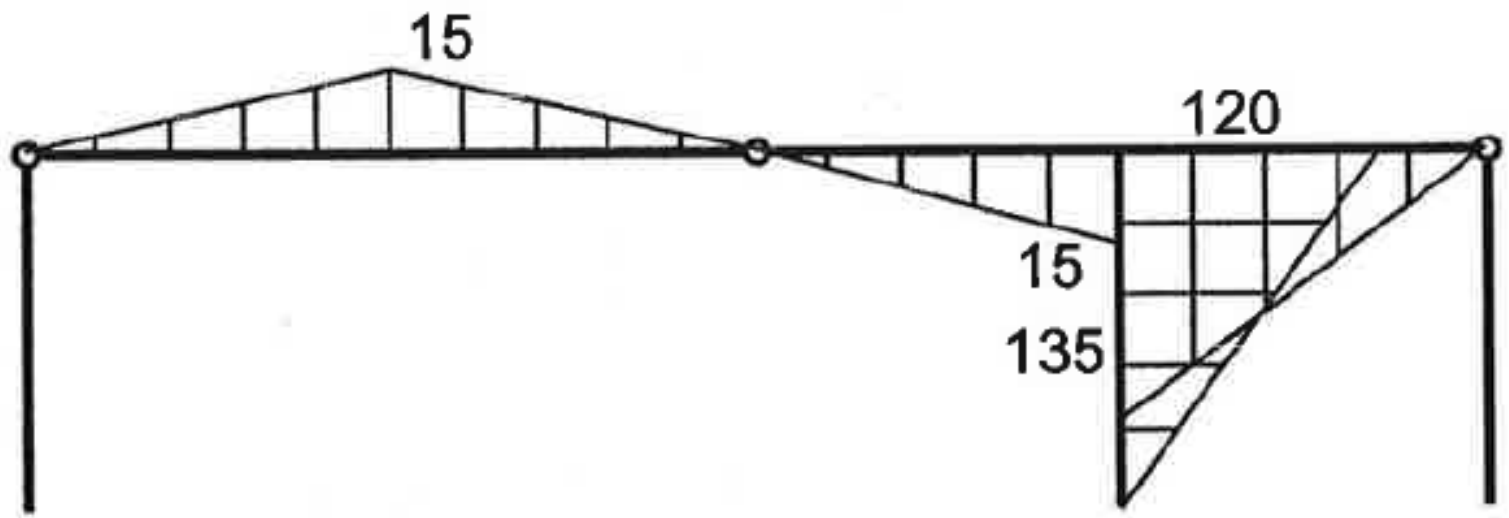
Exemplo 3

Traçar o diagrama de momentos fletores dos trechos retos da estrutura da figura:




40 kN
20 kN
10
30
10
30
10
10
10
10
5
5
10
5
30
30
40
20
45

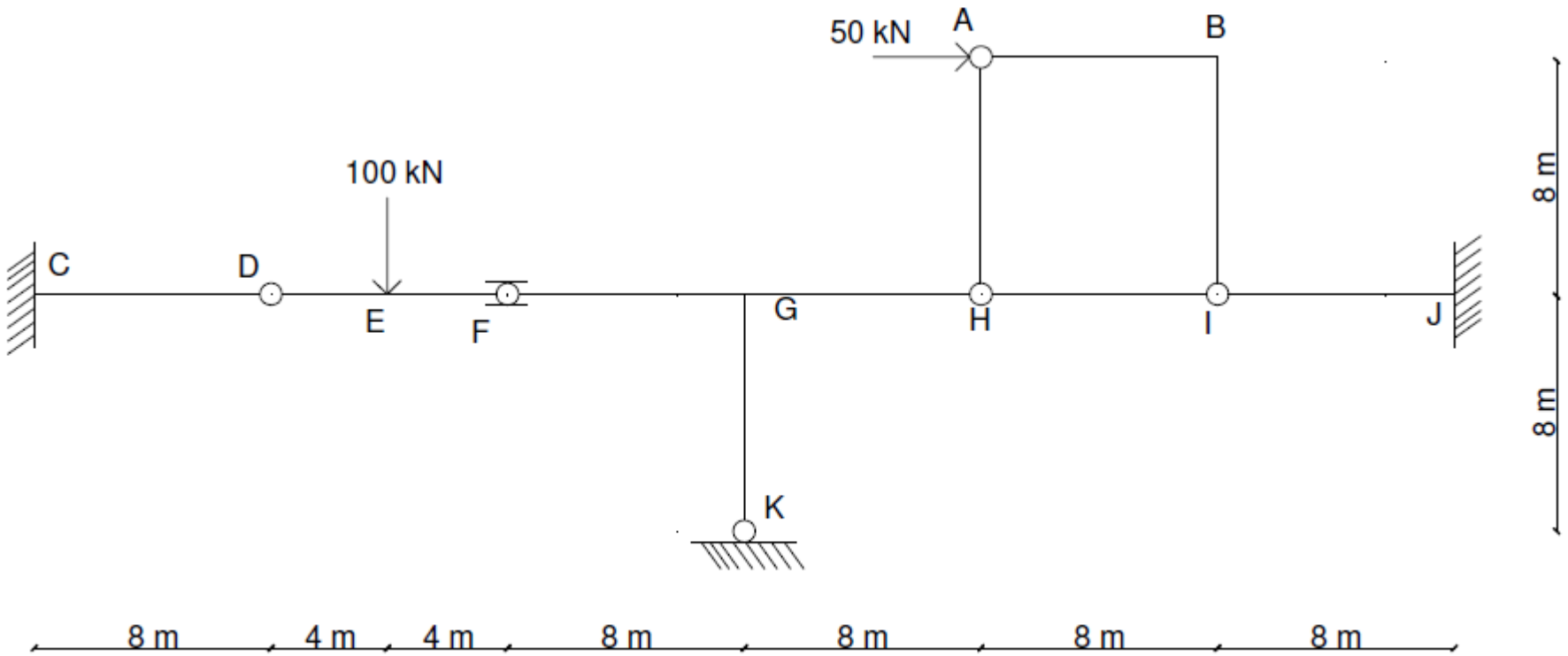
M (kNm)

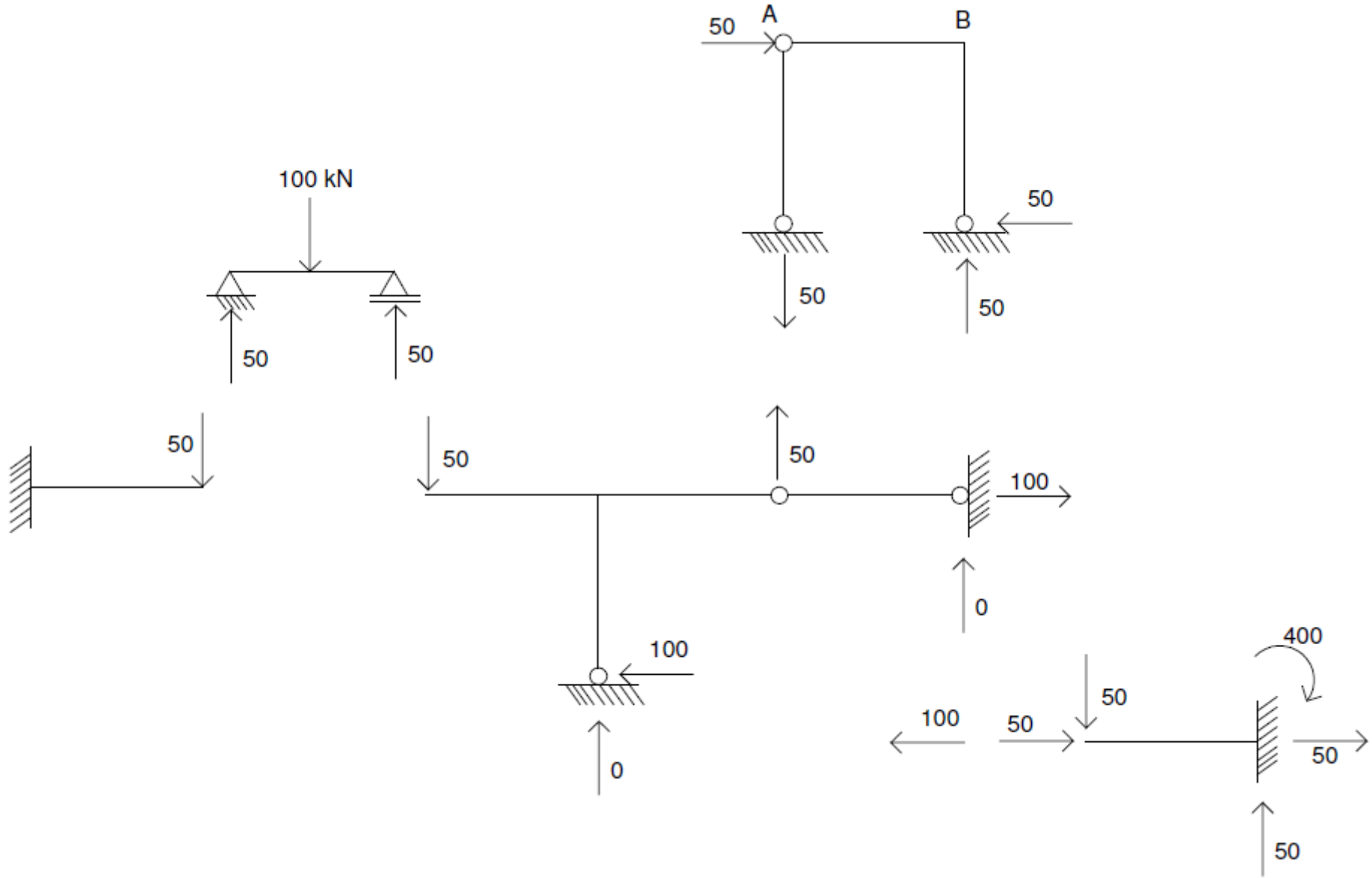


Exemplo 4: SUB 2009

Dada a estrutura associada da figura:

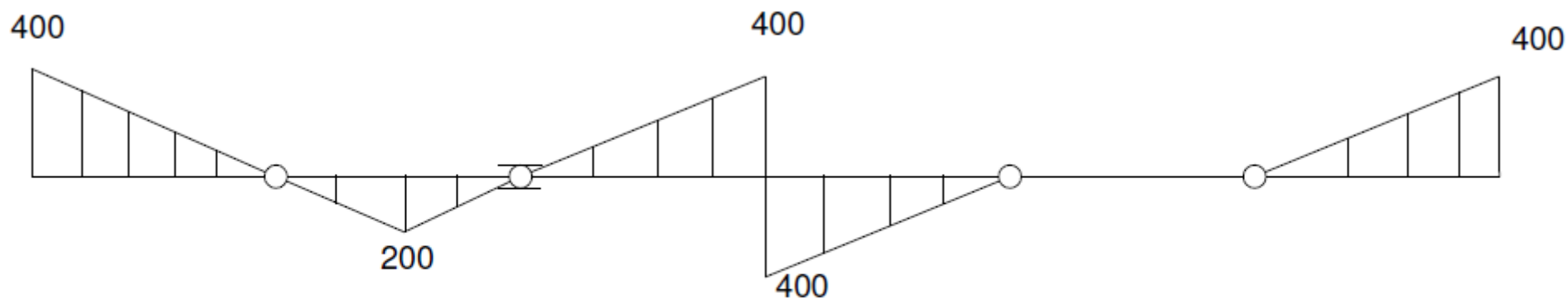
a) Decompô-la nas subestruturas que a formam;
b) Obter as reações de apoio em J e K;
c) Traçar o diagrama de momentos fletores do trecho CDEFGHIJ.




50
A
B
50
50
50
100 kN
50
50
50
50
50
100
0
100
0
400
50
100
50
50
50

$X_J = +50$ kN ($\rightarrow$) $Y_J = +50$ kN ($\uparrow$) $M_J = -400$ kN.m (horário)

$X_K = -100$ kN ($\leftarrow$) $Y_K = 0$



M (kN.m)

Exemplo 5: REC 2009

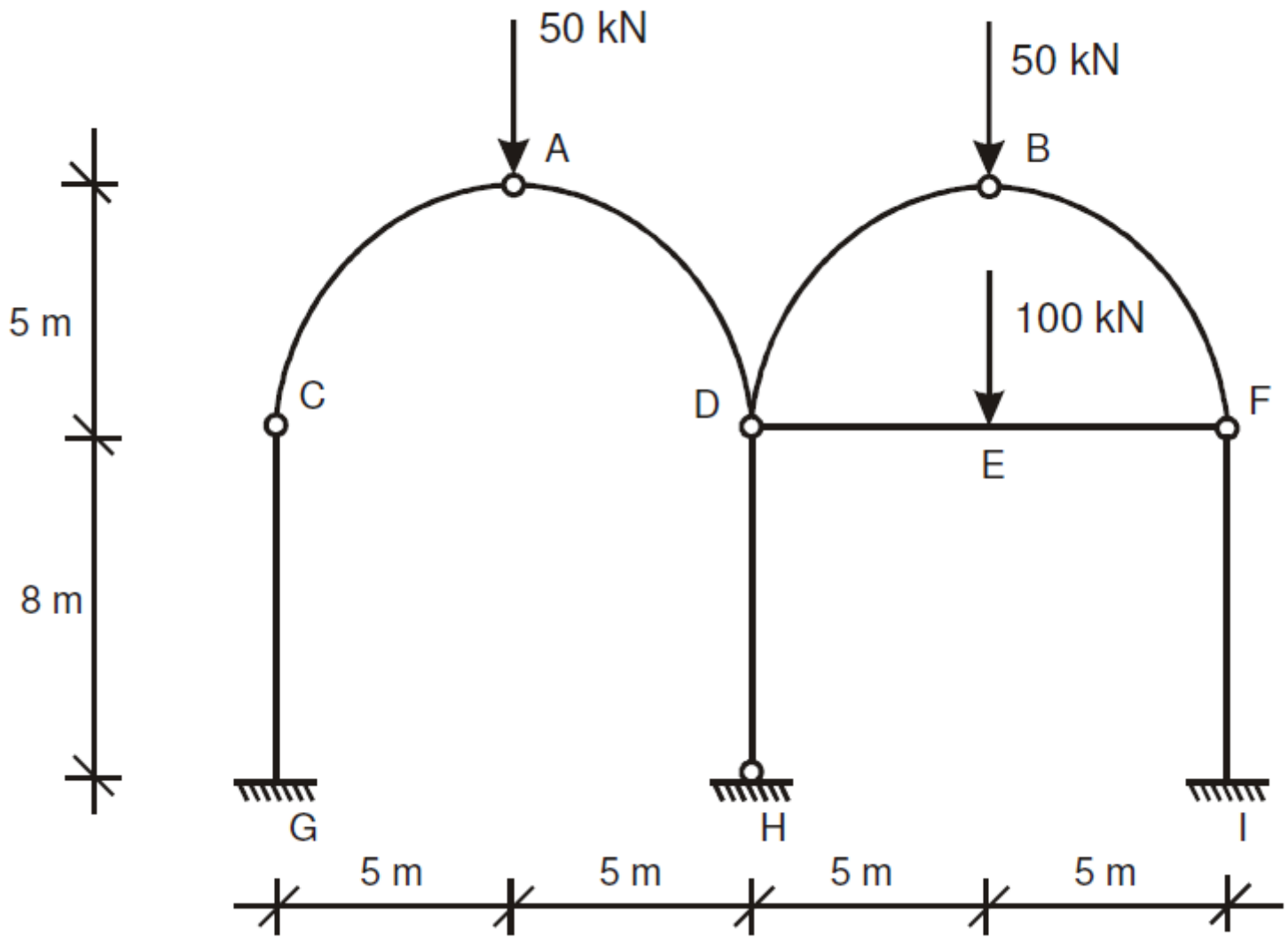
Na figura, mostra-se um corte transversal de uma loja, que possui dois ambientes cobertos por abóbadas semicirculares. O ambiente da direita possui um depósito situado no espaço criado pela abóbada de cobertura.

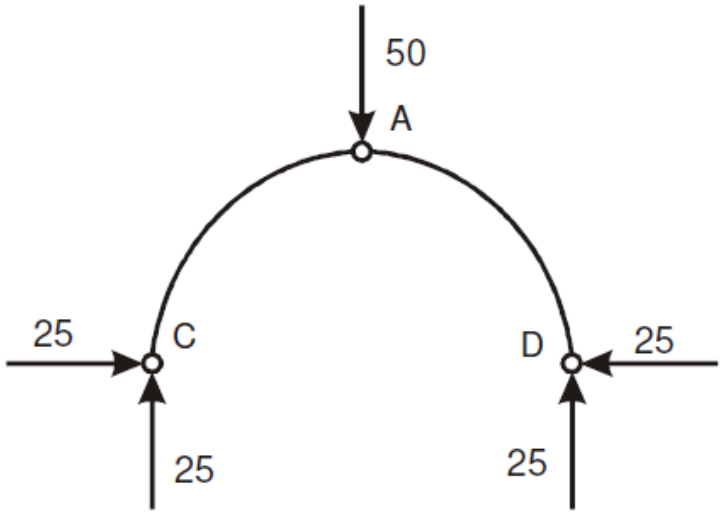
Observa-se que a estrutura transversal desta loja é uma estrutura associada, para a qual pede-se:

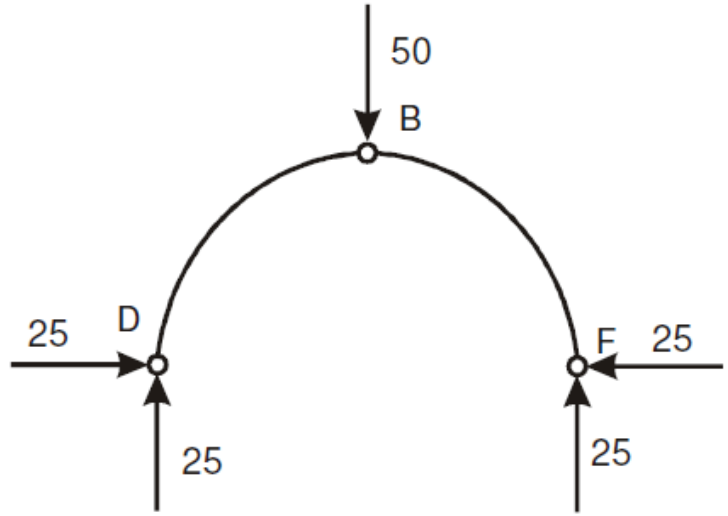
a) Decompor a estrutura associada nas subestruturas que a compõem;

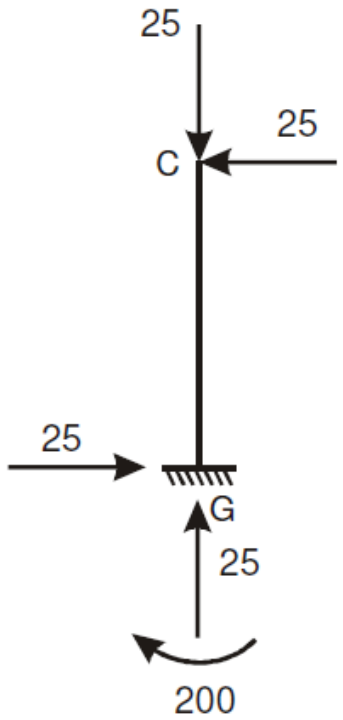
b) Determinar as reações de cada uma destas subestruturas;

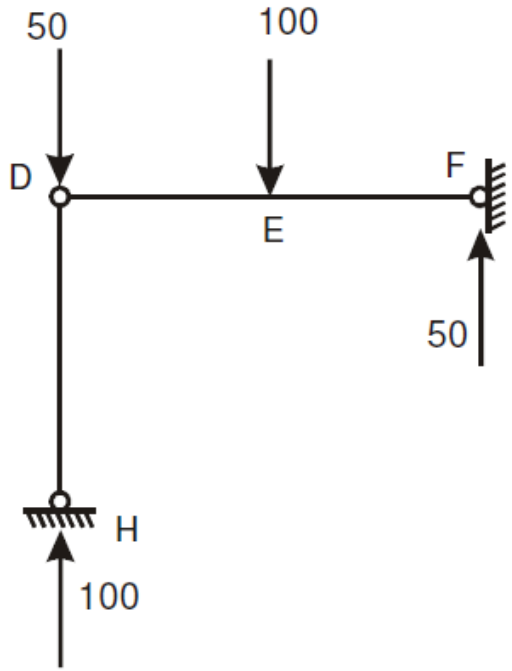
c) Traçar os diagramas de forças normais, de forças cortantes e de momentos fletores **apenas das subestruturas formadas exclusivamente por barras retas.**

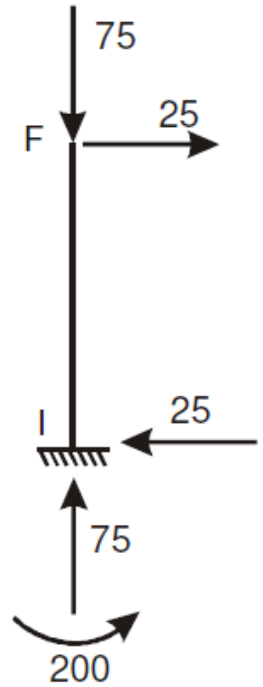

50 kN
50 kN
A
B
100 kN
5 m
8 m
C
D
F
E
G
H
I
5 m
5 m
5 m
5 m

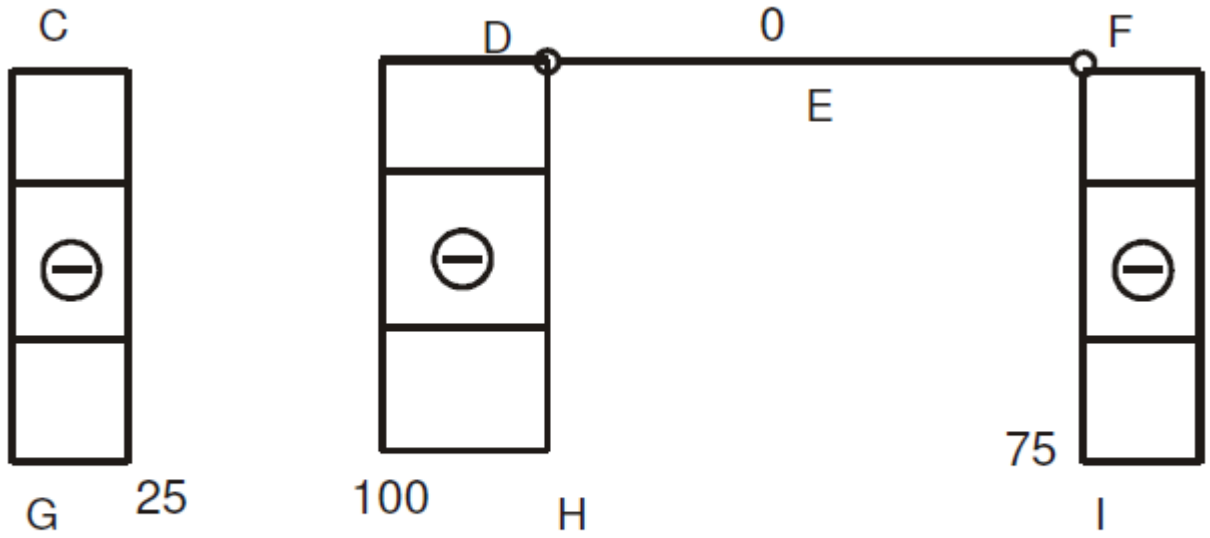

50
A
25
C
D
25
25
25


50
B
25
D
F
25
25
25

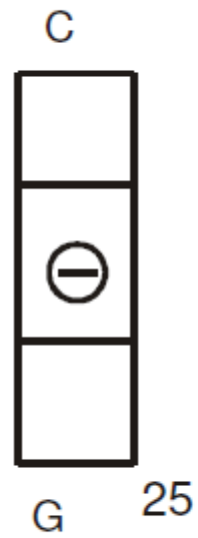

25
25
C
25
G
25
200

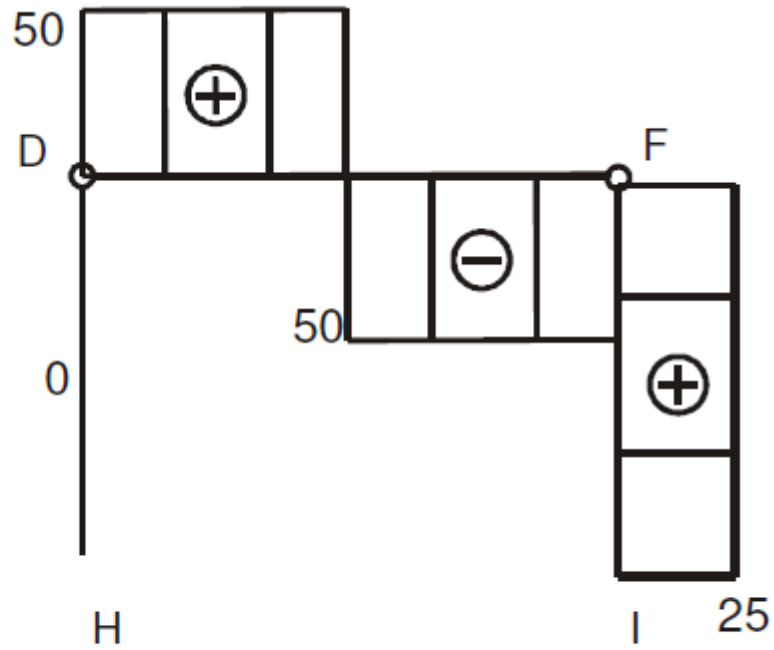

50
100
D
F
E
50
H
100


75
F
25
I
25
75
200

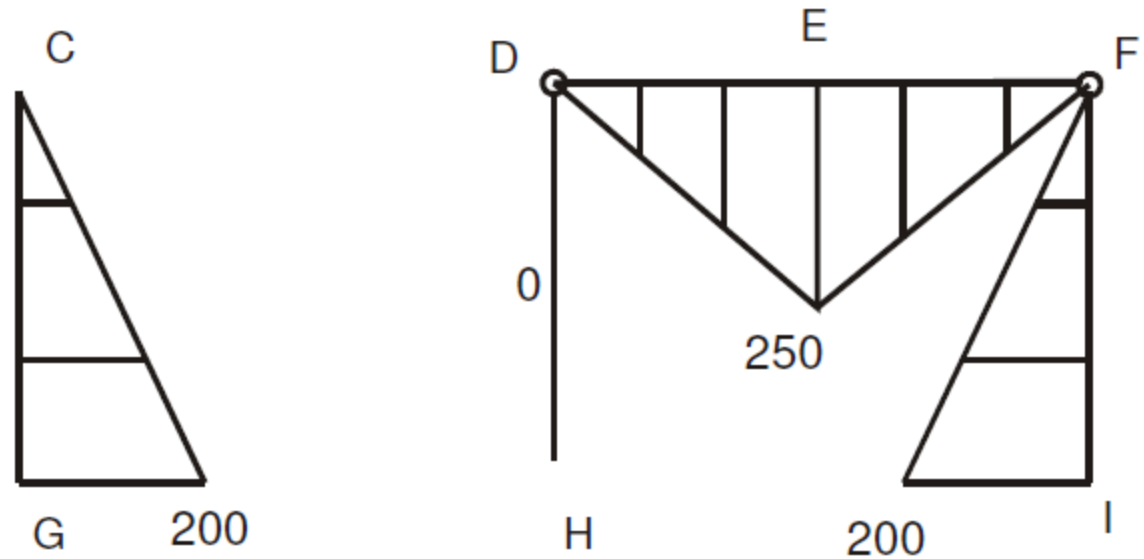


N (kN)





V (kN)

