

# MECHANICS OF SOLIDS

**solution manual**

**C. T. F. ROSS**

Horwood Series in Engineering Science



SOLUTIONS MANUAL  
for  
MECHANICS OF SOLIDS

by

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**FOR**  
**MECHANICS OF SOLIDS**  
**BY**

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**University of Portsmouth**

## CHAPTER 1

### 1a. Moments about A

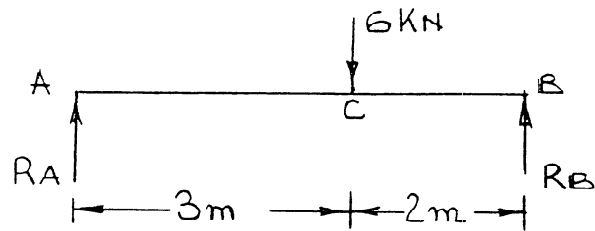
$$R_B \times 5 = 6 \times 2$$

$$R_B = 2.4 \text{ kN}$$

Resolving vertically

$$R_A + R_B = 6$$

$$\therefore R_A = 6 - 2.4 = 3.6 \text{ kN}$$



### 1b. Moments about A

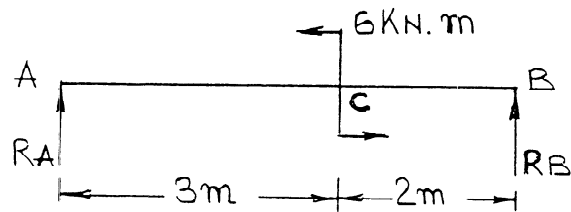
$$R_B \times 5 + 6 = 0$$

$$R_B = -1.2 \text{ kN}$$

Resolving vertically

$$R_A + R_B = 0$$

$$R_A = 1.2 \text{ kN}$$



### 2a. Moments about A

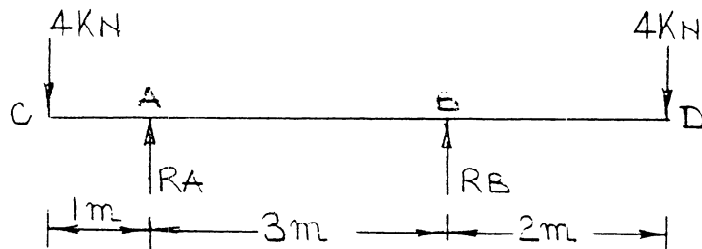
$$R_B \times 3 + 4 \times 1 = 4 \times 5$$

$$R_B = 5.333 \text{ kN}$$

Resolving vertically

$$R_A + R_B = 4 + 4$$

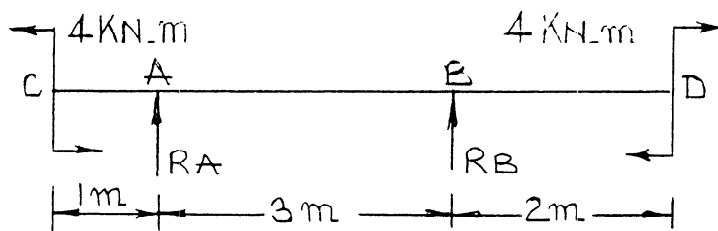
$$R_A = 2.667 \text{ kN}$$



### 2b. Moments about A

$$R_B \times 3 = 4 - 4$$

$$R_B = 0$$



Resolving vertically

$$R_A + R_B = 0$$

$$R_A = 0$$

- 3a. Assume unknown internal forces are in tension, and consider the equilibrium of joint C.

Resolving forces vertically