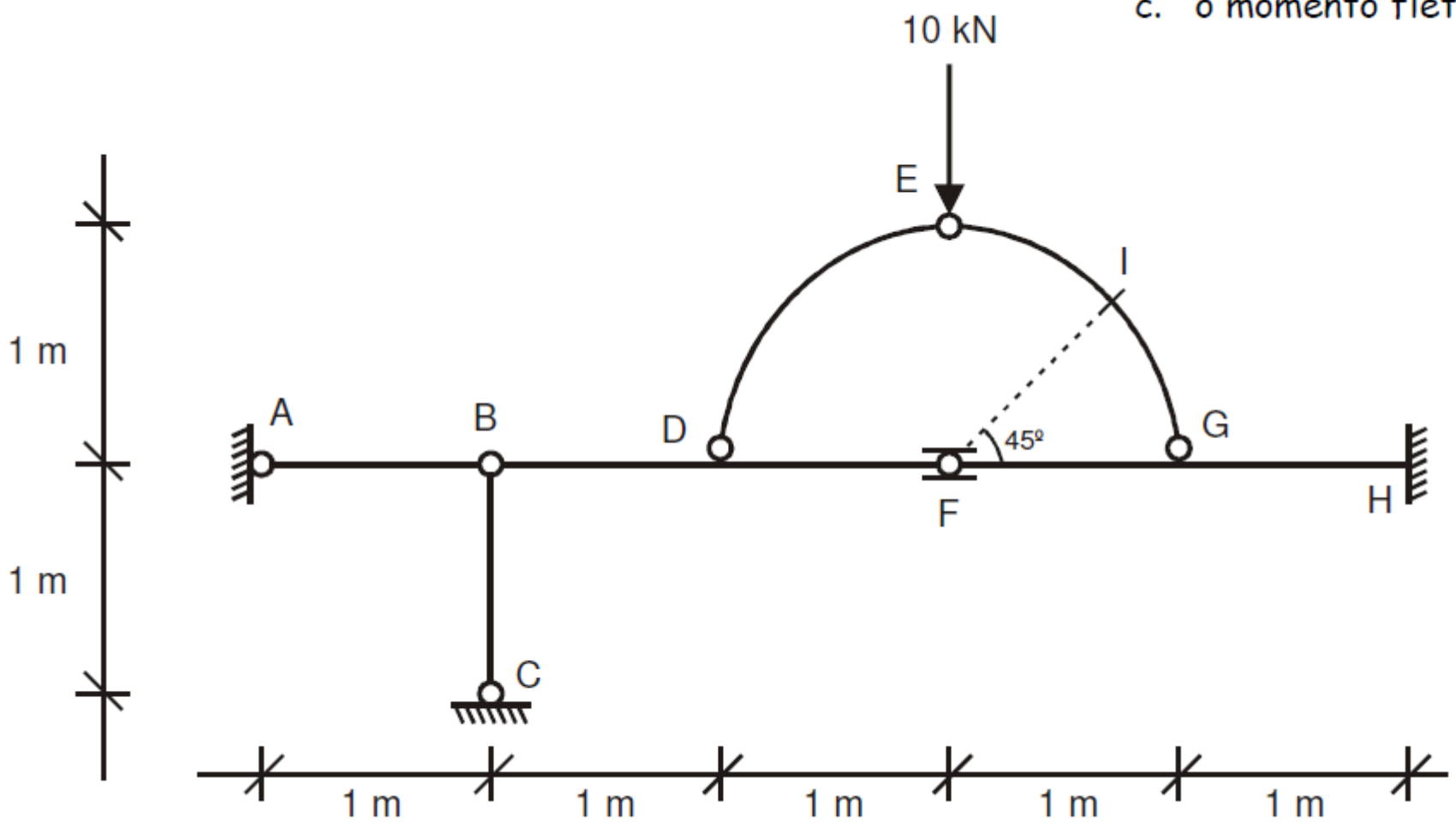


M (kN.m)

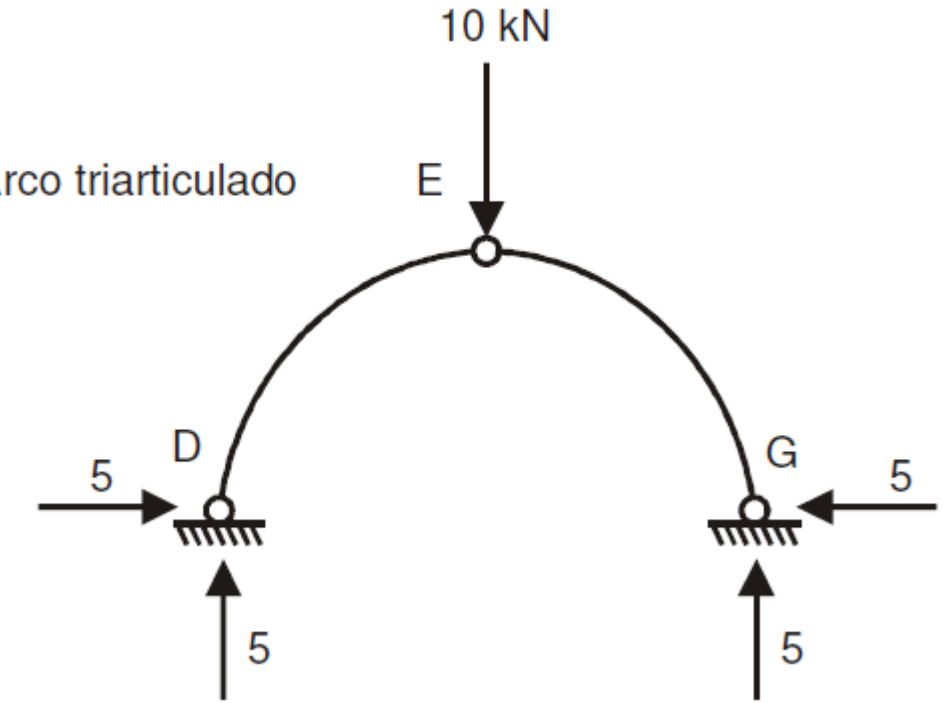
Exemplo 6: P3 2008

Na estrutura associada da figura, determine:

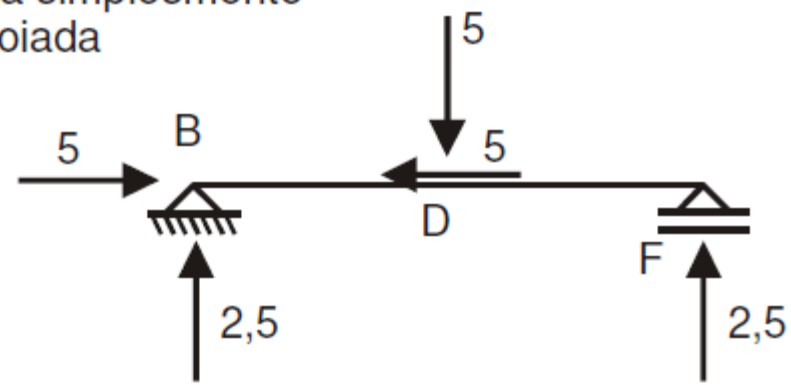
a. as subestruturas e as suas denominações;
b. as reações no apoio **H**;
c. o momento fletor na seção **I**.



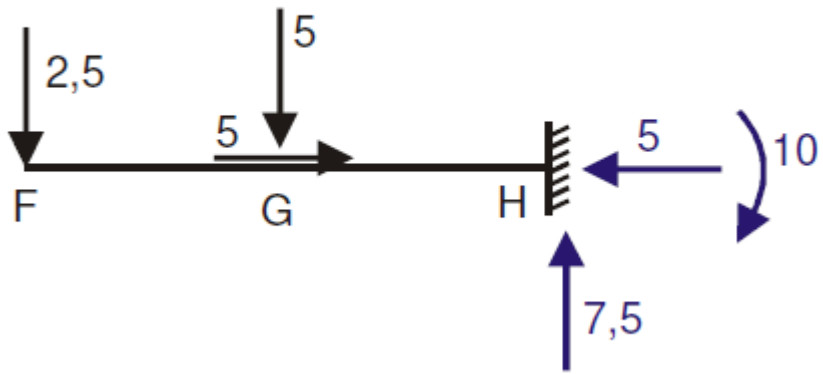
1) Arco triarticulado



2) Viga simplesmente apoiada

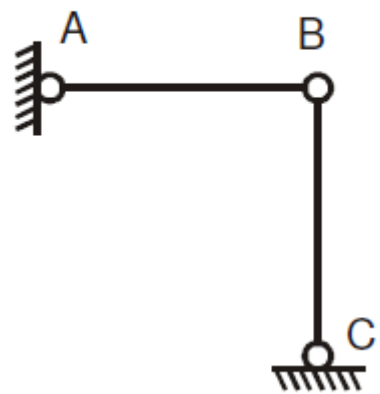


3) Viga engastada

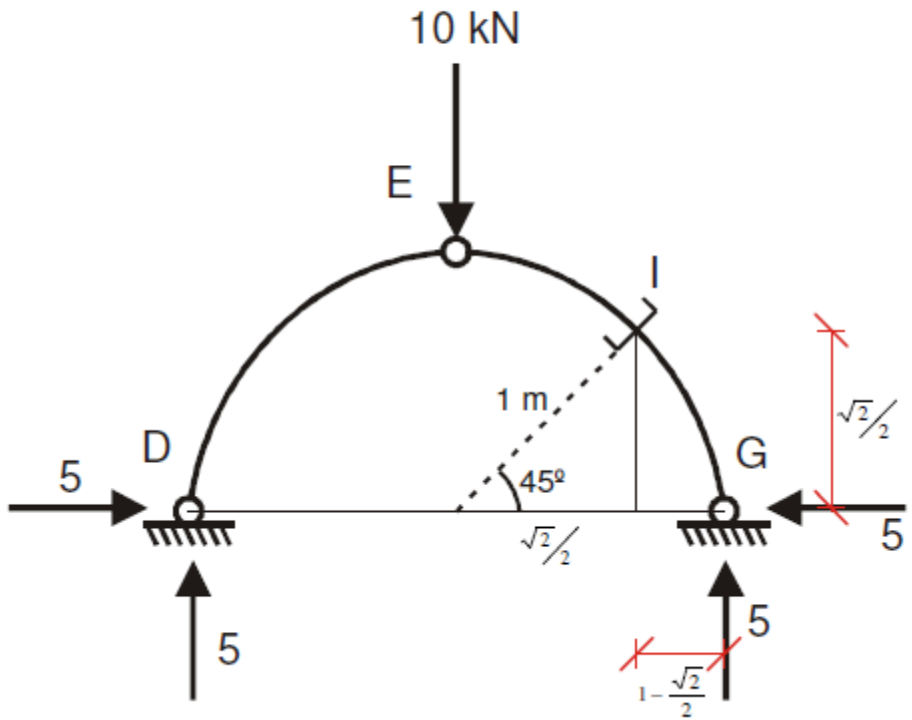


Reações em H:
$X_H = -5$ kN
$Y_H = +7{,}5$ kN
$M_H = -10$ kN.m

4) Pórtico triarticulado



c) Momento fletor na seção I:



$$M = 5\times\left(1-\frac{\sqrt{2}}{2}\right)-5\times\frac{\sqrt{2}}{2} = 5\times\left(1-\sqrt{2}\right)\text{kN}\cdot\text{m}$$

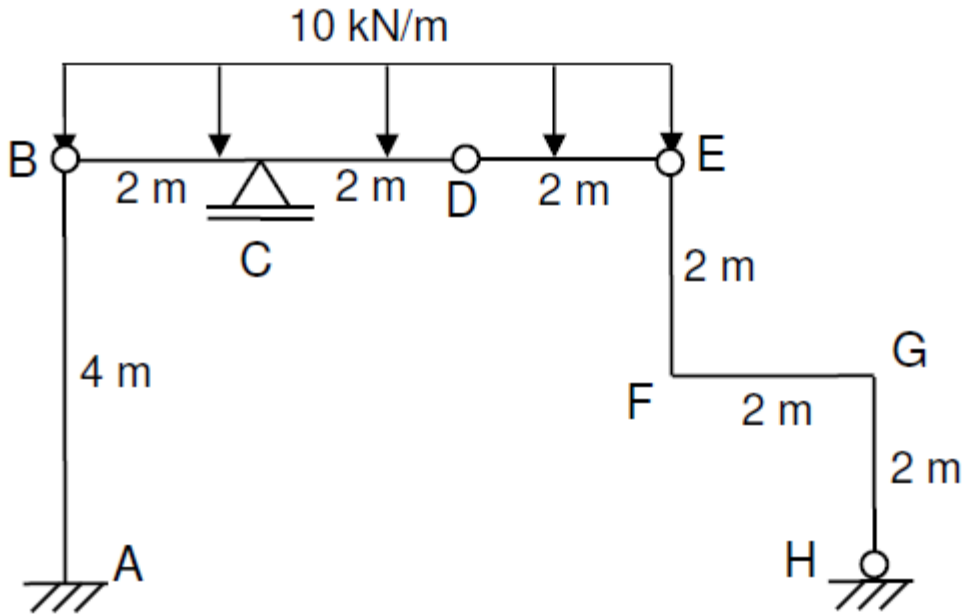
$$\boxed{M = -2{,}07\ \text{kN}\cdot\text{m}}$$

(traciona fibras superiores/externas)

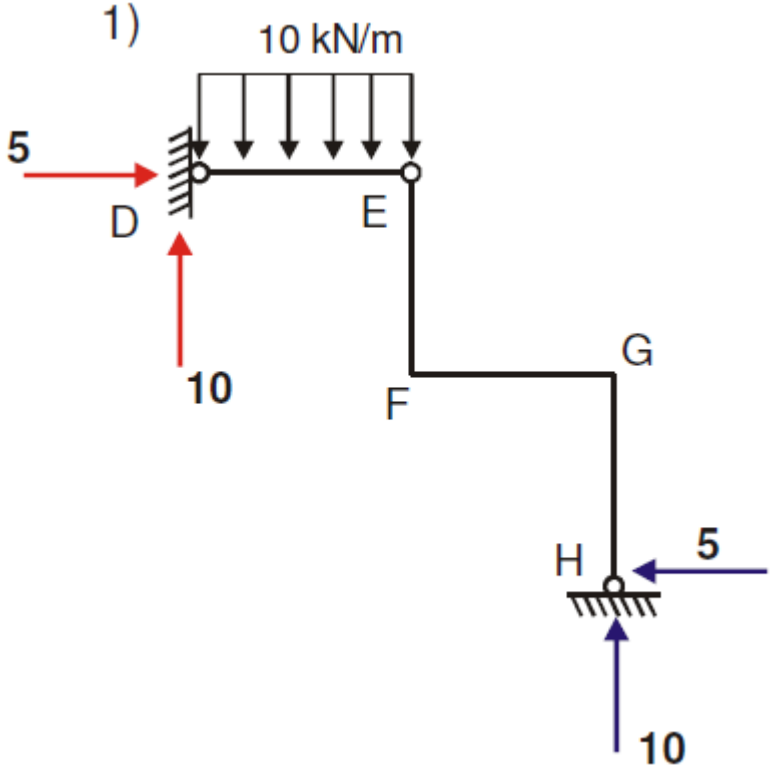
Exemplo 7: REC 2007

Para a estrutura associada da figura:

1. Divida a estrutura em subestruturas.
2. Obtenha os carregamentos e as reações de cada subestrutura.
3. Desenhe os diagramas de esforços solicitantes do trecho BCDE.

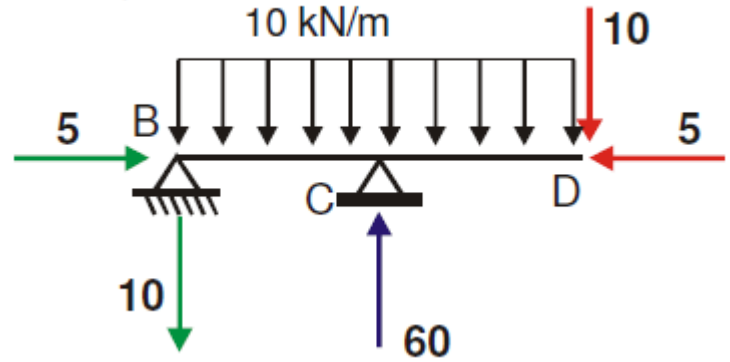


1)

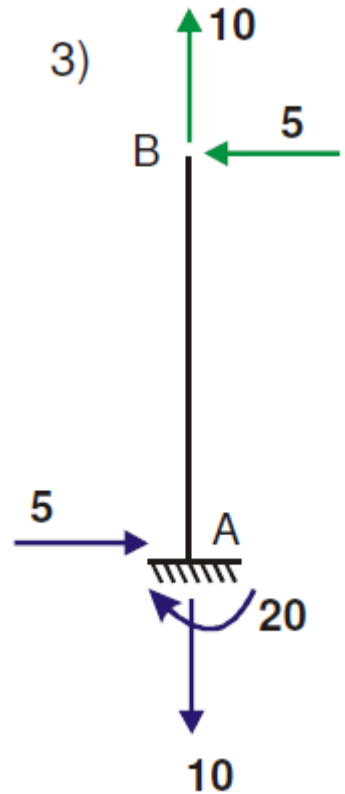


Divisão em 3 subestruturas:

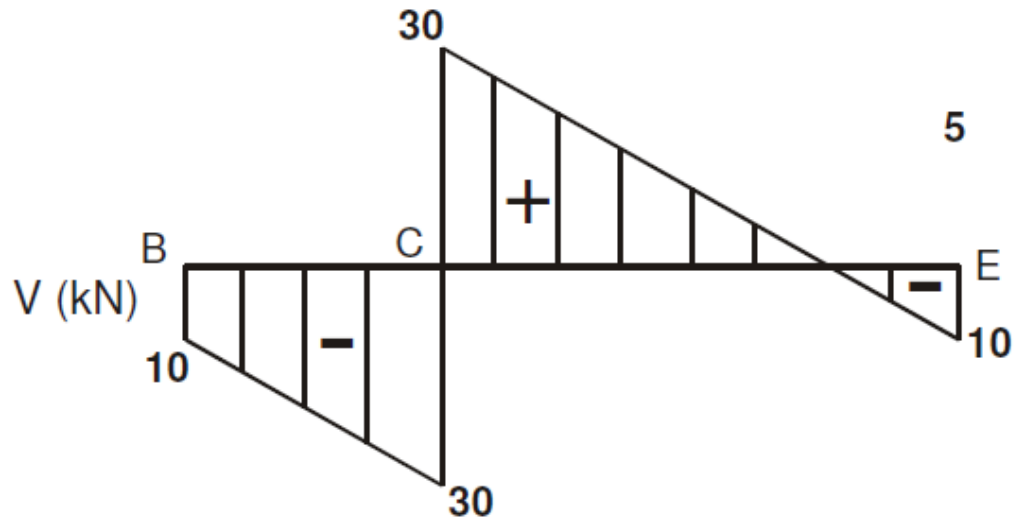
2)

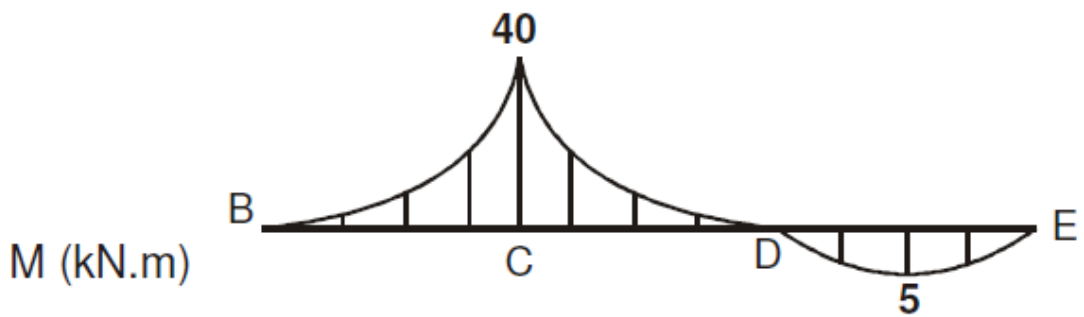


3)




5
5
B
E
N (kN)


30
5
B
C
E
V (kN)
10
10
30


40
B
E
M (kN.m)
C
D
5

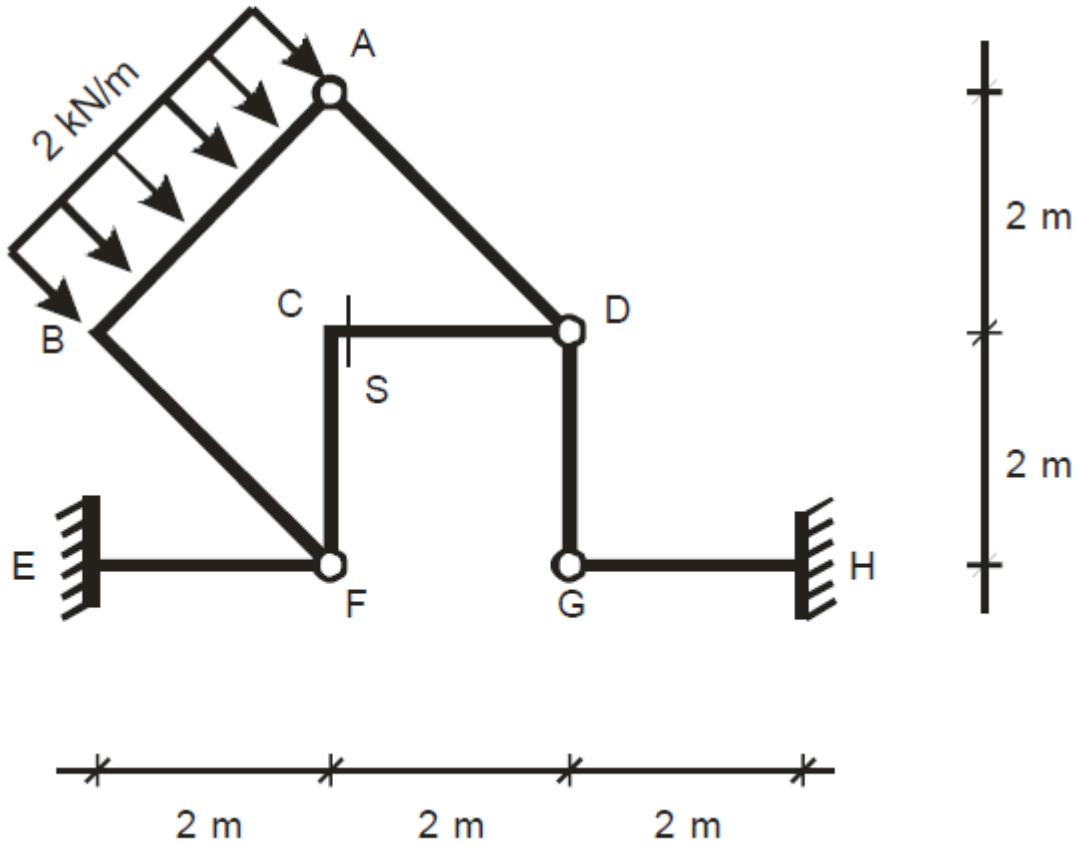
Exemplo 8: SUB 2005

Para a estrutura da figura:

a) Planejar, por meio de figuras, sua resolução;

b) Obter as reações de apoio;

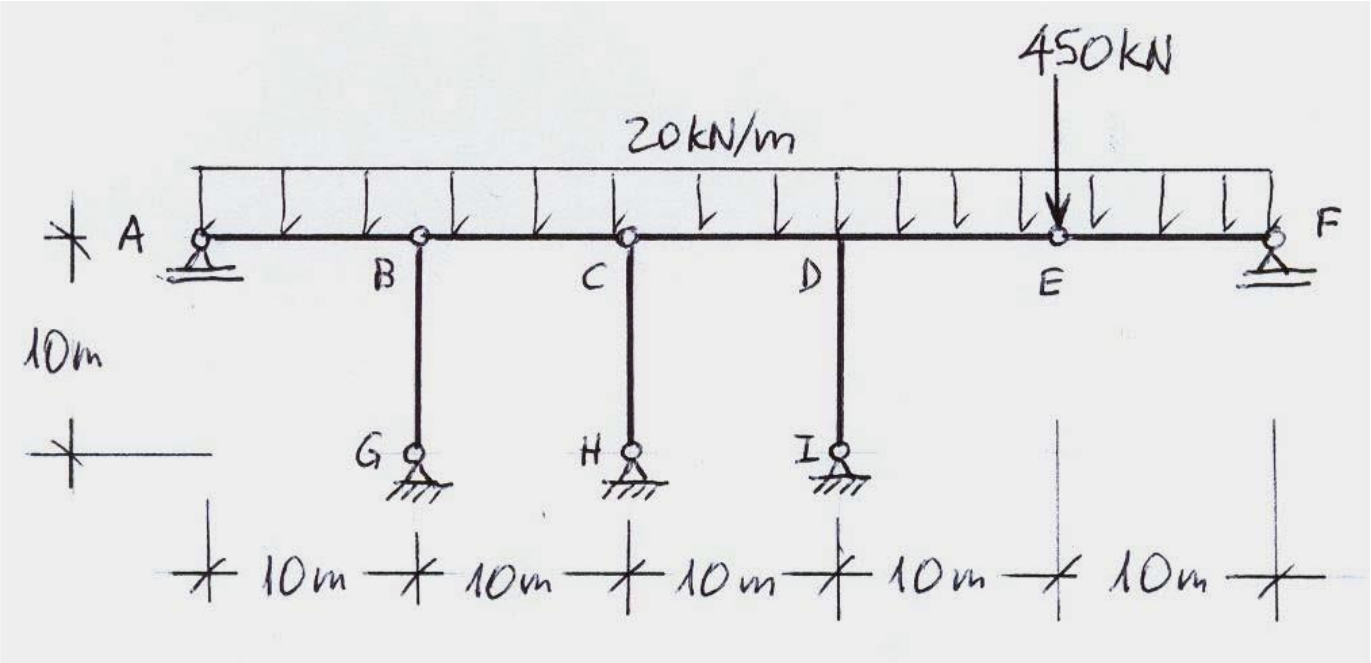
c) Calcular os esforços solicitantes na seção S imediatamente à direita de C.



R:
$$X_E = -4kN$$
$$Y_H = 4kN$$
$$M_H = -8kNm$$

Seção S [:
$$M = 4kNm$$
$$N = 2kN$$
$$V = -2kN$$

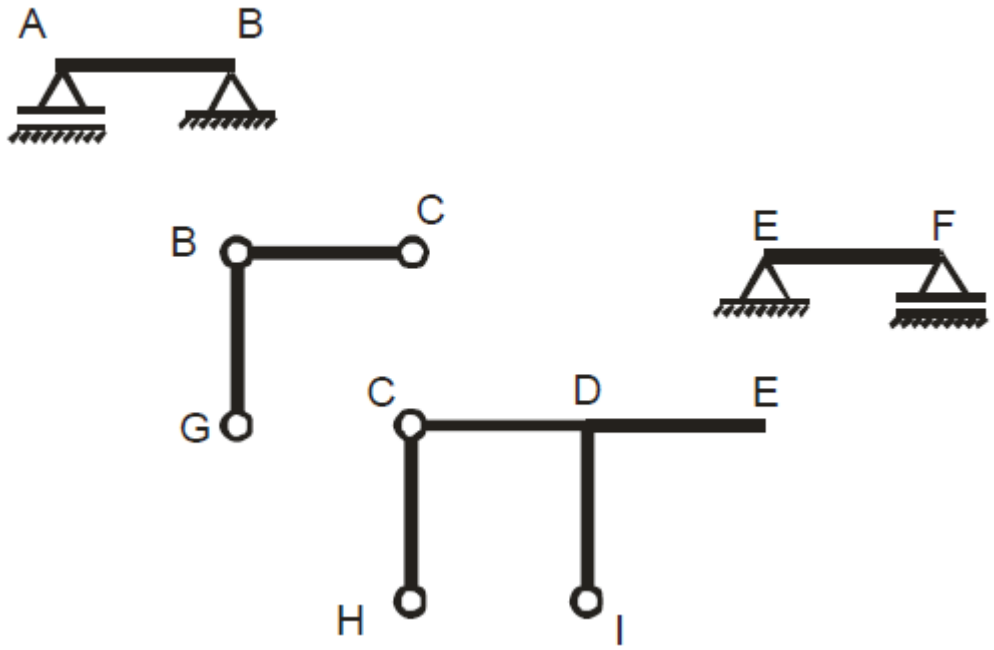
Exemplo 9: REC 2005



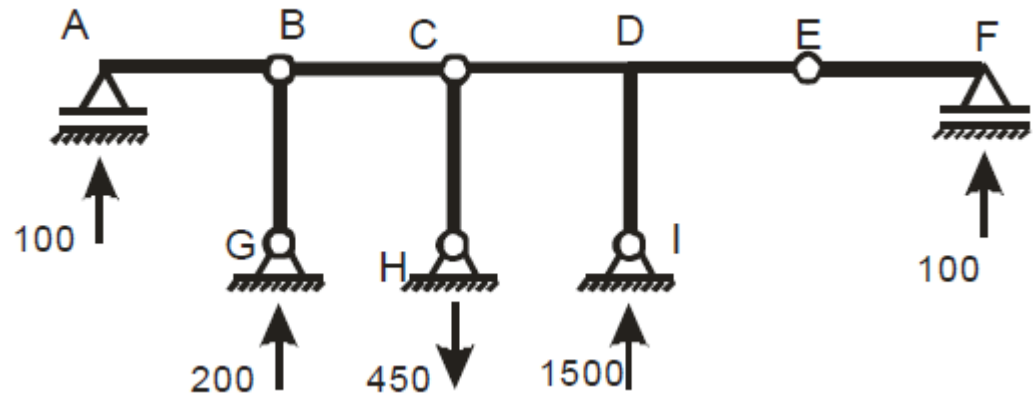
Para a estrutura ilustrada:

a. conceba e ilustre uma estratégia de resolução;
b. obtenha as reações de apoio;
c. calcule e ilustre todos os esforços solicitantes atuantes nas seções em torno do nó D.

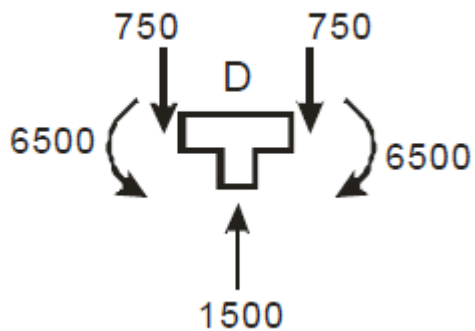
a.


A
B
C
B
G
E
F
C
D
E
H
I

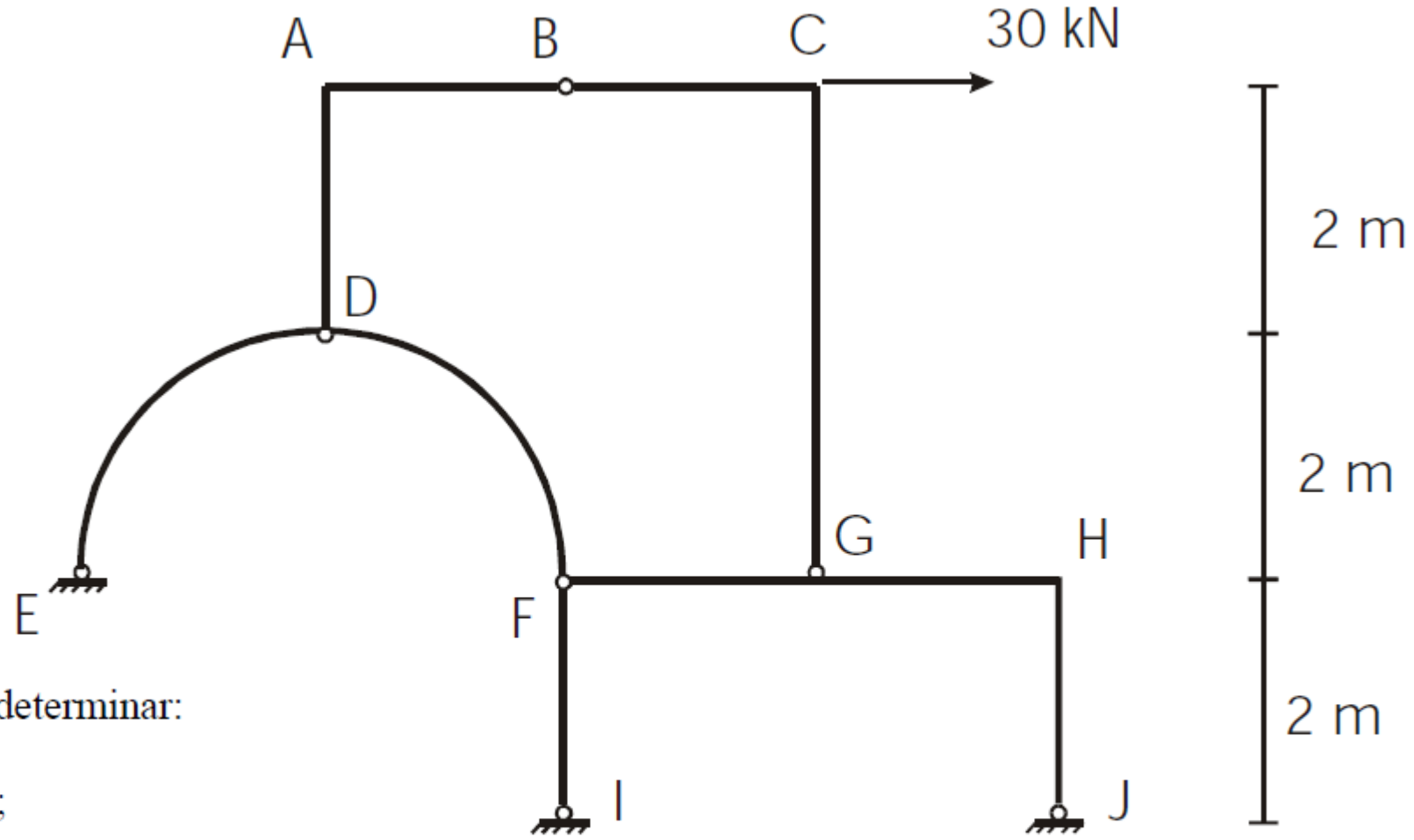
b.


A
B
C
D
E
F
100
G
H
I
100
200
450
1500

c.


750
750
D
6500
6500
1500

Exemplo 10: REC 2004

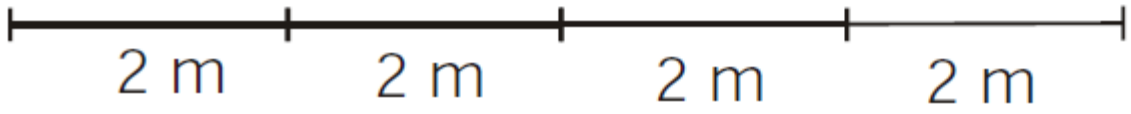


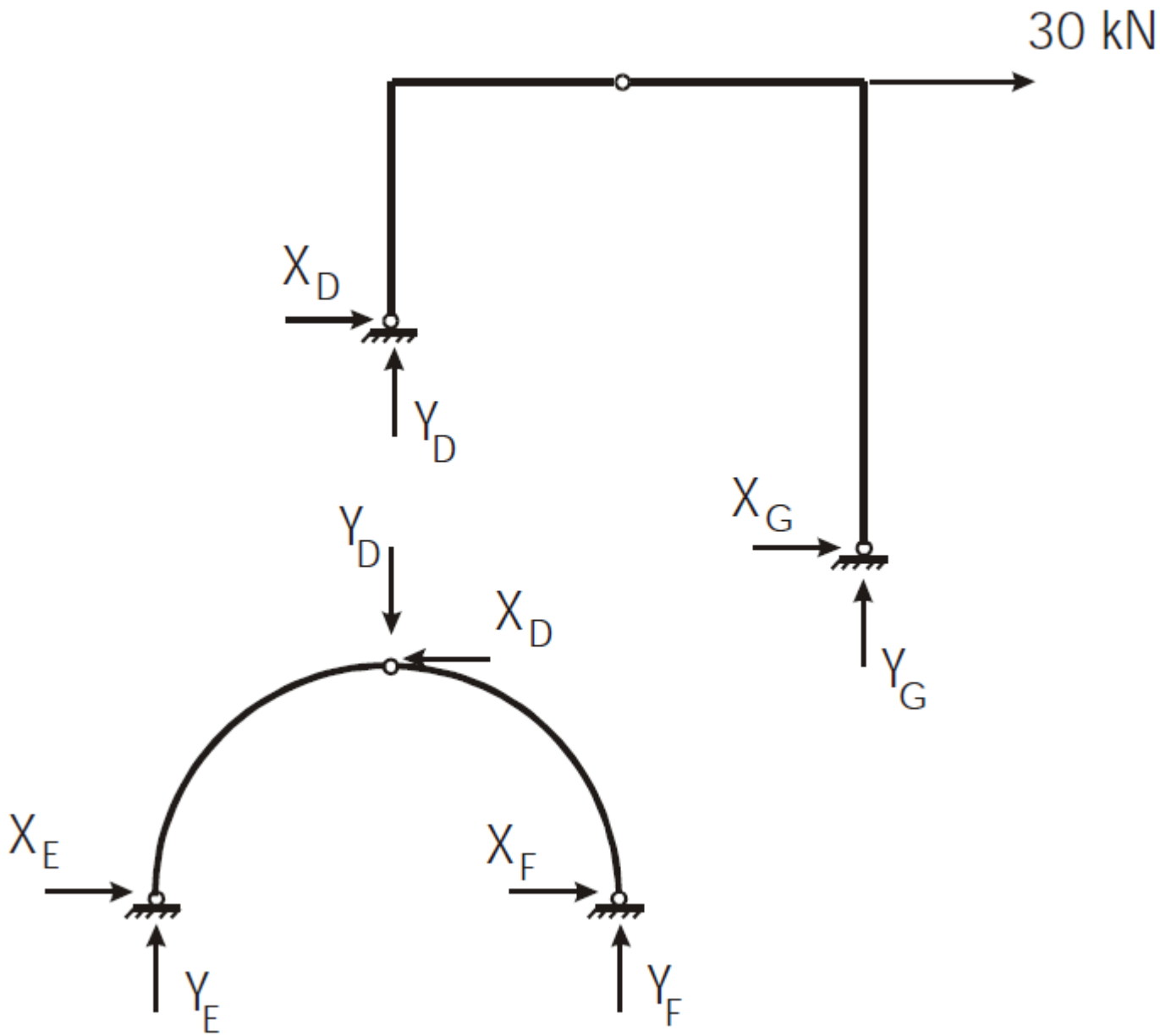
Para a estrutura associada da figura, determinar:

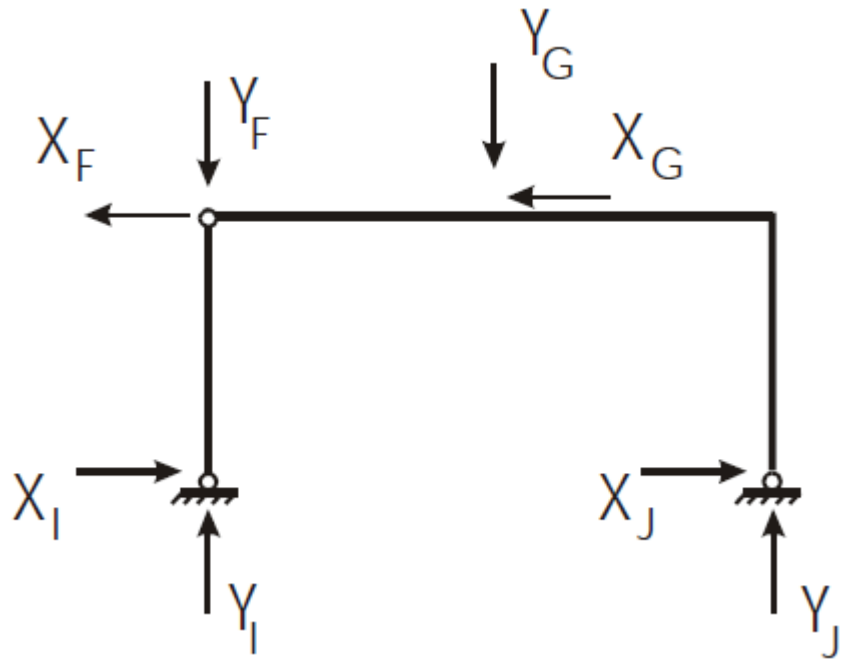
a) As subestruturas que a compõem;

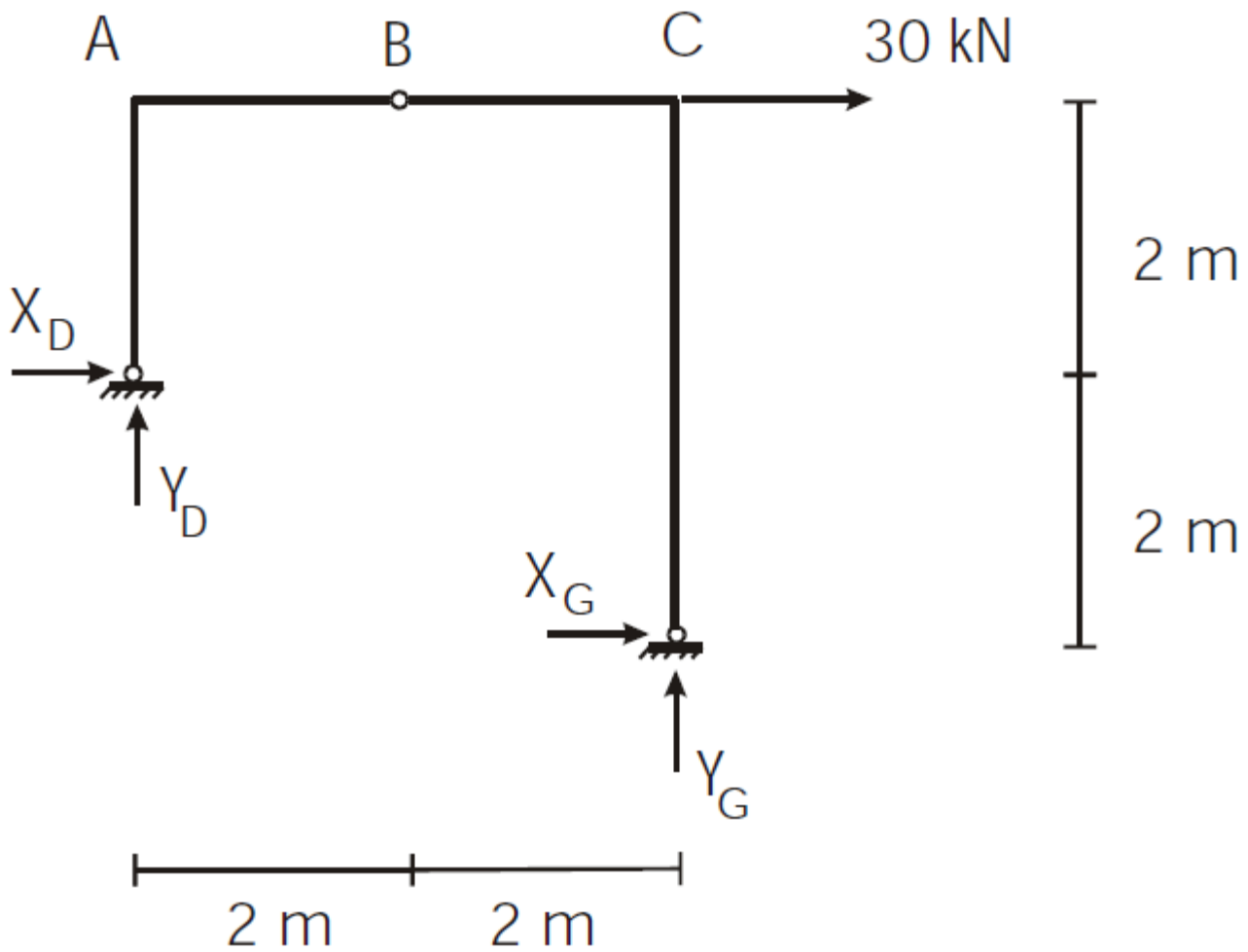
b) As reações de apoio de cada uma destas subestruturas;

c) O diagrama de momentos fletores **do trecho *IFGHJ***.




30 kN
X_D
Y_D
X_G
Y_G
Y_D
X_D
X_E
Y_E
X_F
Y_F


Y_G
Y_F
X_F
X_G
X_I
Y_I
X_J
Y_J



$\Sigma X = 0 \qquad X_D + X_G + 30 = 0$

$\Sigma Y = 0 \qquad Y_D + Y_G = 0$

$\Sigma M_G = 0 \qquad -X_D .2 - Y_D .4 - 30 .4 = 0$

$M_{fletor\ em\ B} = 0 \qquad Y_D .2 - X_D .2 = 0$

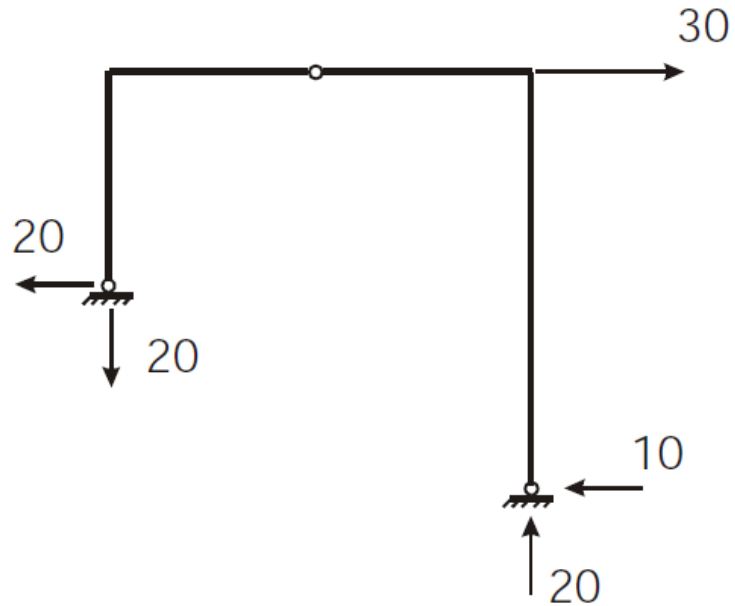
$Y_D = X_D$

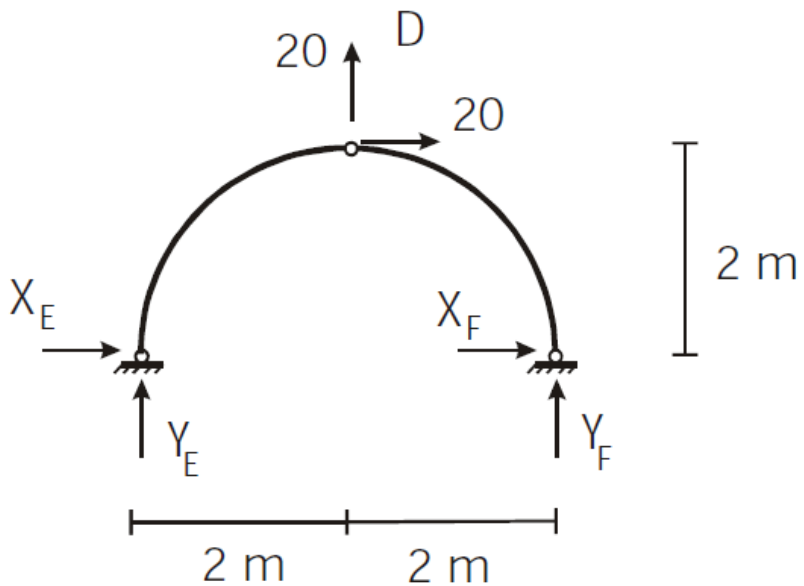
$-2 . Y_D - 4 . Y_D = 120$

$Y_D = -20 = X_D$

$Y_G = 20$

$-20 + X_G + 30 = 0 \qquad X_G = -10$





$\Sigma X = 0 \qquad X_E + X_F + 20 = 0$

$\Sigma Y = 0 \qquad Y_E + Y_F + 20 = 0$

$\Sigma M_G = 0 \qquad 20 .2 - 20 .2 + Y_F .4 = 0$

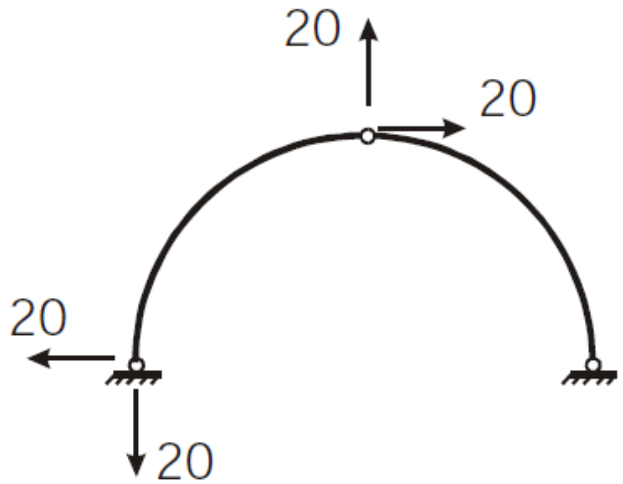
$M_{\text{fletor em D}} = 0 \qquad Y_F .2 + X_F .2 = 0$

$Y_F = 0$

$X_F = 0$

$Y_E = -20$

$X_E = -20$

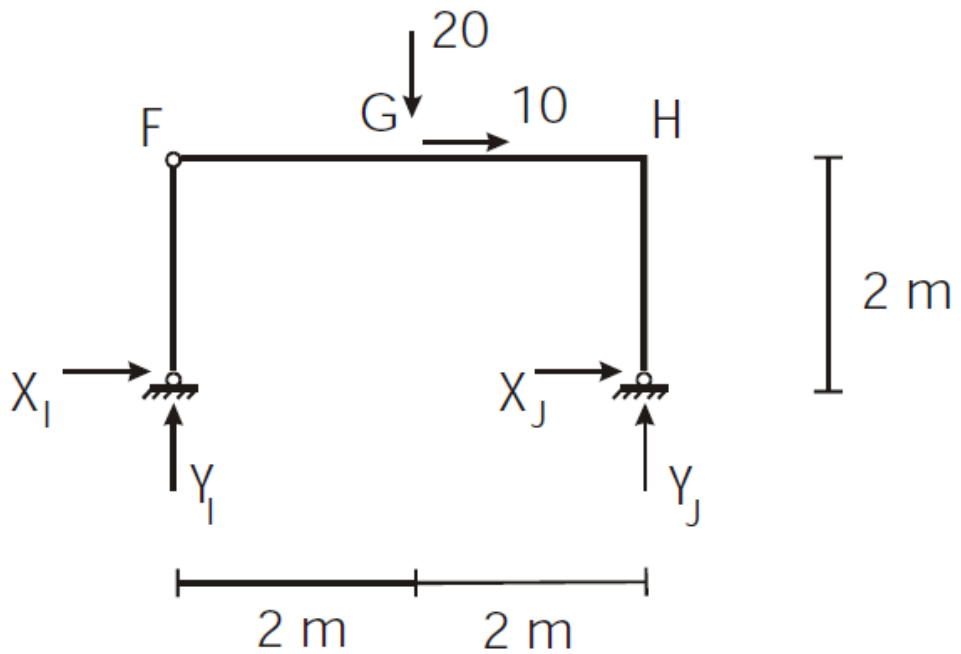


$\Sigma X = 0 \qquad X_I + X_J + 10 = 0$

$\Sigma Y = 0 \qquad Y_I + Y_J - 20 = 0$

$\Sigma M_G = 0 \qquad -20 .2 - 10 .2 + Y_J .4 = 0$

$M_{\text{fletor em F}} = 0 \qquad -X_I .2 = 0$

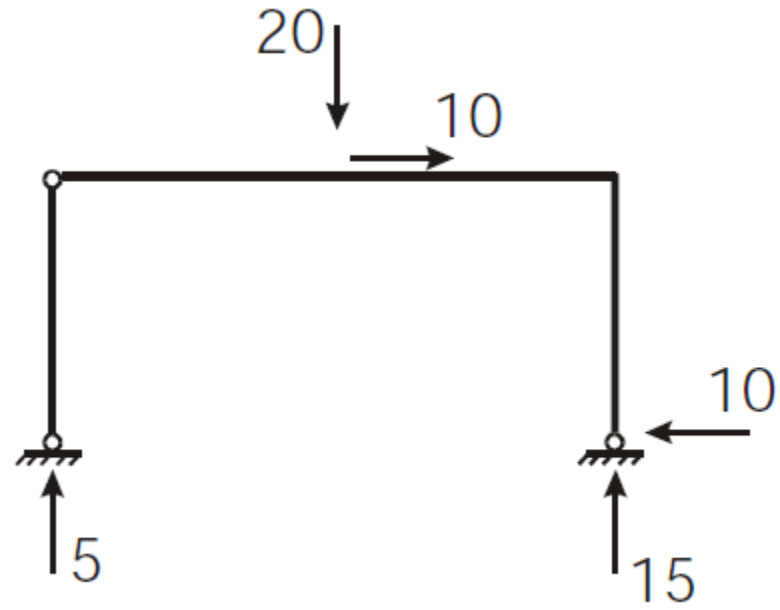


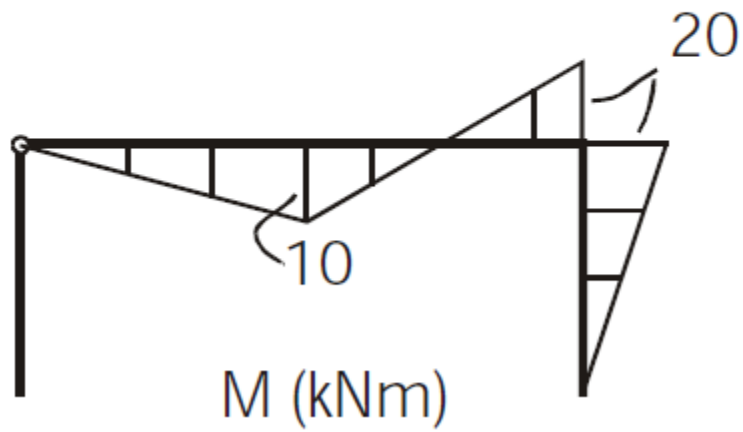
$X_I = 0$

$Y_J = 15$

$Y_I = 5$

$X_G = -10$

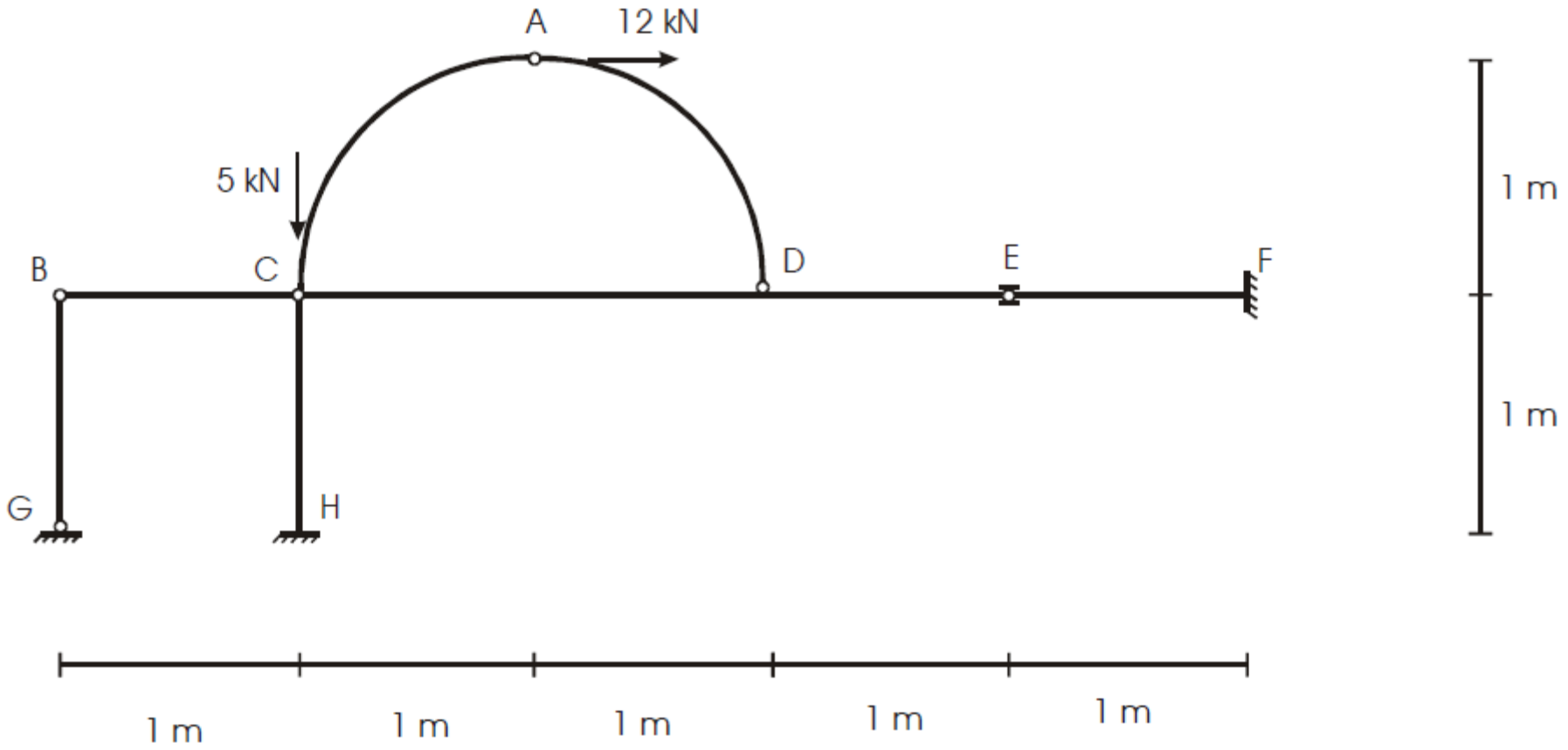

20
10
10
5
15


20
10
M (kNm)

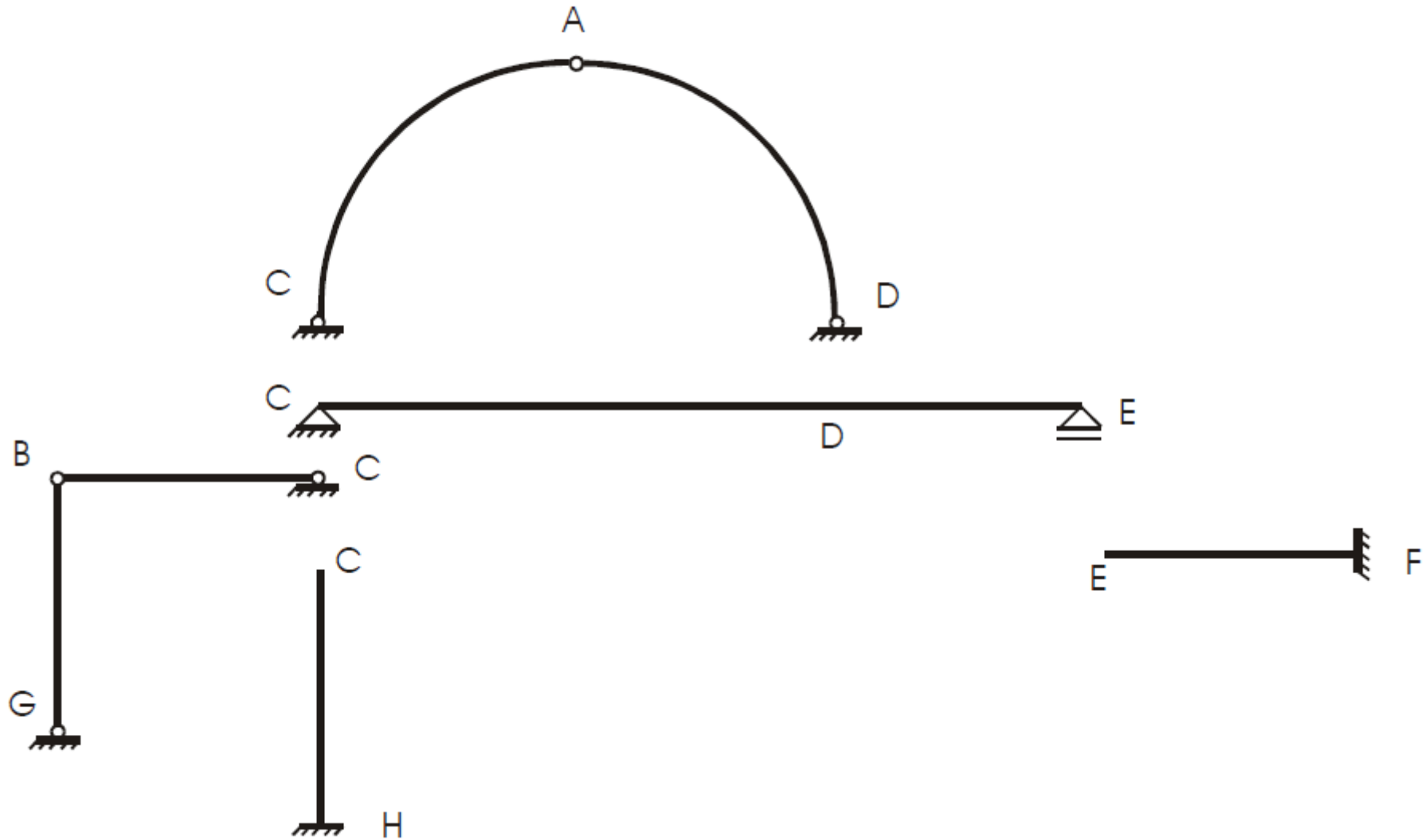
Exemplo 11: P3 2004

Para a estrutura associada da figura, determinar:

a) As subestruturas que a compõem;
b) As reações de cada uma destas subestruturas.

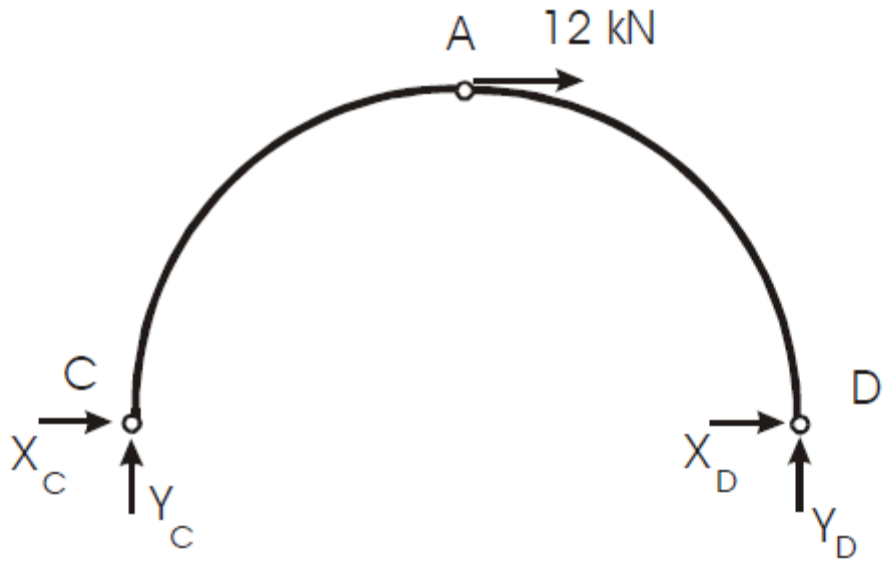


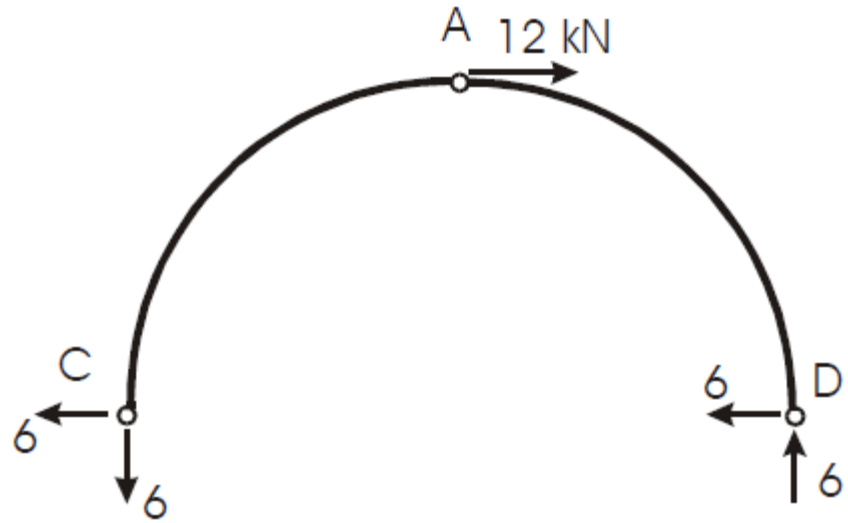
a)



b)

1)



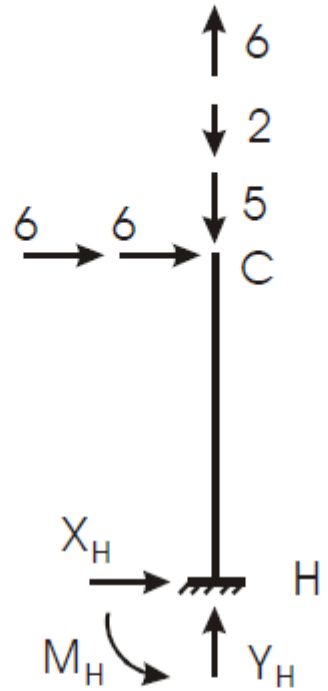


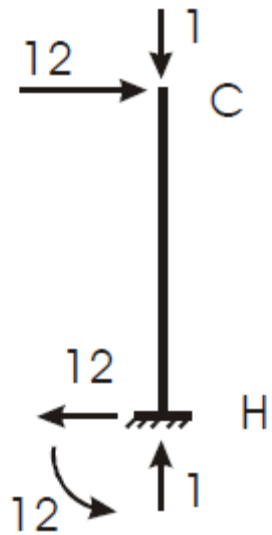
$\sum M_{(C)} = 0$	$-12 .1 + Y_D .2 = 0$	$Y_D = 6$ kN
$\sum Y = 0$	$Y_C + Y_D = 0$	$Y_C = -6$ kN
$M_{\text{fletor em A}} = 0$	$X_D .1 + Y_D .1 = 0$	$X_D = -6$ kN
$\sum X = 0$	$X_C + X_D + 12 = 0$	$X_C = -6$ kN

2)

$\sum M_{(E)} = 0$	$-Y'_C .3 + 6 .1 = 0$	$Y'_C = 2$ kN
$\sum X = 0$	$X'_C + 6 = 0$	$X'_C = -6$ kN
$\sum Y = 0$	$Y'_C - 6 + Y_E = 0$	$Y_E = 4$ kN

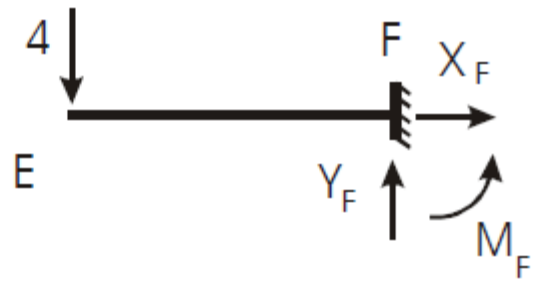
3)





$\sum X = 0$	$X_H + 6 + 6 = 0$	$X_H = -12$ kN
$\sum Y = 0$	$Y_H - 5 - 2 + 6 = 0$	$Y_H = 1$ kN
$\sum M_{(H)} = 0$	$M_H - 6 .1 .2 = 0$	$M_H = 12$ kNm

4)



$\sum X = 0$ $\quad X_F = 0$

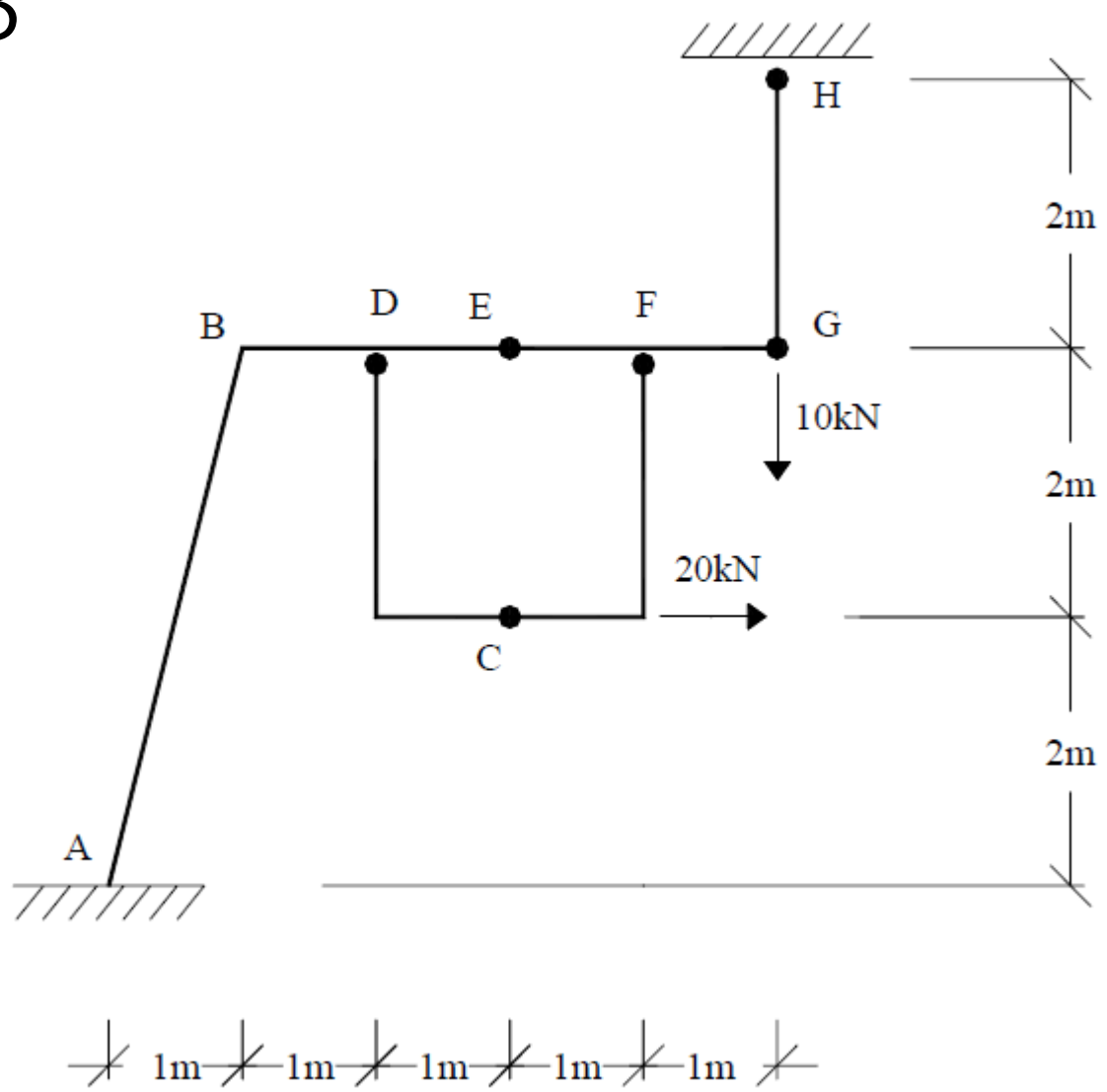
$\sum Y = 0$ $\quad -4 + Y_F = 0$ $\quad Y_F = 4$ kN

$\sum M_{(F)} = 0$ $\quad 4 \,.1 + M_F = 0$ $\quad M_F = -4$ kNm

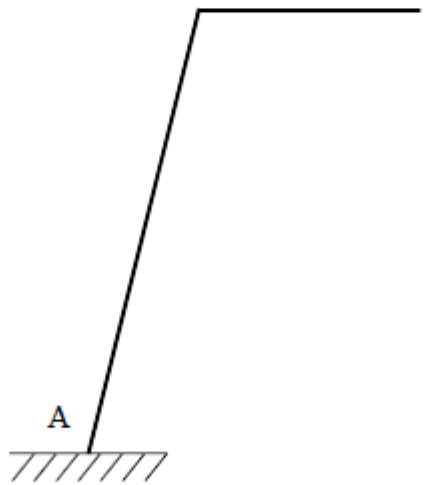
Exemplo 12: SUB 2003

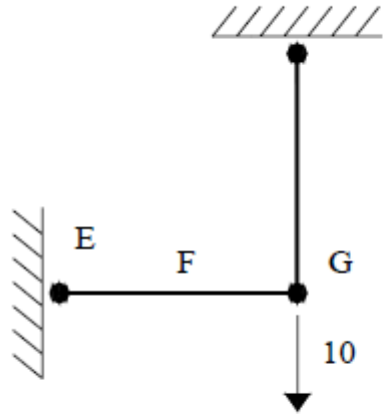
Na estrutura associada da figura, determine:

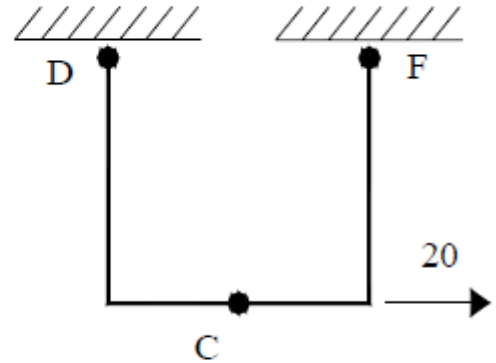
a) as subestruturas;
b) as reações em *A*;
c) o diagrama do momento fletor no trecho *EFGH*.



a) (1,0)

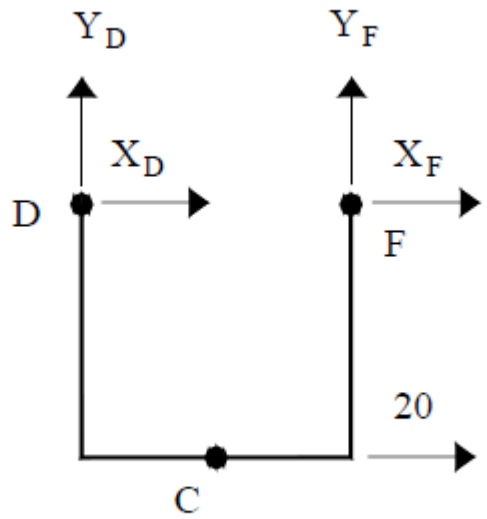






b)

1)

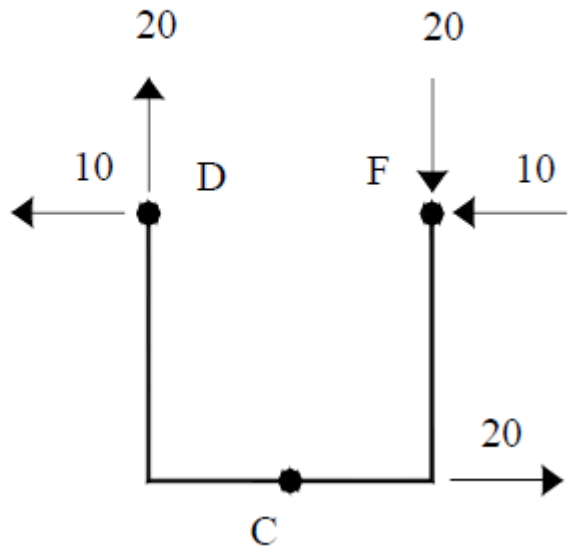


$$\sum M_D = 0 = Y_F \cdot 2 + 20 \cdot 2 \Rightarrow Y_F = -20kN$$

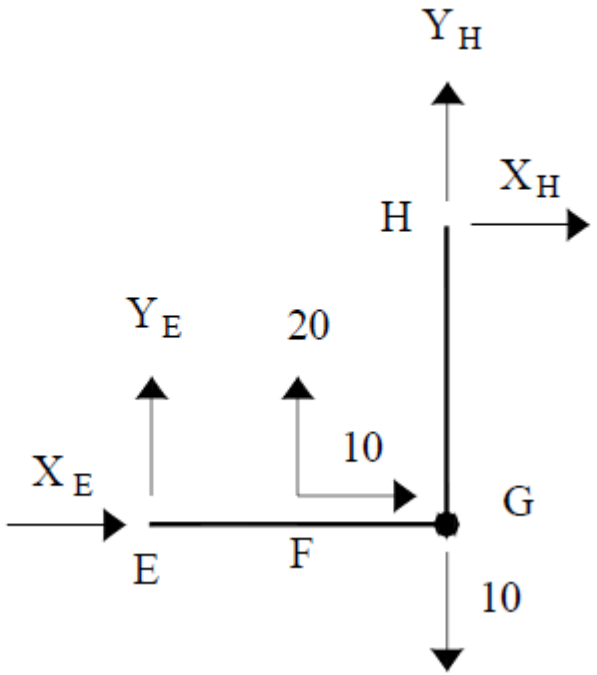
$$\sum Y = 0 = Y_D + Y_F \Rightarrow Y_D = 20kN$$

$$M_C = 0 = Y_F \cdot 1 - X_F \cdot 2 \Rightarrow X_F = -10kN$$

$$\sum X = 0 = X_D + X_F + 20 \Rightarrow X_D = -10kN$$



2)

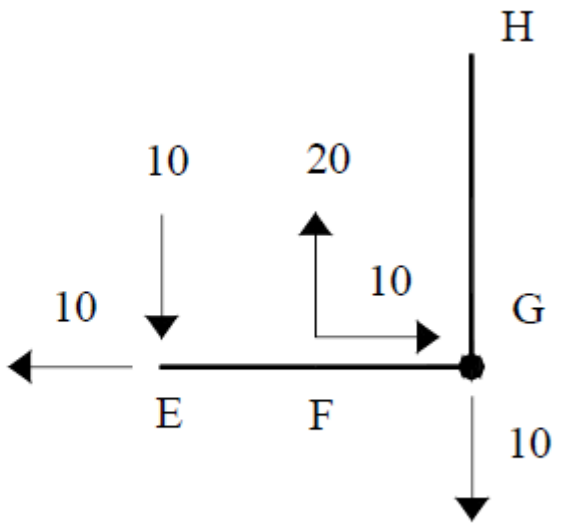


$$M_G = 0 = X_H$$

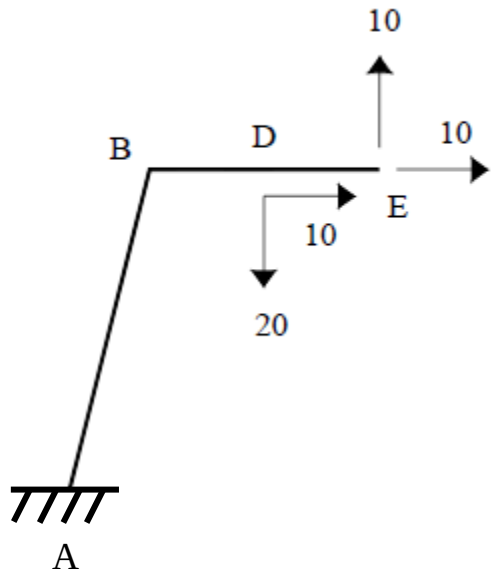
$$\sum X = 0 = X_E + 10 + X_H \Rightarrow X_E = -10kN$$

$$\sum M_E = 0 = 20 \cdot 1 - 10 \cdot 2 + Y_H \cdot 2 - X_H \cdot 2 \Rightarrow Y_H = 0$$

$$\sum Y = 0 = Y_E + 20 - 10 + Y_H \Rightarrow Y_E = -10kN$$



3)

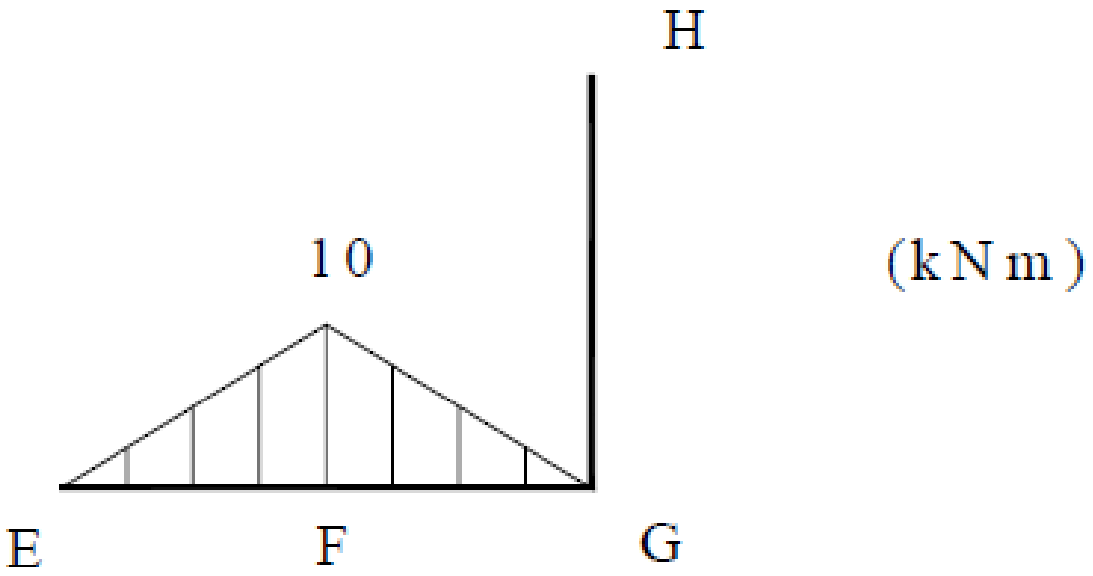


$$\sum X = 0 = Y_A + 10 + 10 \Rightarrow X_A = -20kN$$

$$\sum Y = 0 = Y_A + 10 - 20 \Rightarrow Y_A = 10kN$$

$$\sum M_A = 0 = -20 \cdot 2 - 10 \cdot 4 - 10 \cdot 4 + 10 \cdot 3 + M_A \Rightarrow M_A = 90kN$$

c)

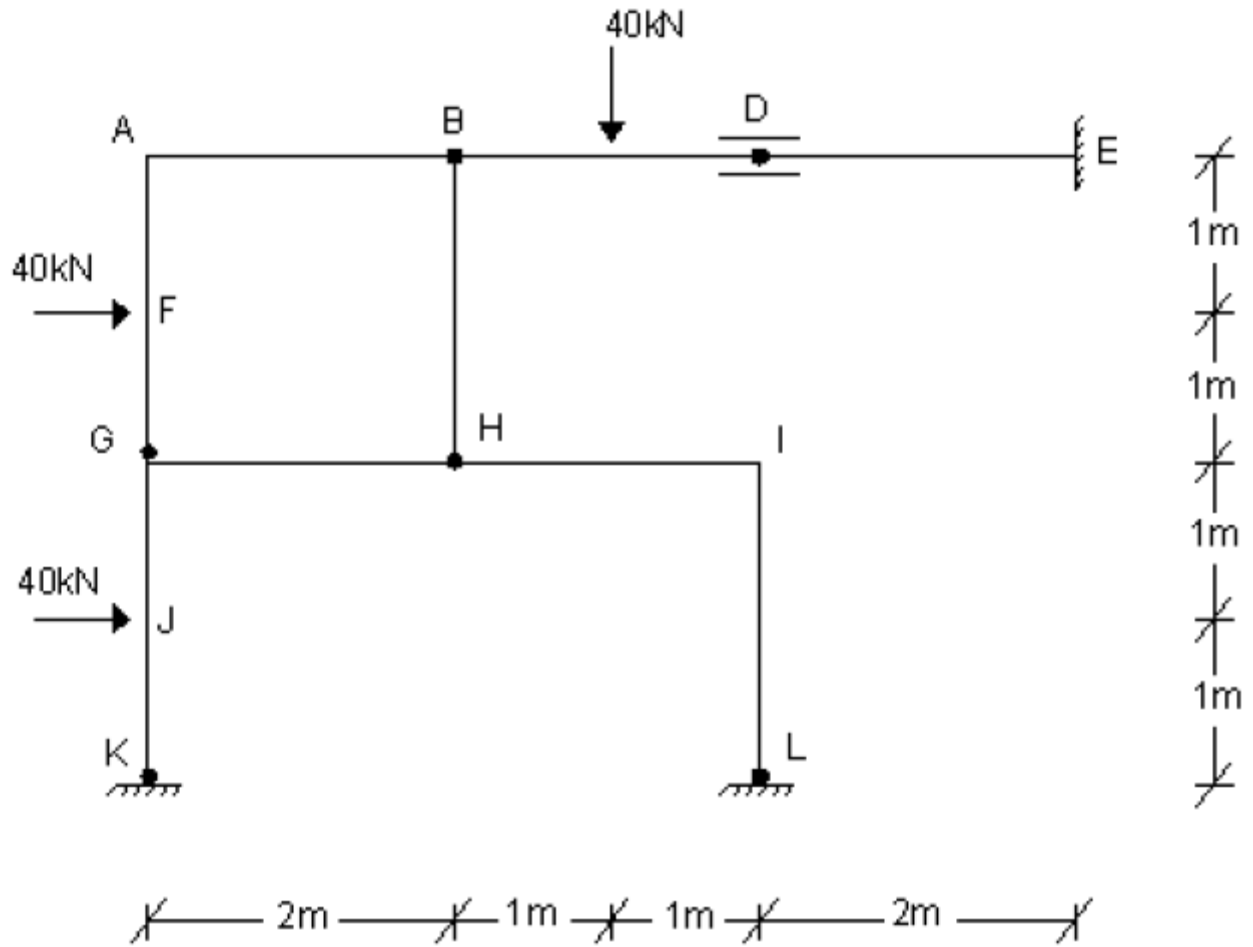


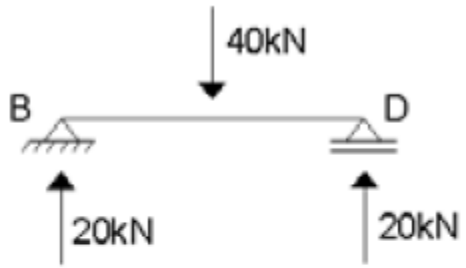
Exemplo 13: Q3 2003

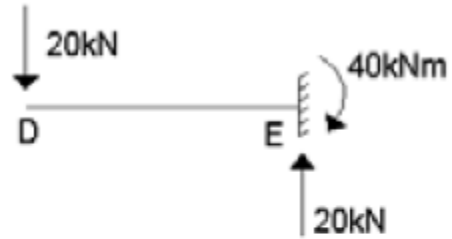
Para a estrutura associada da figura:

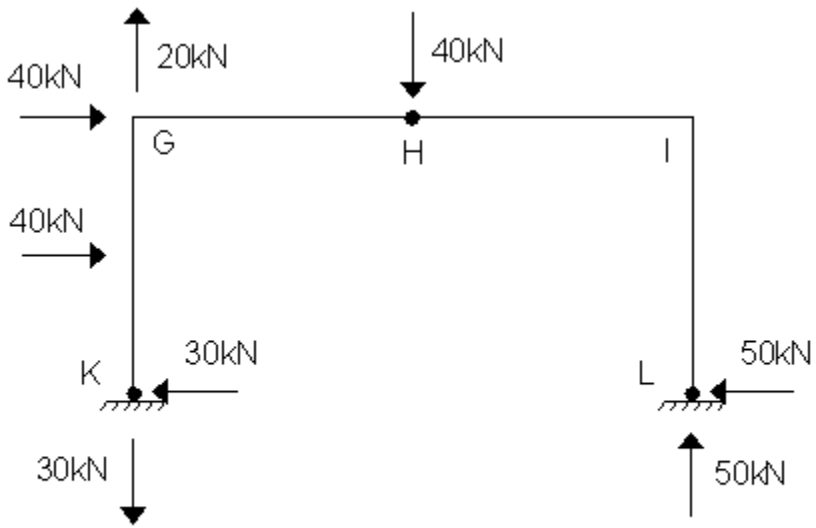
a) Decompô-la nas subestruturas que a formam;

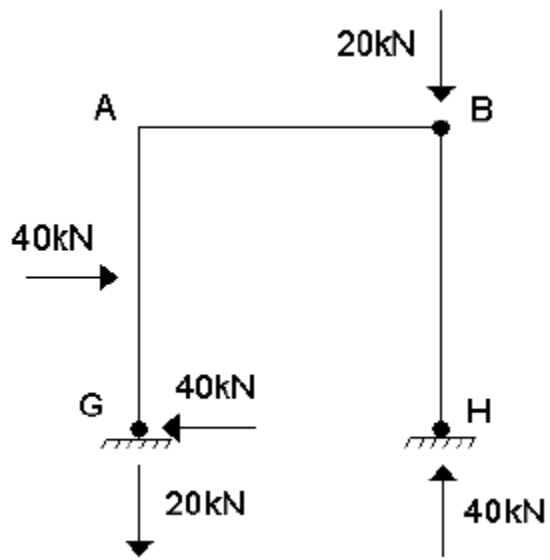
b) Determinar as reações de apoio de cada uma destas subestruturas.




40kN
B
D
20kN
20kN


20kN
40kNm
D
E
20kN


40kN
20kN
40kN
G
H
I
40kN
K
30kN
L
50kN
30kN
50kN


20kN
A
B
40kN
G
40kN
H
20kN
40kN

Exemplo 14: P3 2002

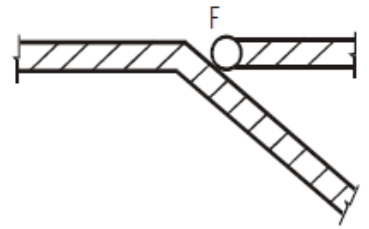
Para a estrutura da figura, solicitada por uma carga vertical de 60 kN em B, obter:

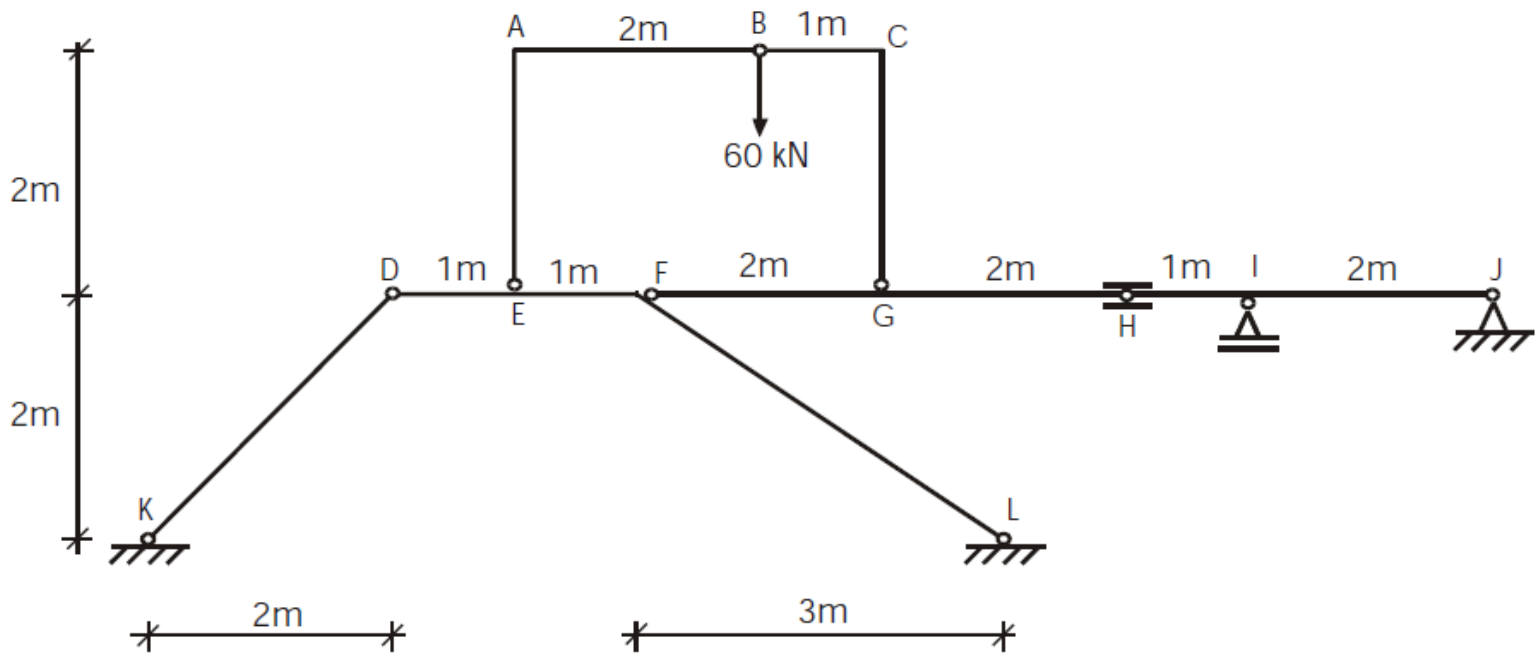
a) as subestruturas das quais ela se compõe;

b) as reações de apoio das subestruturas e da estrutura como um todo;

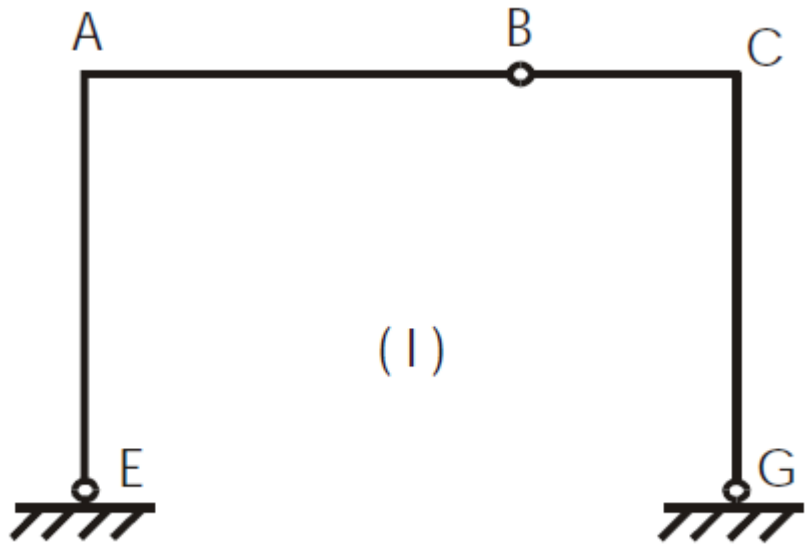
c) os diagramas de esforços solicitantes do trecho DEF.

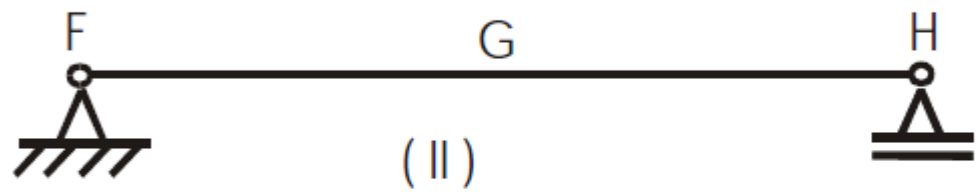
Obs: a articulação em F é externa ao trecho DEFL, conforme o detalhe.

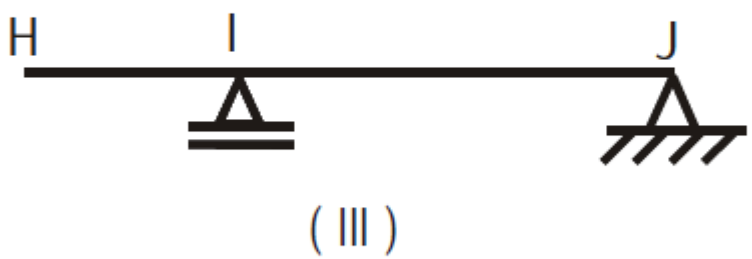


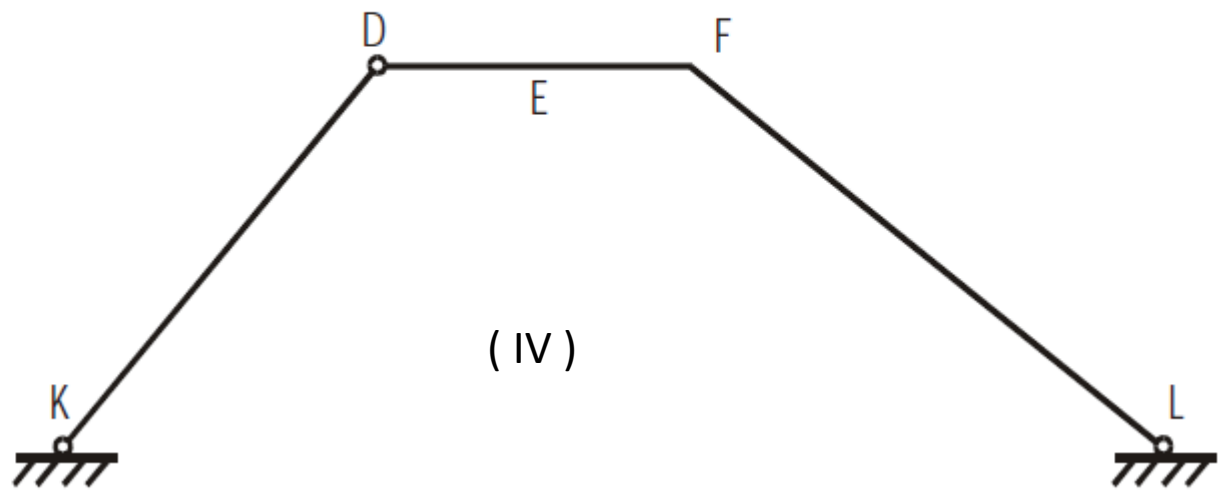


a)









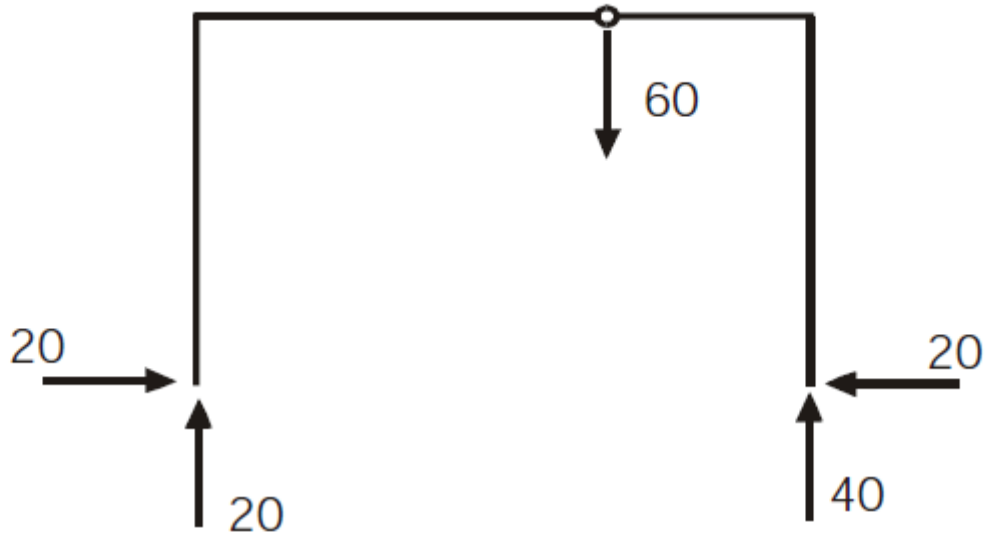
b)

(I) $\sum M_E = 0$

$\sum V = 0$

$M_{Ee} = 0$

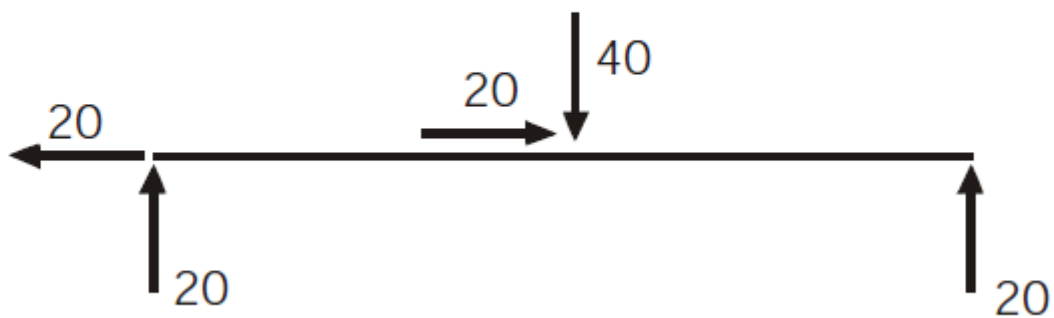
$\sum H = 0$



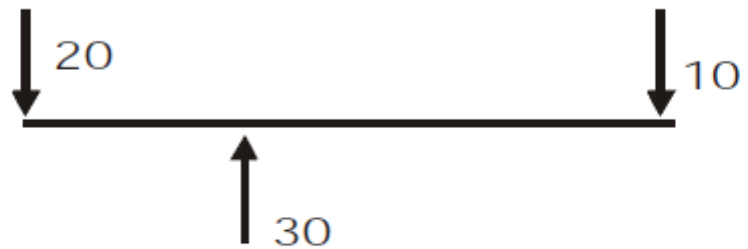
(II) $\sum H = 0$

$\sum M_F = 0$

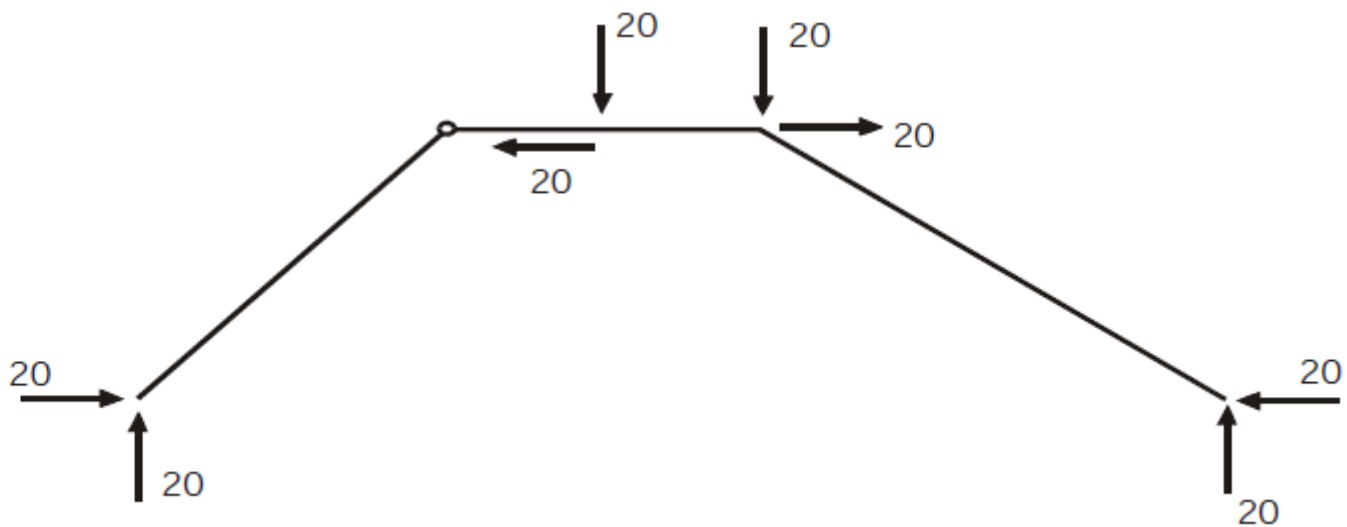
$\sum V = 0$



$$(III)\quad \sum H = 0$$
$$\sum M_I = 0$$
$$\sum V = 0$$



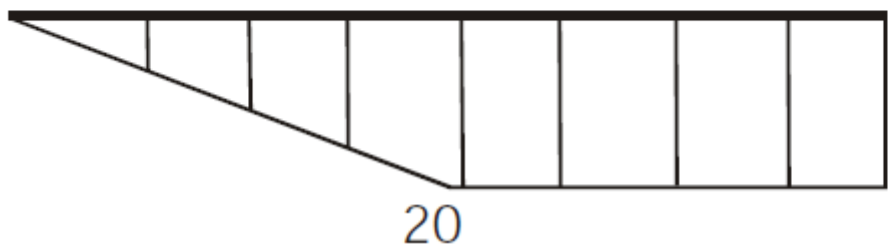
$$(IV)\quad \sum M_K = 0$$
$$\sum V = 0$$
$$M_{De} = 0$$
$$\sum H = 0$$



c)

N (kN)

V (kN)

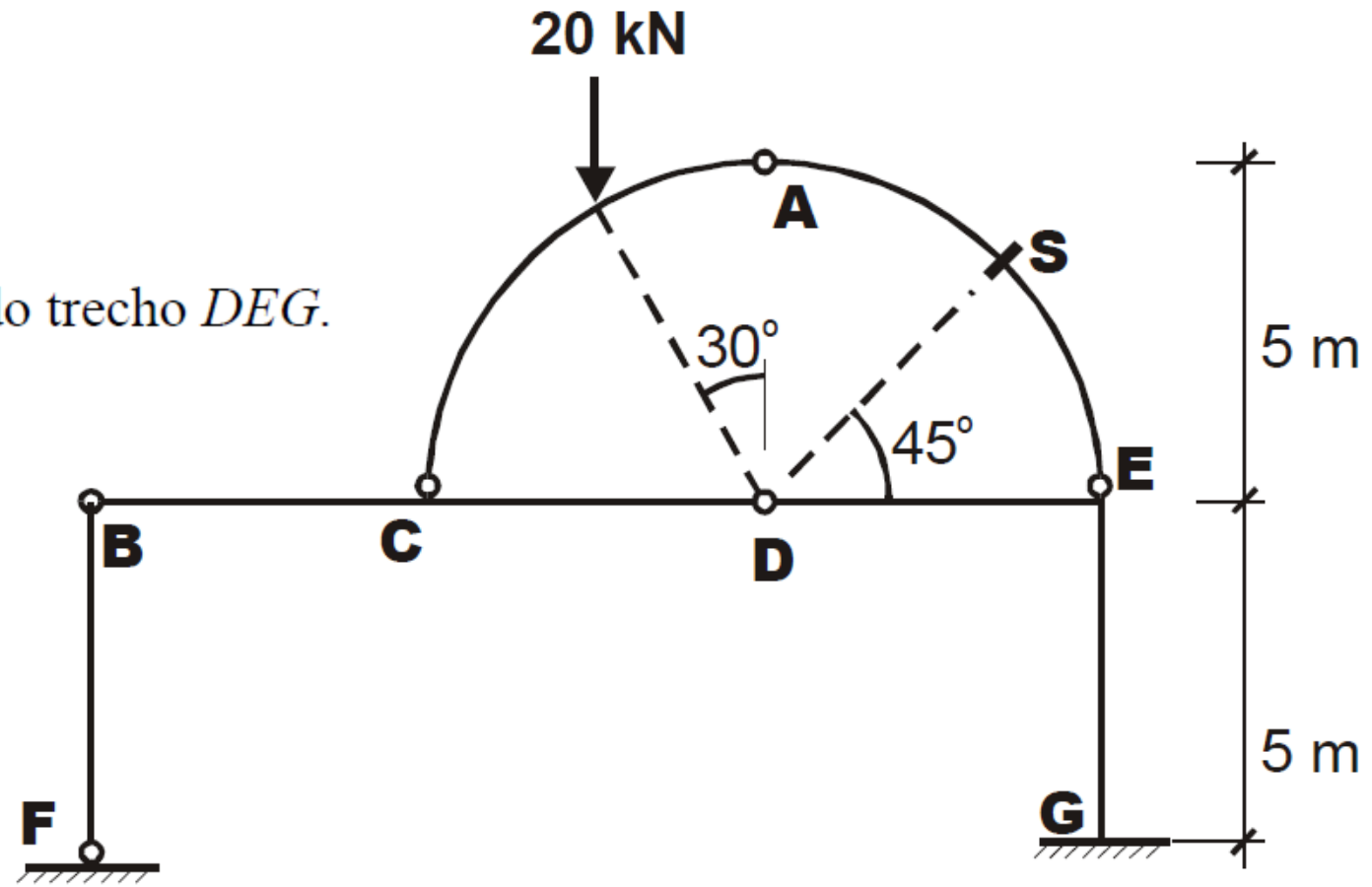


M (kNm)

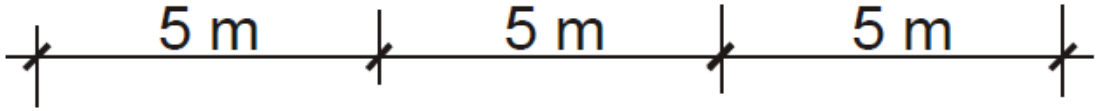
Para a estrutura da figura, determinar:

a) os esforços solicitantes em *S*;

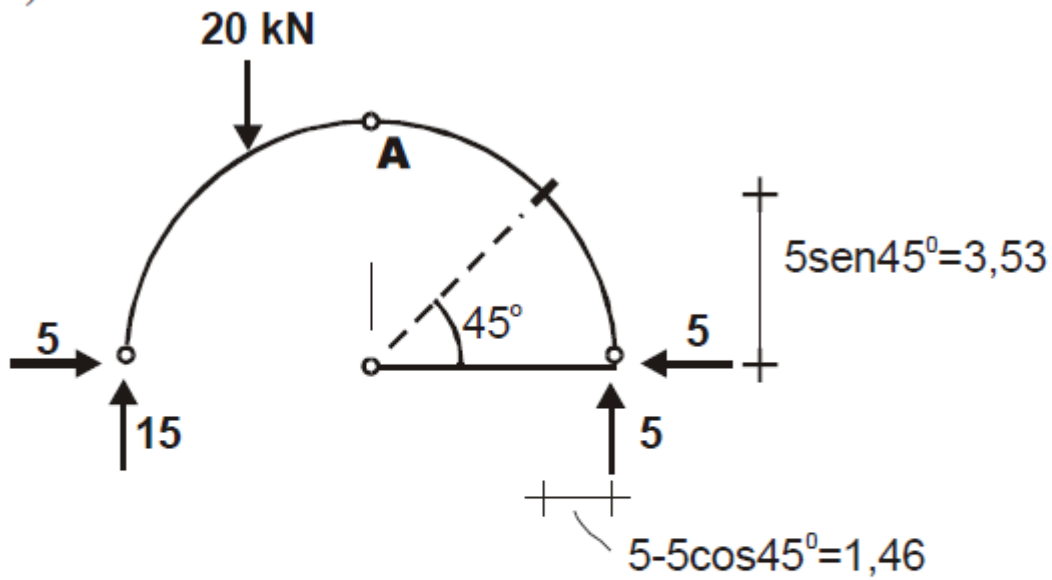
b) o diagrama de momentos fletores do trecho *DEG*.

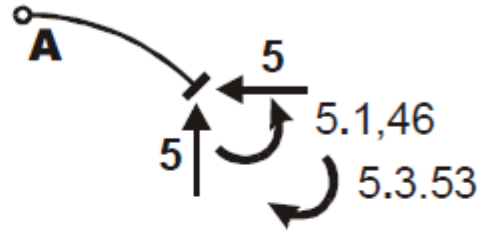


Exemplo 15
P3 2001



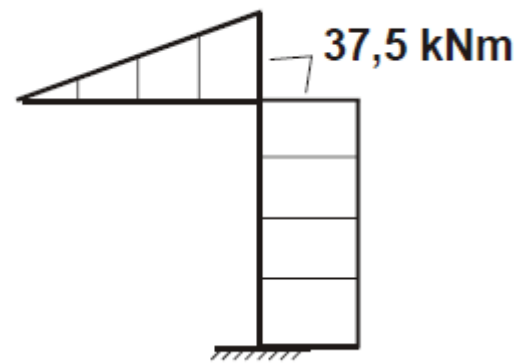
a)





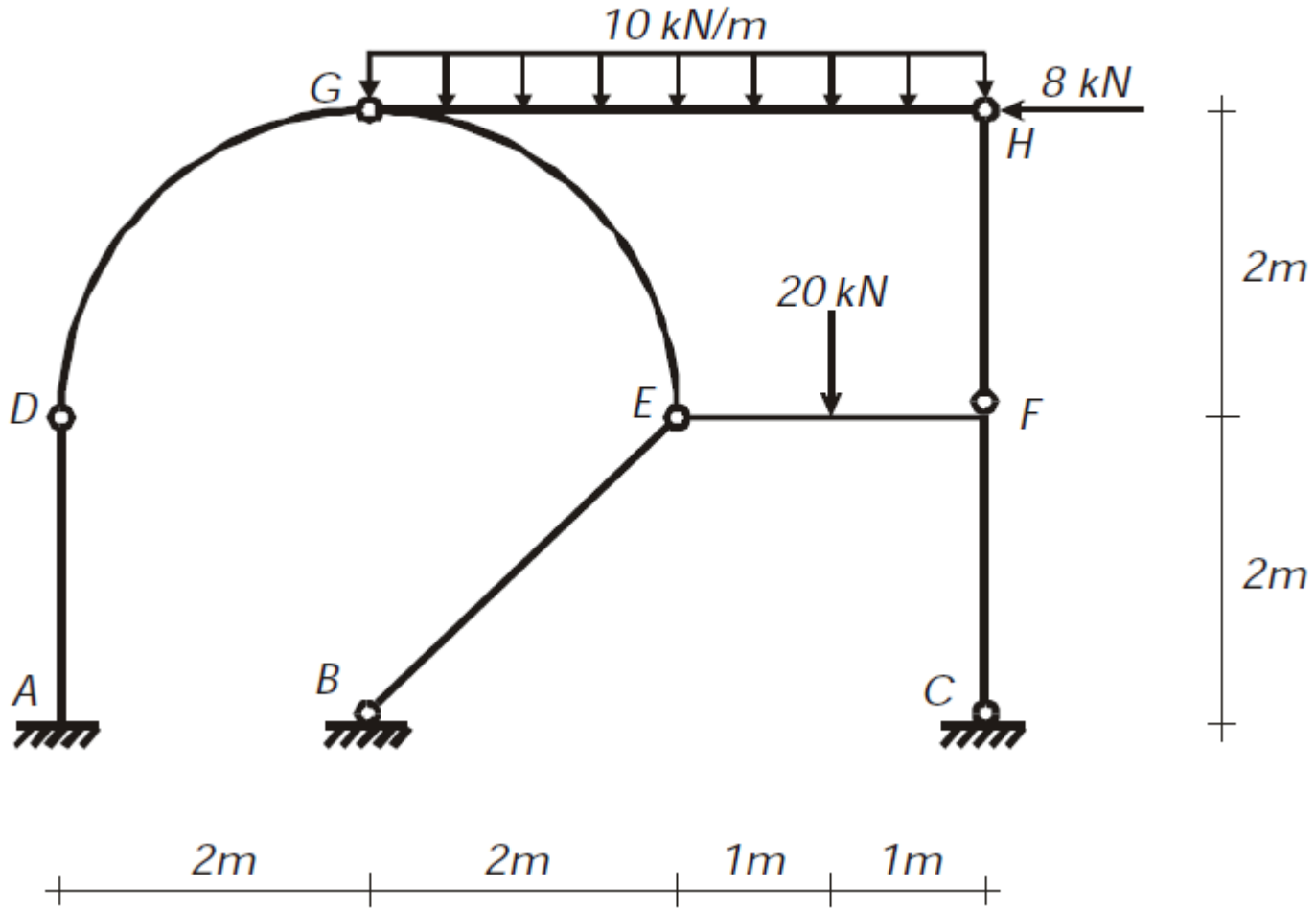
N = -7,07 kN
V = 0
M = -10,35 kNm

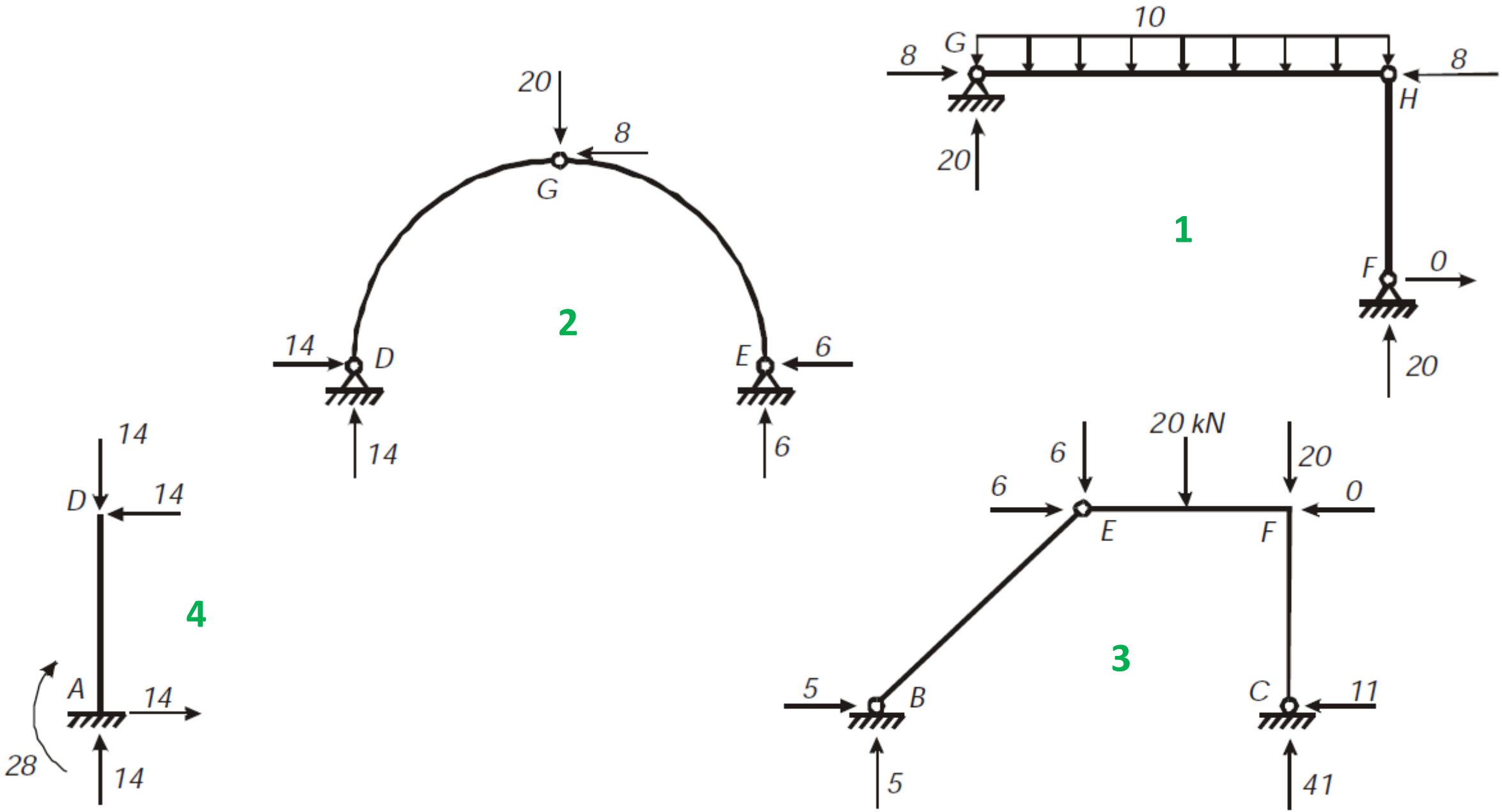
b)



Exemplo 16: P3 1999

Determinar as reações vinculares da estrutura associada da figura abaixo.




10
G
8
8
H
20
1
F
0
20
20
8
G
2
14
D
E
6
14
6
14
D
14
4
A
14
28
14
20 kN
6
6
20
0
E
F
3
5
B
C
11
5
41

Exemplo 17: P3 1998

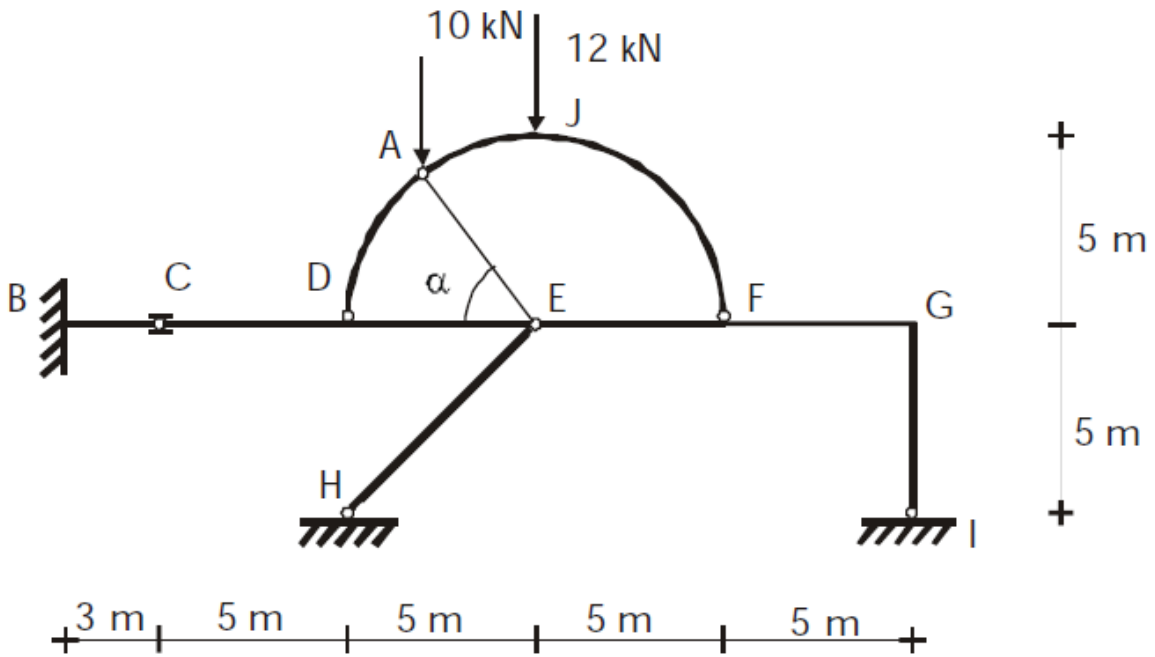
Para a estrutura da figura abaixo:

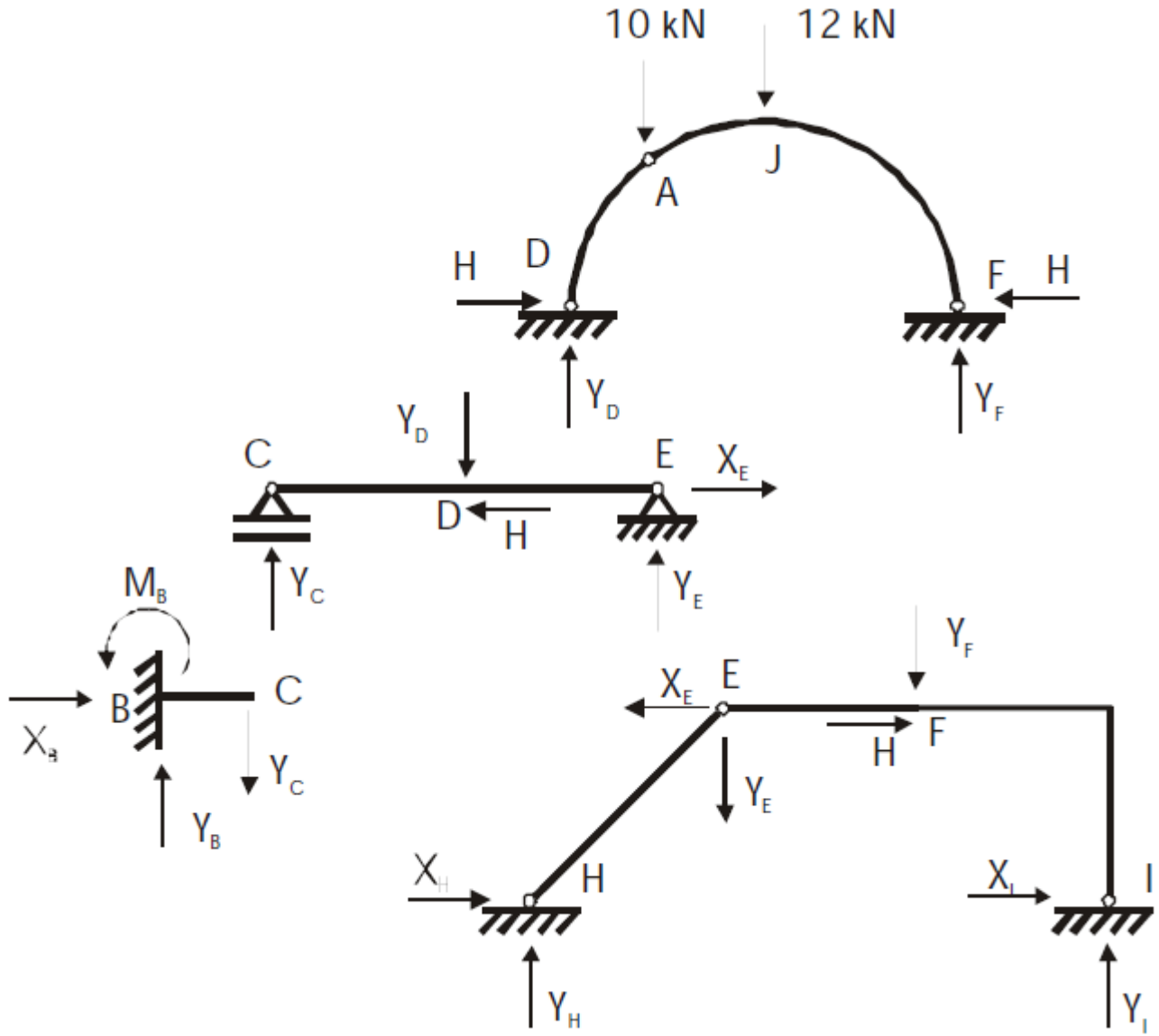
a) Determinar as reações vinculares;

b) Traçar os diagramas de esforços solicitantes **do trecho *BCDE***.

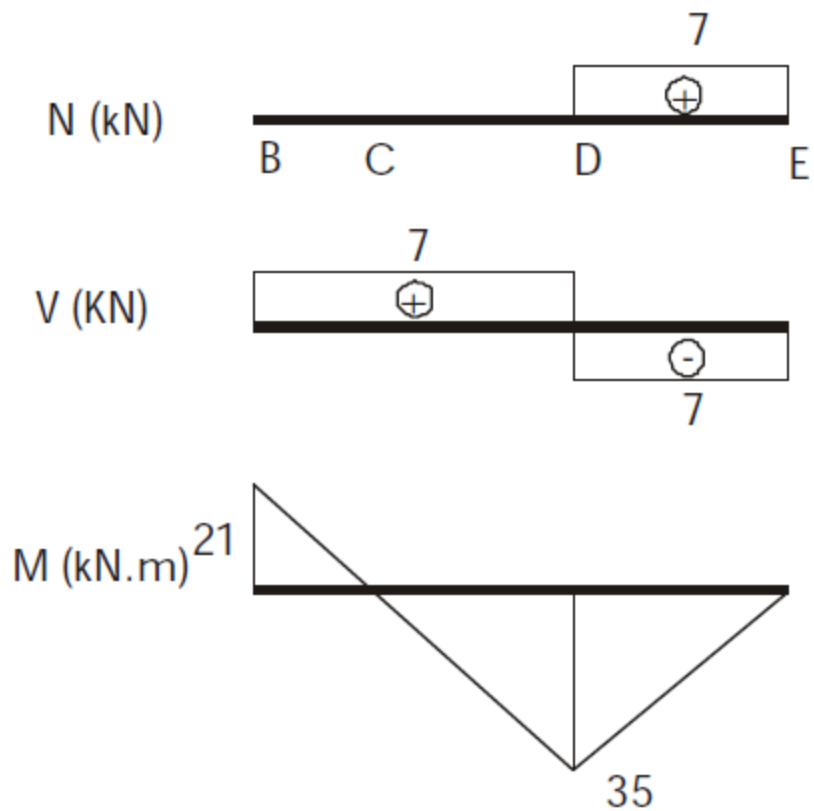
O trecho *DAJF* corresponde a uma semicircunferência de raio igual a 5 m e centro em *E*.

São dados: $sen\alpha = 0{,}8$ e $cos\alpha = 0{,}6$.





1. $H = 7$ kN
2. $Y_D = 14$ kN
3. $Y_F = 8$ kN
4. $Y_C = 7$ kN
5. $X_E = 7$ kN
6. $Y_E = 7$ kN
7. $X_B = 0$
8. $Y_B = 7$ kN
9. $M_B = 21$ kN.m
10. $Y_I = 7{,}67$ kN
11. $X_I = -7{,}33$ kN
12. $Y_H = 7{,}33$ kN
13. $X_H = 7{,}33$ kN

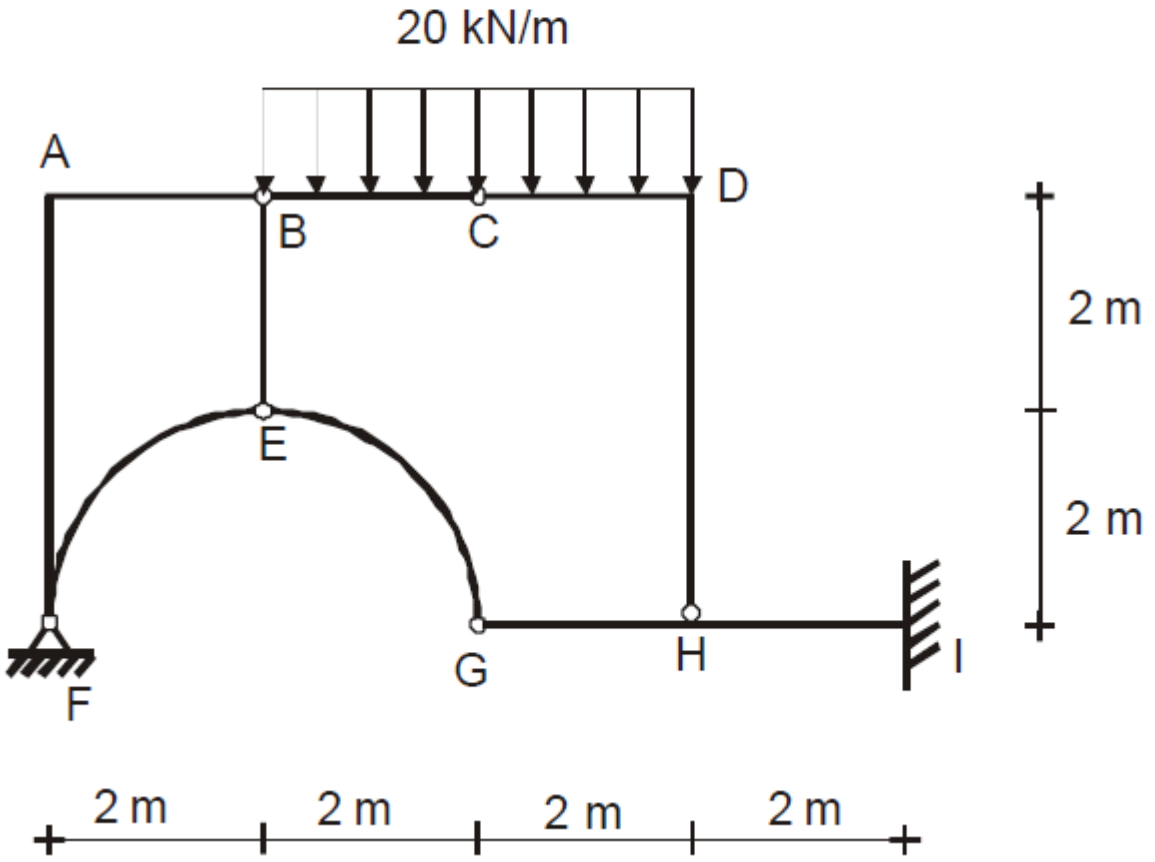

7
N (kN)
B
C
D
E
7
V (KN)
7
M (kN.m)
21
35

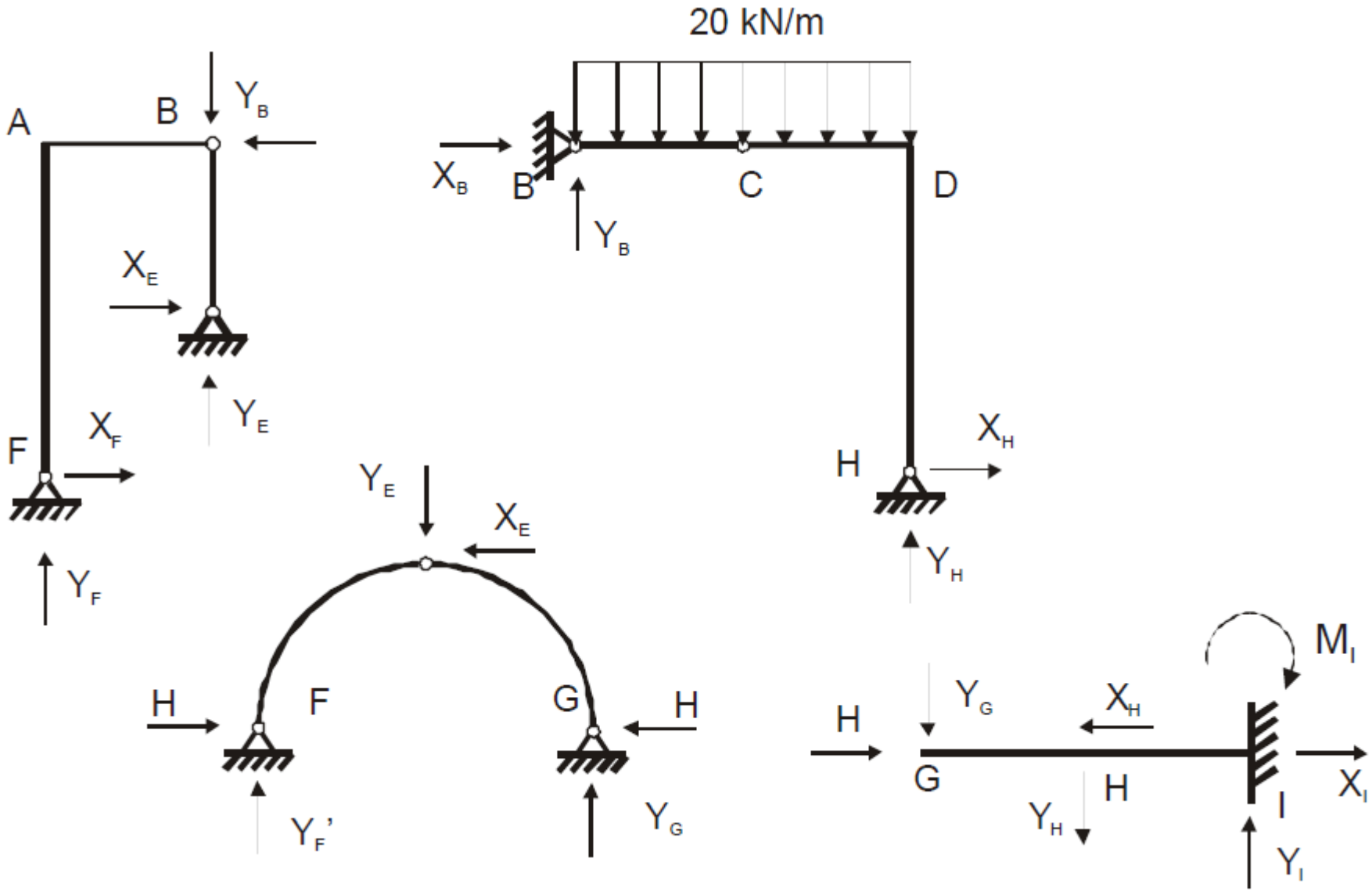
Exemplo 18: REC 1998

Para a estrutura da figura:

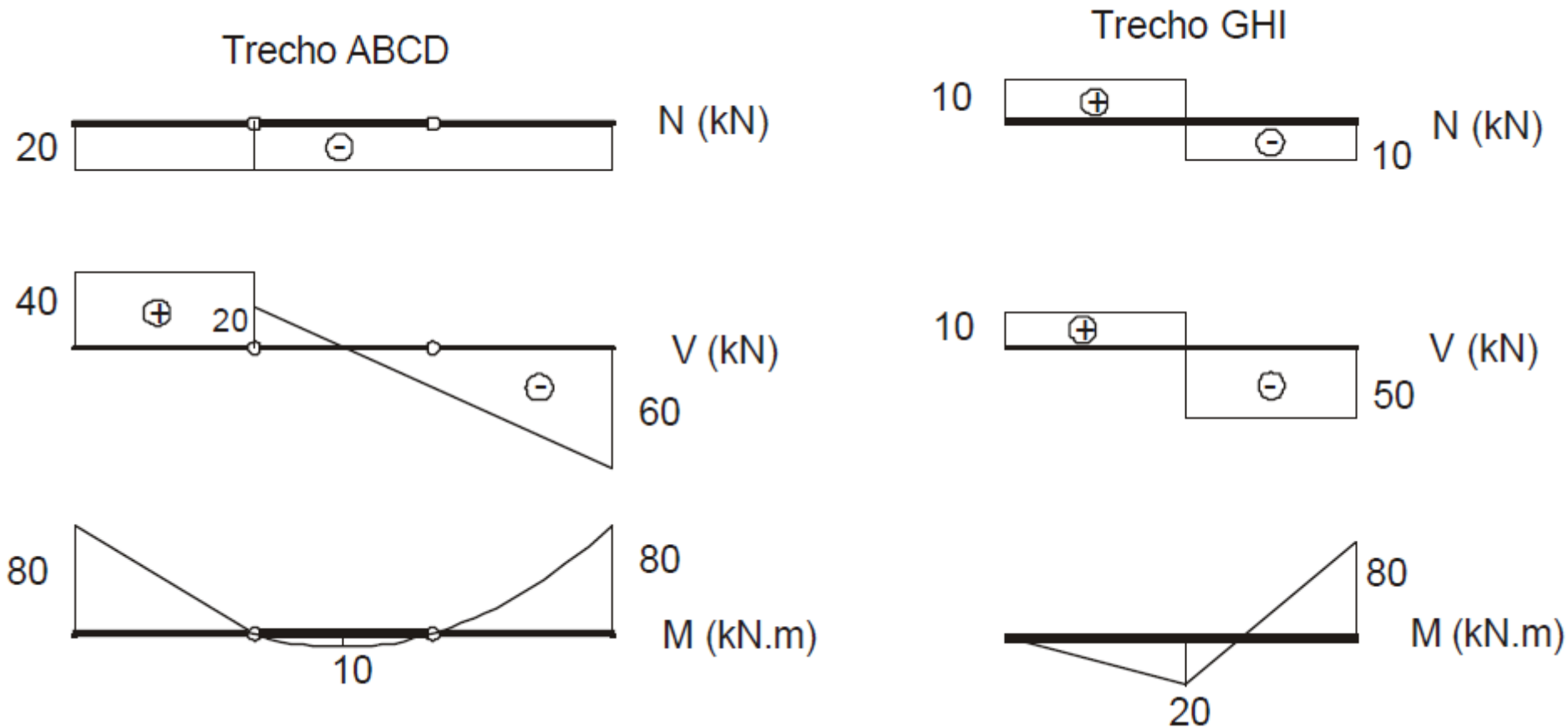
a) Determinar as reações de apoio em *F* e *I*.

b) Traçar os diagramas de esforços solicitantes dos trechos *ABCD* e *GHI*.

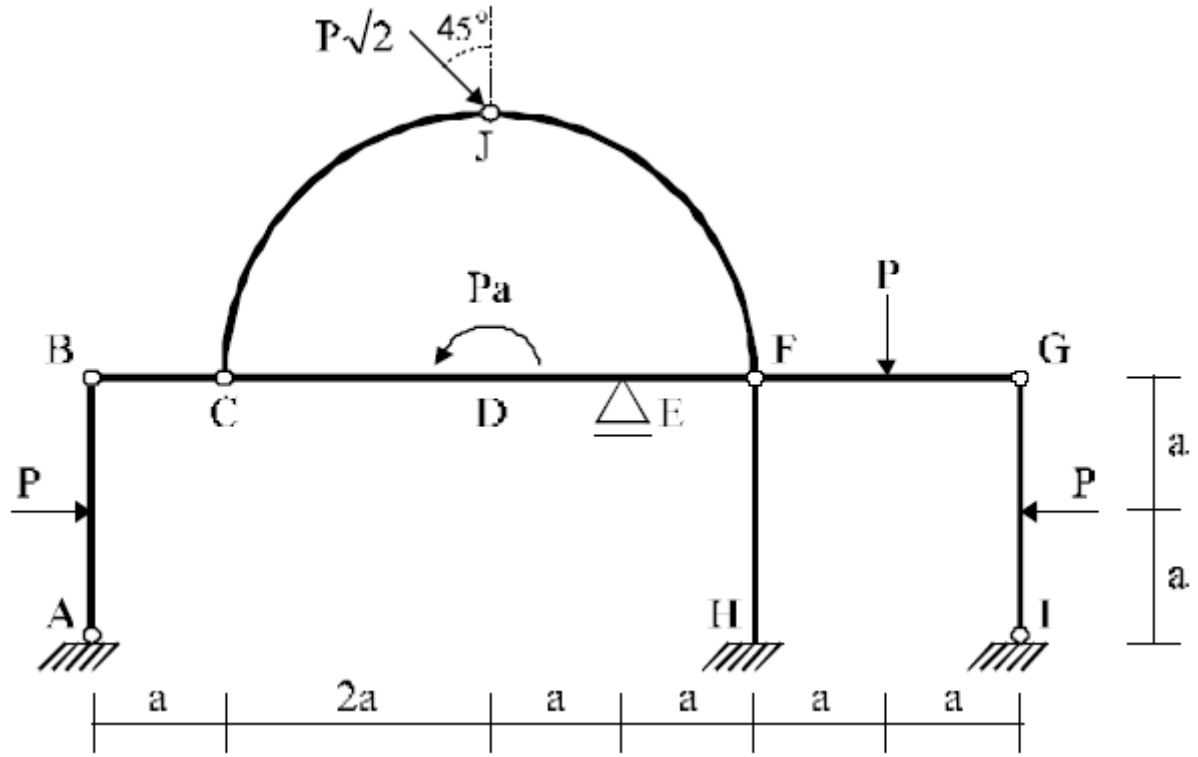




1. $X_B = 20$
2. $Y_B = 20$
3. $X_H = -20$
4. $Y_H = 60$
5. $X_E = 0$
6. $Y_E = -20$
7. $X_F = 20$
8. $Y_F = 40$
9. $Y_F' = -10$
10. $Y_G = -10$
11. $H = -10$
12. $X_I = -10$
13. $Y_I = 50$
14. $M_I = 80$


Trecho ABCD
20
N (kN)
40
20
V (kN)
60
80
80
M (kN.m)
10
Trecho GHI
10
10
N (kN)
10
50
V (kN)
80
M (kN.m)
20

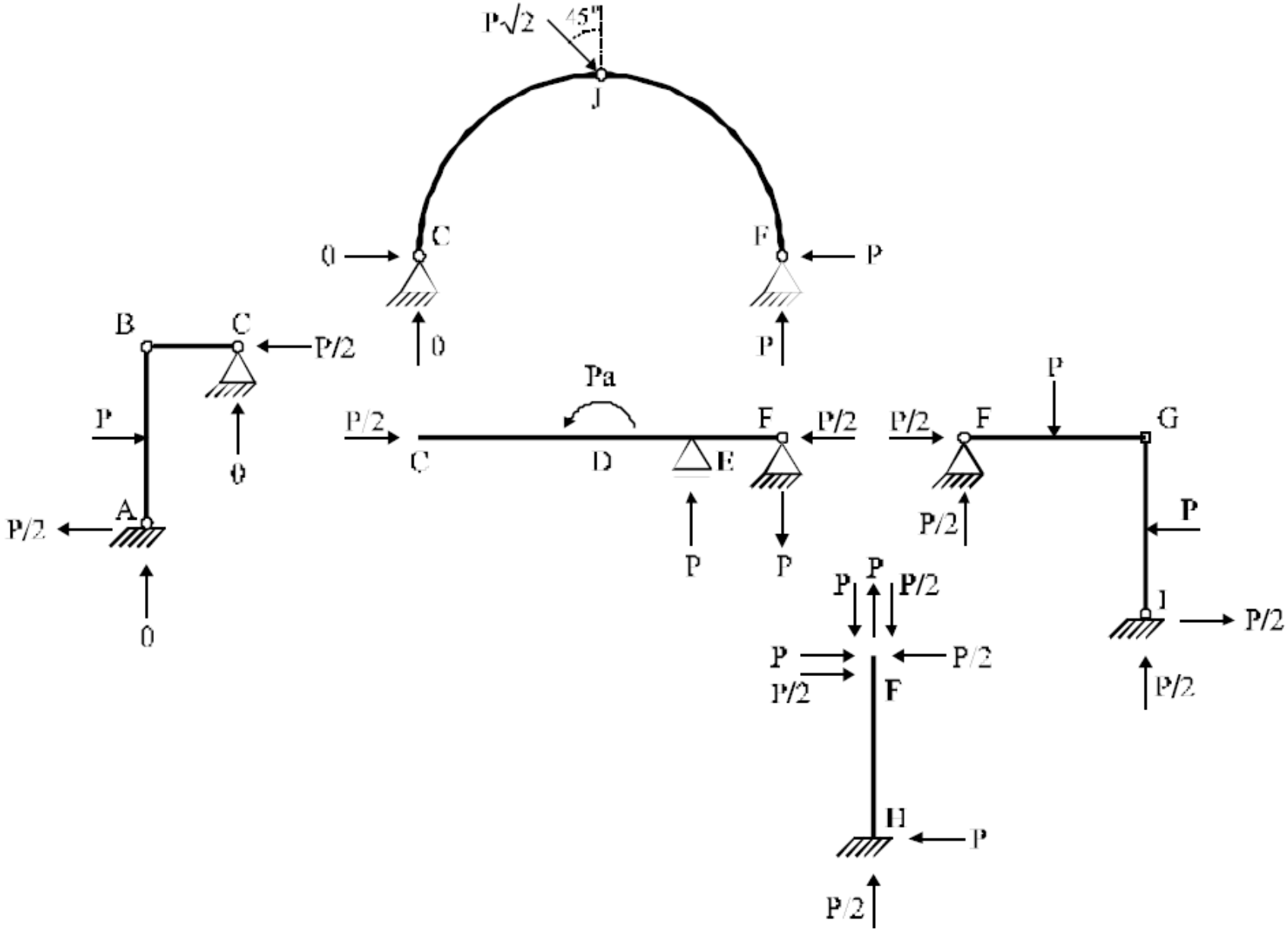
Exemplo 19: P2 1996



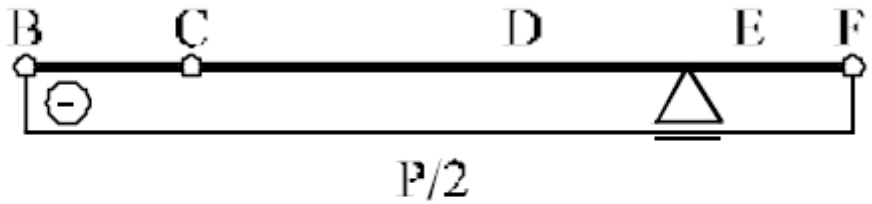
Determinar as reações vinculares para a estrutura abaixo. Traçar os diagramas de esforços solicitantes para o trecho BCDEF.

CJF corresponde a uma semi-circunferência de raio 2a e centro D.

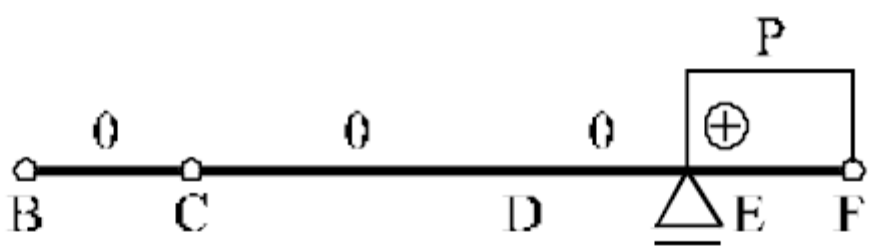
O momento concentrado Pa está aplicado em D.


P√2
45°
J
0
C
F
P
0
P
B
C
P/2
P
0
A
P/2
0
Pa
P/2
C
D
E
F
P/2
P
P
P/2
F
G
P
P/2
P
P
P
P
P/2
P
P/2
F
P/2
J
P/2
P/2
H
P
P/2

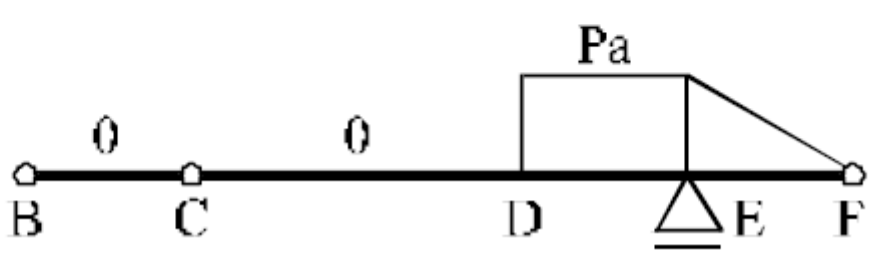
Ⓝ


B
C
D
E
F
⊖
P/2

Ⓥ

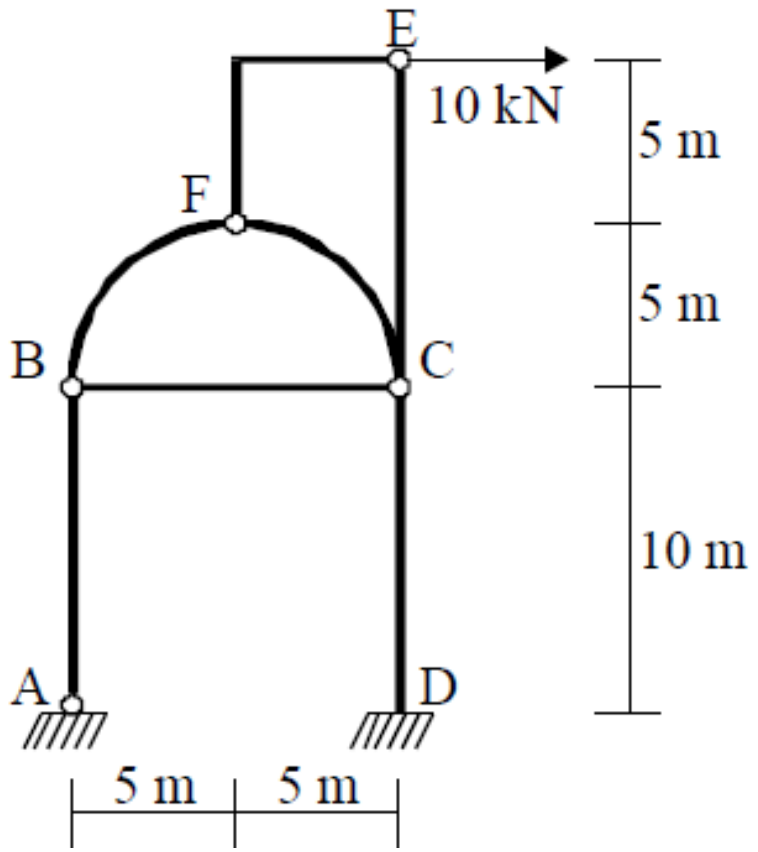

P
0
0
0
⊕
B
C
D
E
F

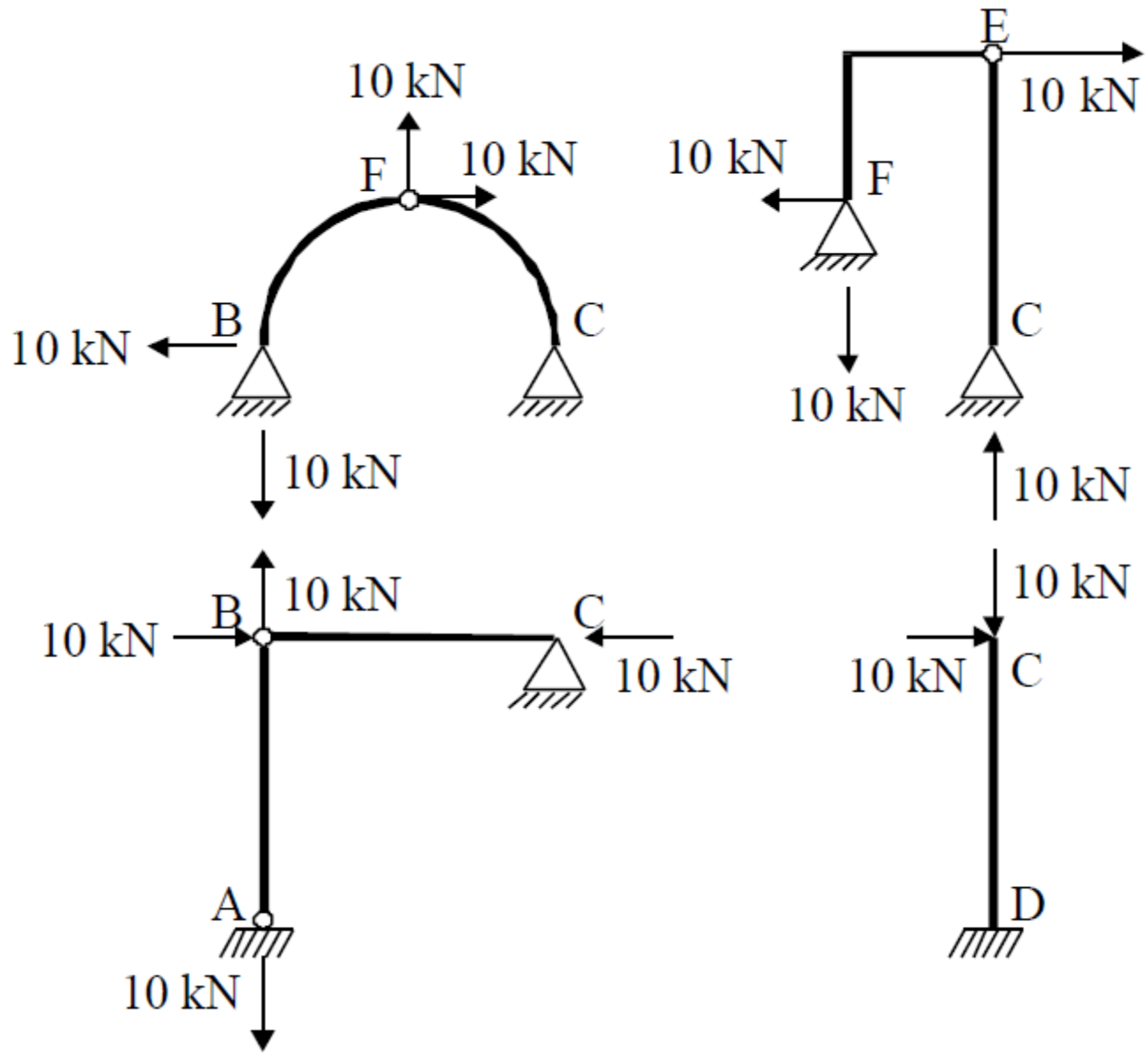
Ⓜ

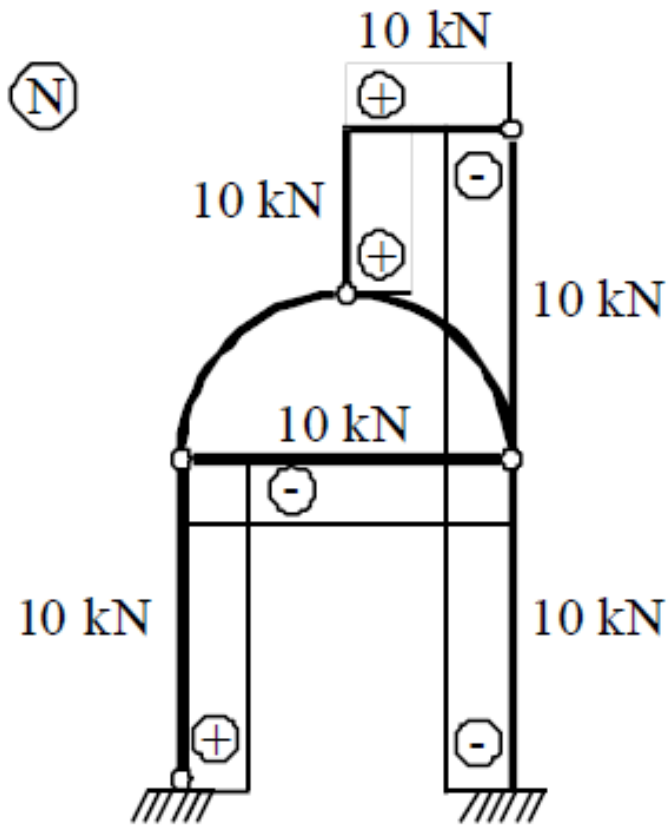

Pa
0
0
B
C
D
E
F

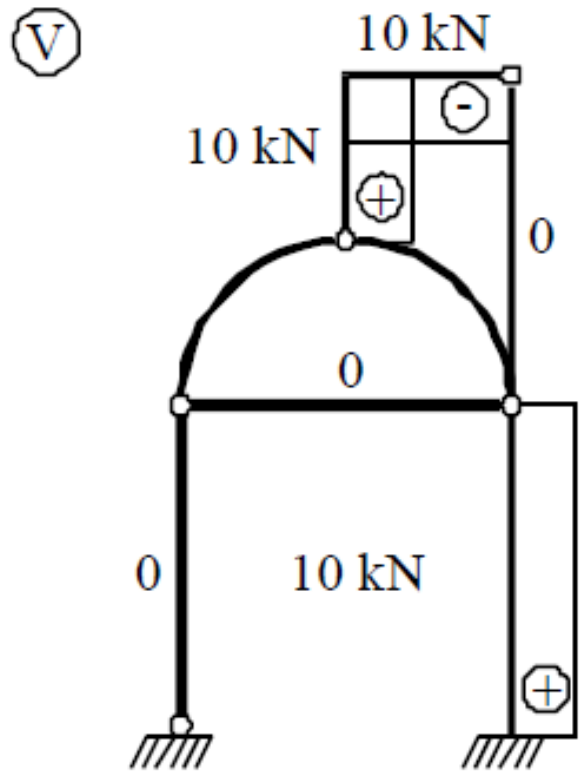
Exemplo 20: P2 1995

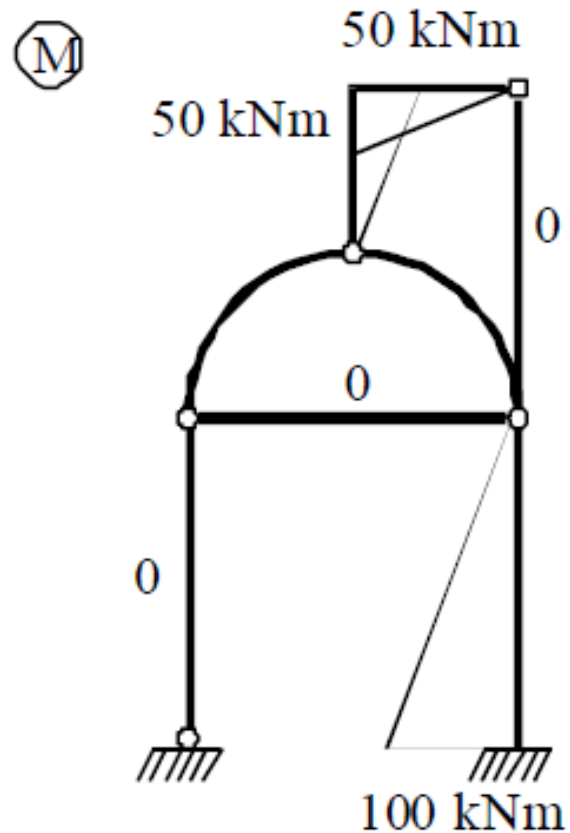
Traçar os diagramas de esforços solicitantes dos trechos retilíneos da estrutura abaixo esquematizada.



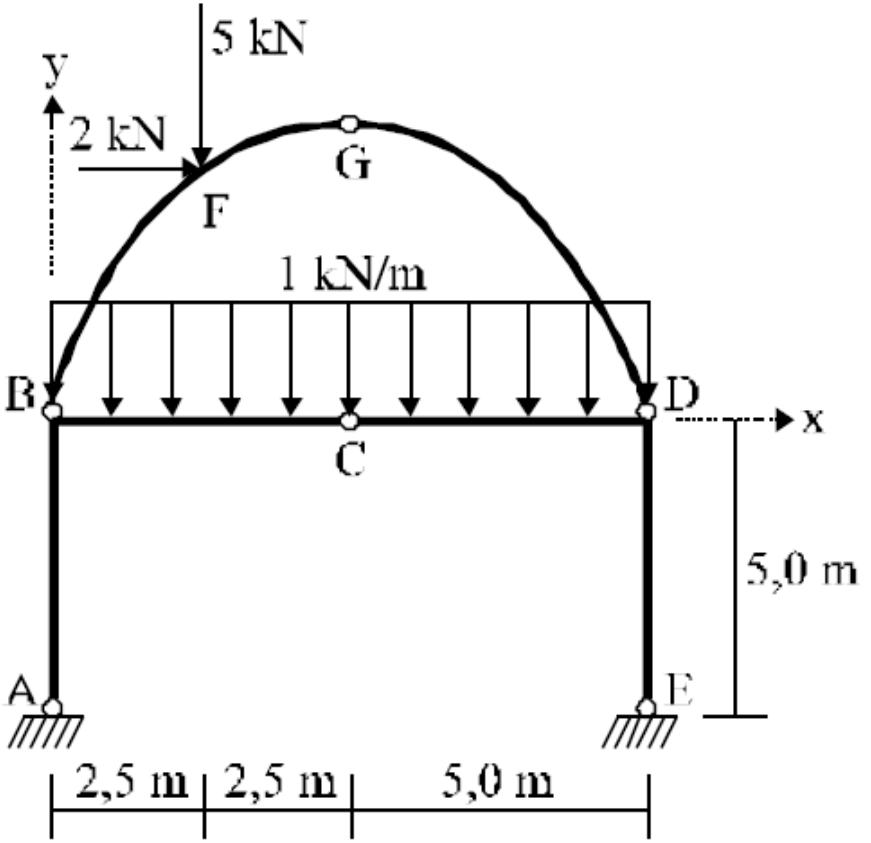

10 kN
F
10 kN
B
10 kN
C
10 kN
E
10 kN
10 kN
F
C
10 kN
10 kN
10 kN
B
10 kN
C
10 kN
10 kN
10 kN
C
A
D
10 kN


N
10 kN
10 kN
10 kN
10 kN
10 kN
10 kN
+
-
+
-
+
-


V
10 kN
10 kN
0
0
0
10 kN
-
+
+


M
50 kNm
50 kNm
0
0
0
100 kNm

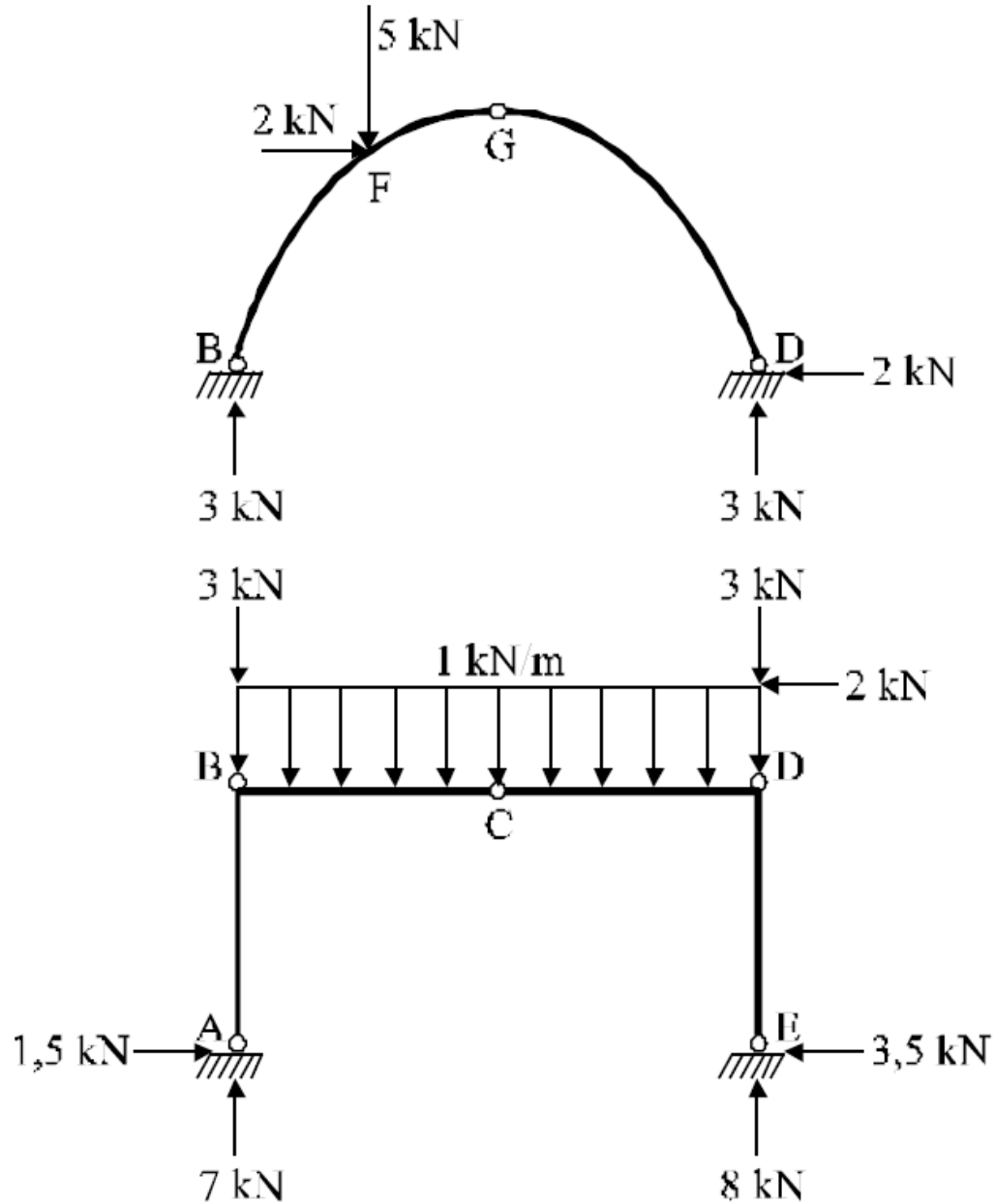
Exemplo 21: P2 1994

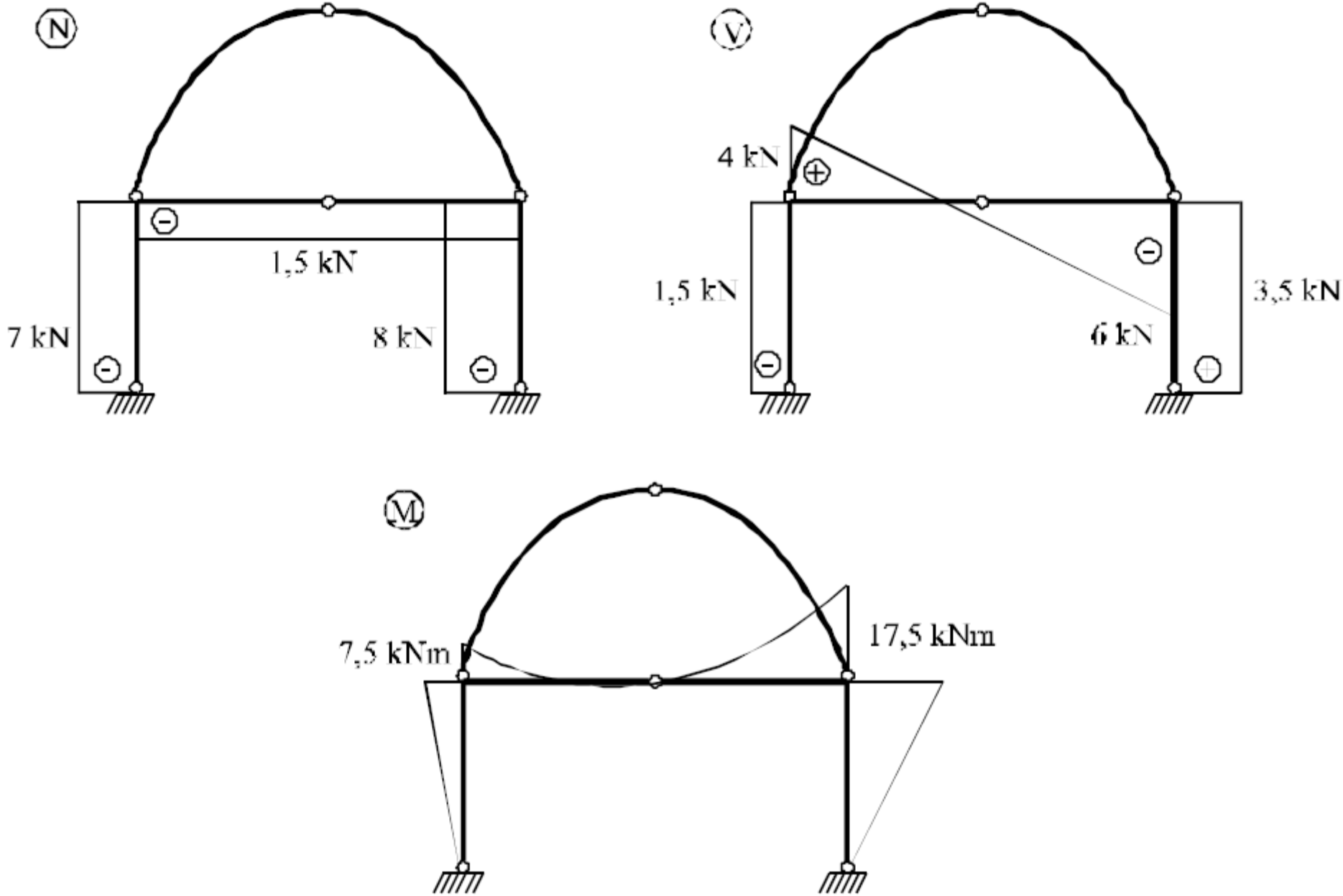


Desenhar os diagramas de esforços solicitantes do trecho ABCDE da estrutura esquematizada e calcular os esforços solicitantes na seção F (seção imediatamente abaixo daquela onde são aplicados os esforços concentrados). O trecho BFGD da estrutura é descrito pela função

$$y = -\frac{x^2}{5} + 2x$$

conforme o sistema de referência indicado.


5 kN
2 kN
G
F
B
D
2 kN
3 kN
3 kN
3 kN
3 kN
1 kN/m
2 kN
B
D
C
A
E
1,5 kN
3,5 kN
7 kN
8 kN


N
1,5 kN
7 kN
8 kN
V
4 kN
1,5 kN
6 kN
3,5 kN
M
7,5 kNm
17,5 kNm

A tangente à curva no ponto F é dada pela derivada da função:

$$y = -\frac{x^2}{5} + 2x$$

$$y' = -\frac{2x}{5} + 2$$

- para $x = 2,5 \Longrightarrow y' = 1 \Longrightarrow \theta = 45°$.

$\therefore$ no ponto F: $N = -3*\sqrt{2}\ /\ 2$ *kN (de compressão)*

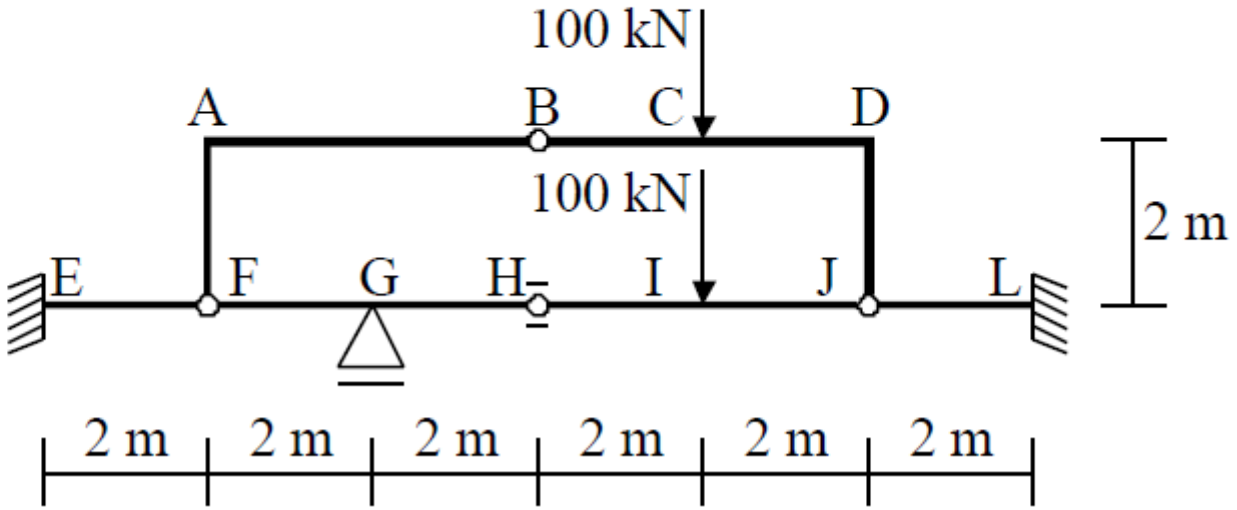
$V = 3*\sqrt{2}\ /\ 2$ *kN*

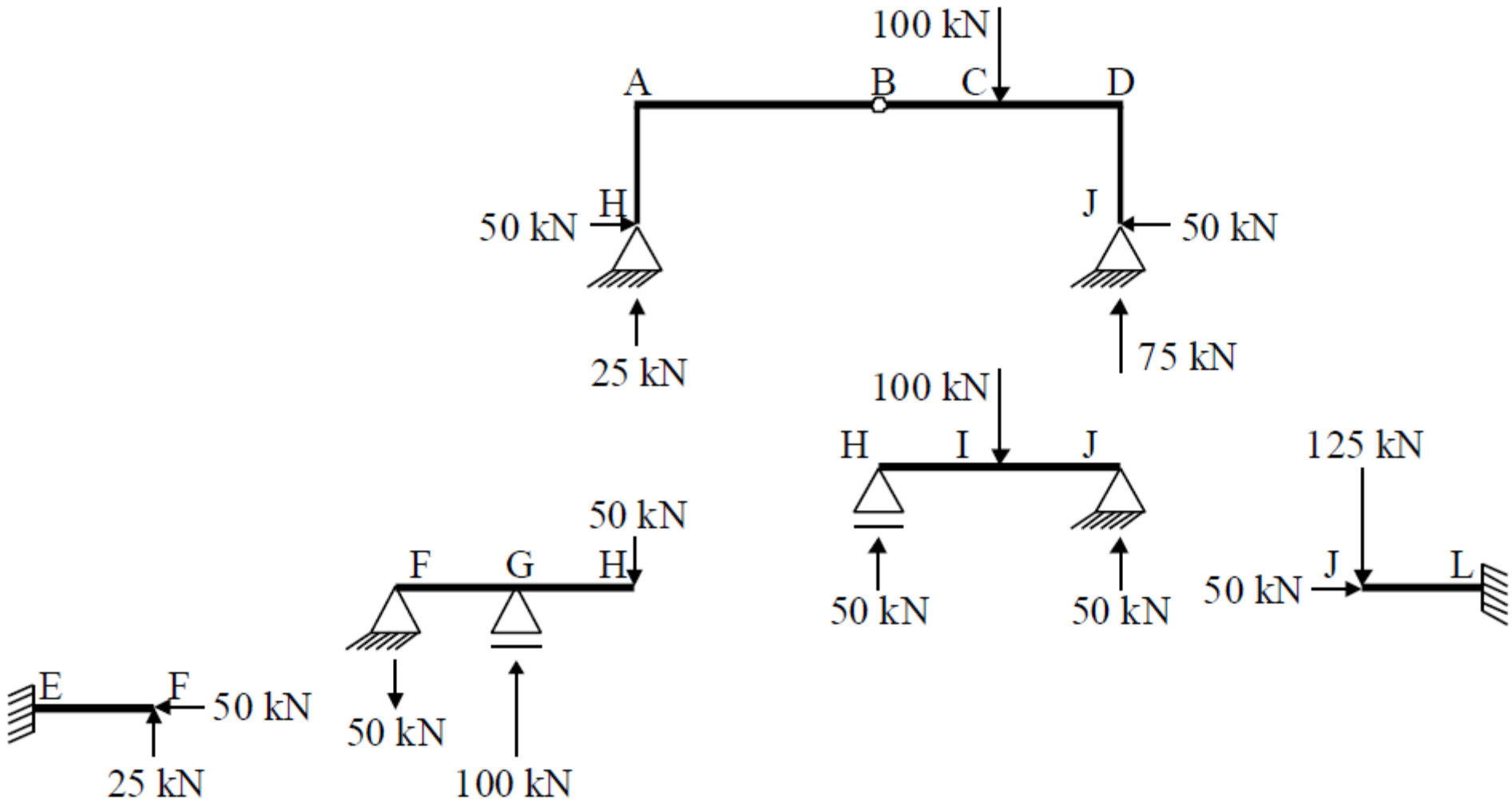
Exemplo 22: SUB 1993

Para a estrutura da figura pede-se:

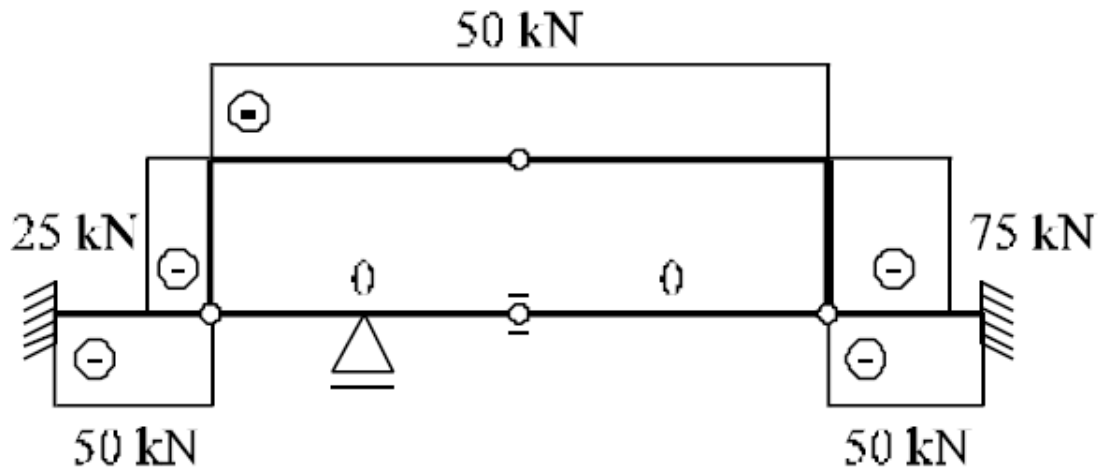
a) Decompor a estrutura;

b) Traçar os diagramas de esforços solicitantes.

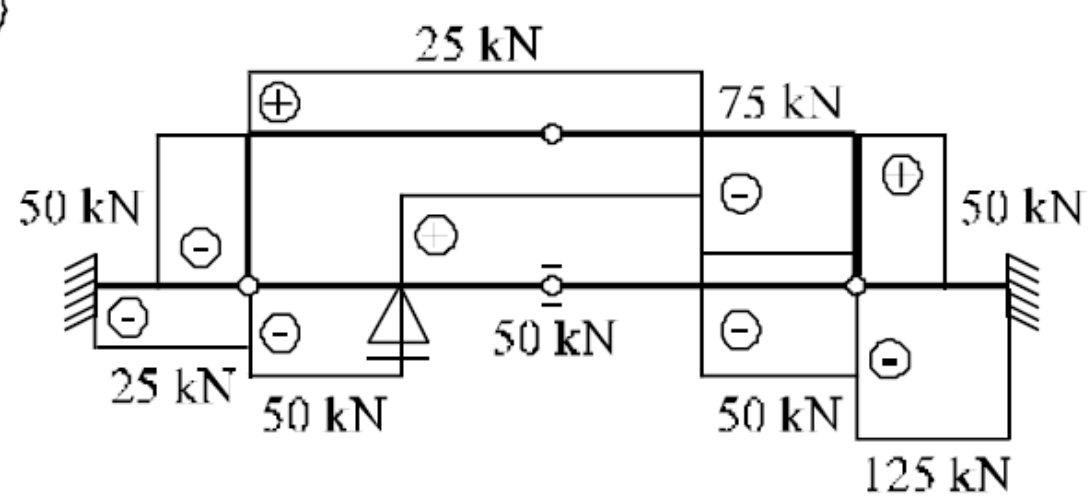



100 kN
A
B
C
D
H
50 kN
J
50 kN
25 kN
75 kN
100 kN
H
I
J
125 kN
50 kN
50 kN
50 kN
J
L
50 kN
F
G
H
50 kN
E
F
50 kN
50 kN
25 kN
100 kN

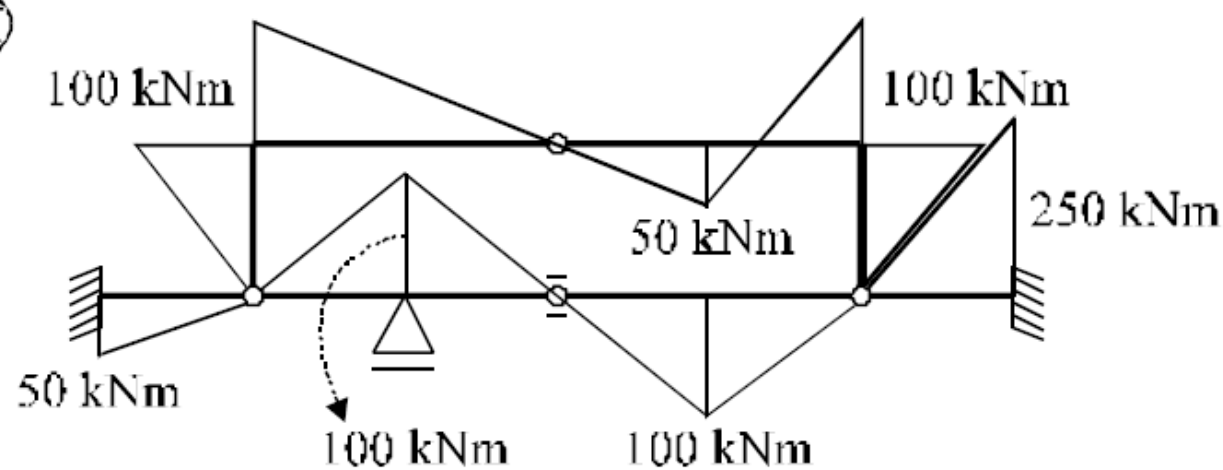
(N)


50 kN
25 kN
75 kN
0
0
50 kN
50 kN

(V)


25 kN
75 kN
50 kN
50 kN
50 kN
25 kN
50 kN
50 kN
125 kN

(M)

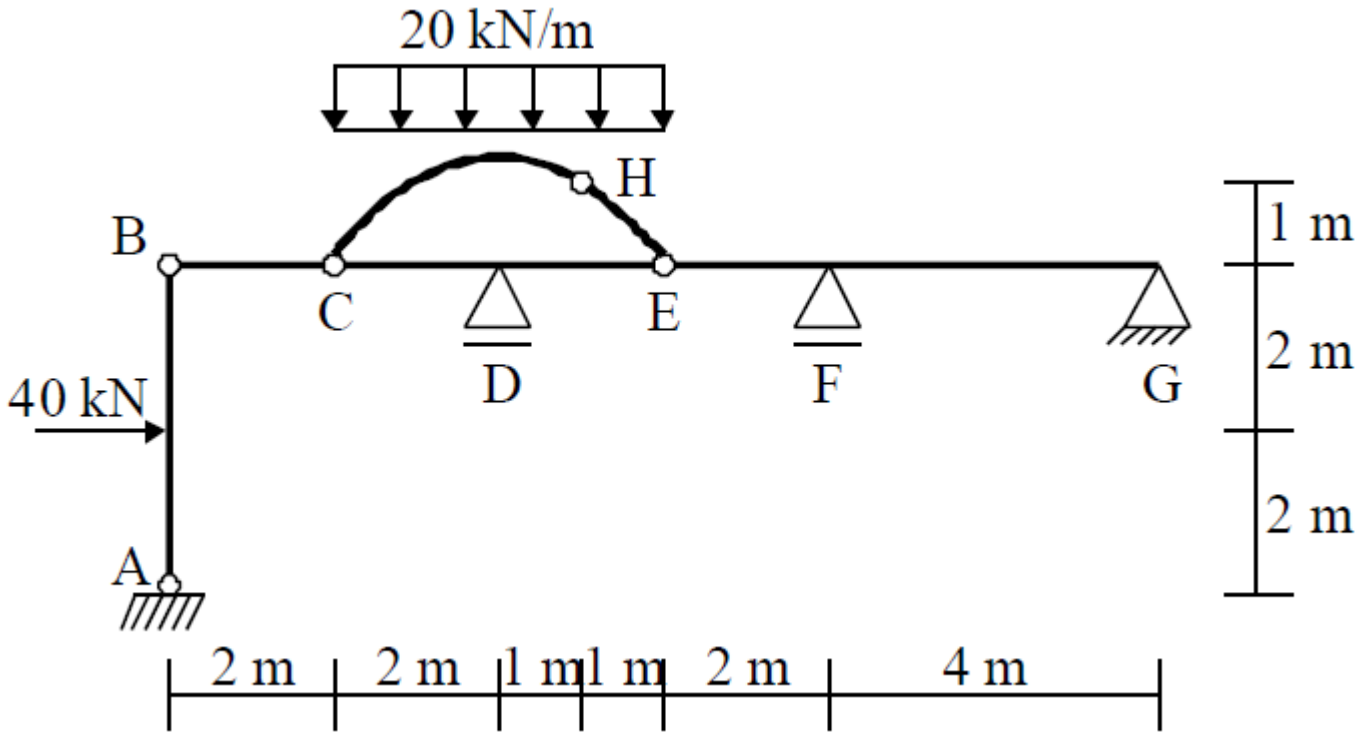

100 kNm
100 kNm
250 kNm
50 kNm
50 kNm
100 kNm
100 kNm

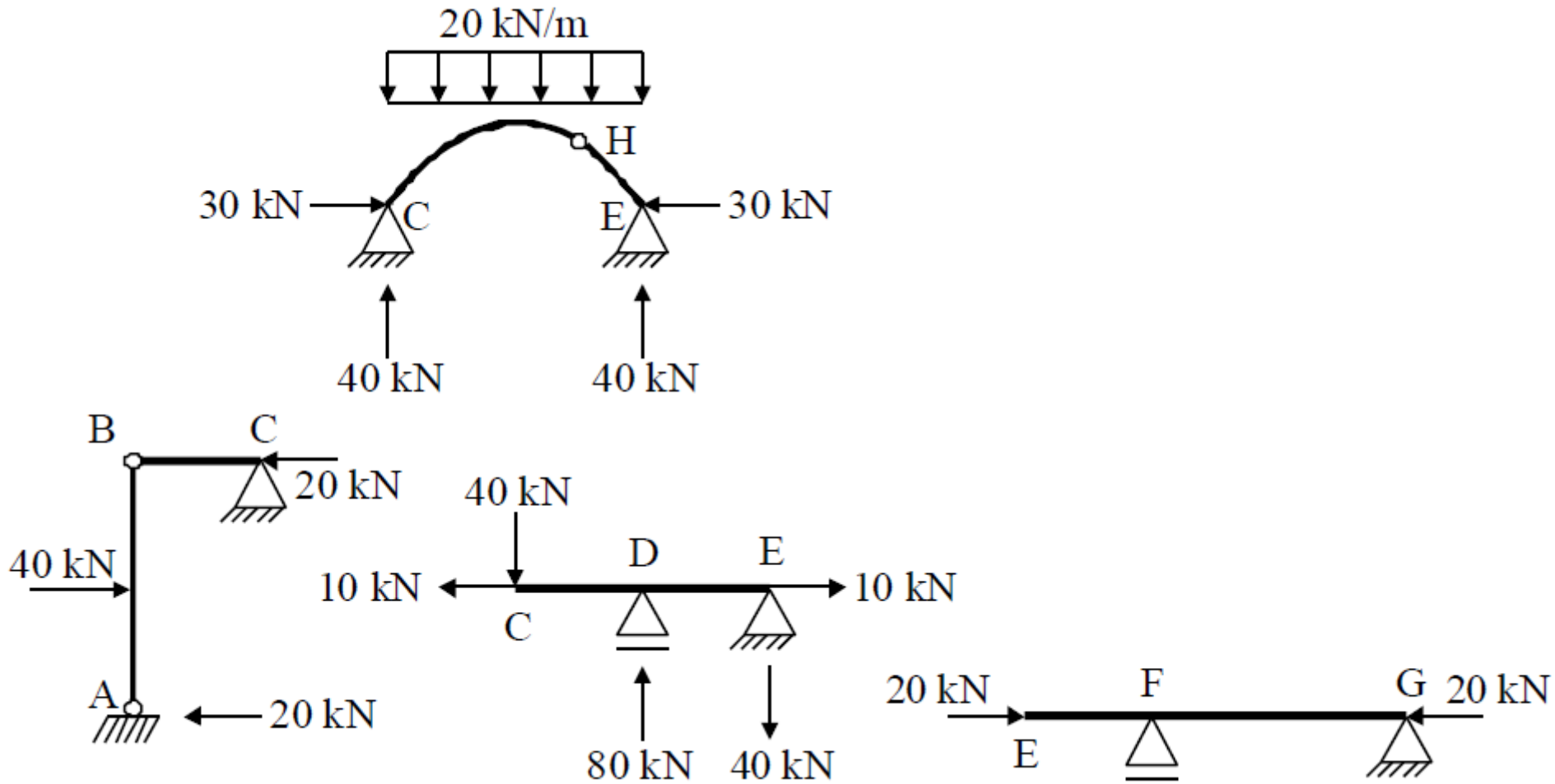
Exemplo 23: P3 1993

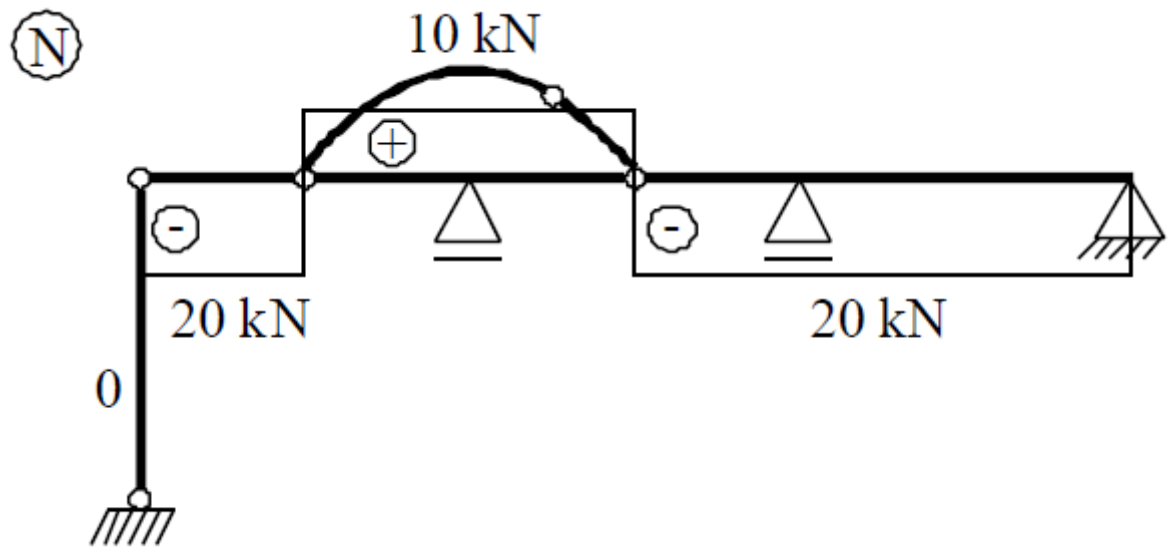
Considere a estrutura abaixo

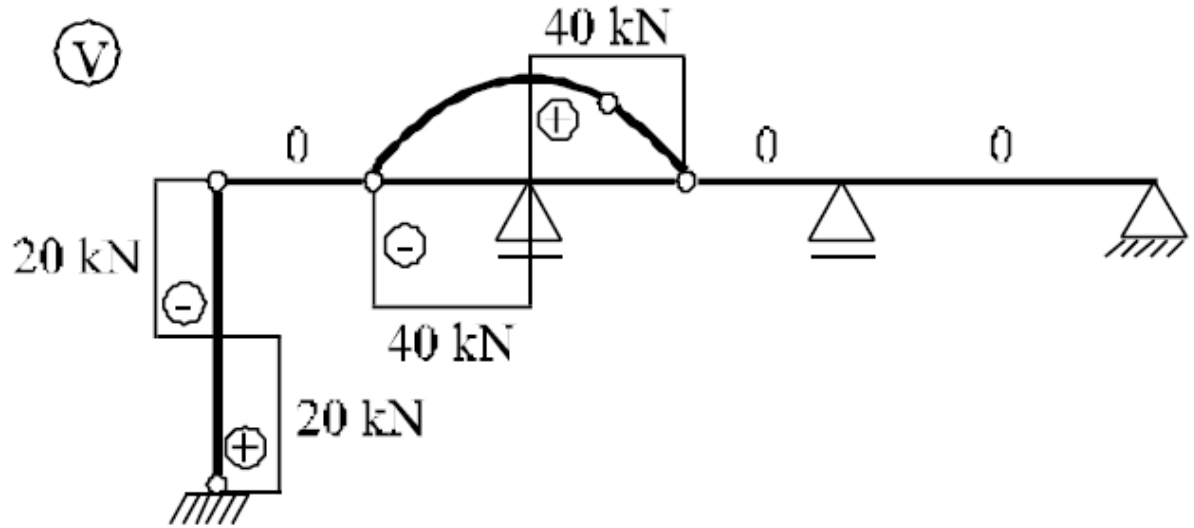
a) Decomponha a estrutura;

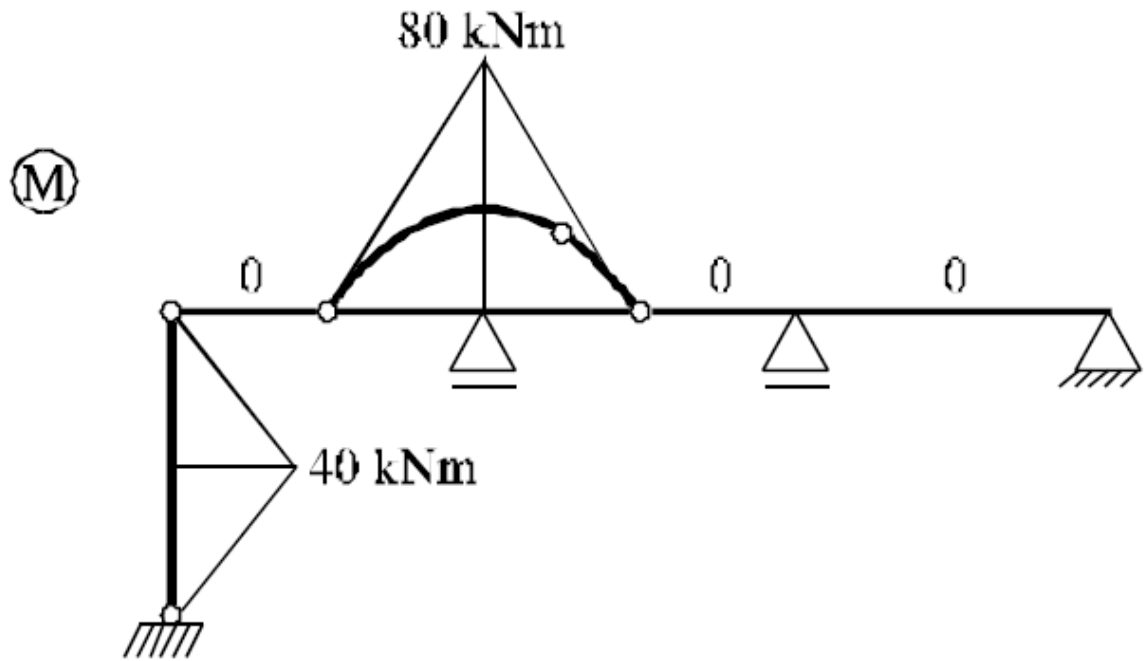
b) Trace os diagramas de esforços solicitantes. Não é preciso traçar os diagramas no trecho CHE.




20 kN/m
H
30 kN
C
E
30 kN
40 kN
40 kN
B
C
20 kN
40 kN
40 kN
D
E
10 kN
10 kN
C
A
20 kN
80 kN
40 kN
20 kN
F
G
20 kN
E


N
10 kN
20 kN
20 kN
0


V
40 kN
0
0
0
20 kN
40 kN
20 kN


M
80 kNm
0
0
0
40 kNm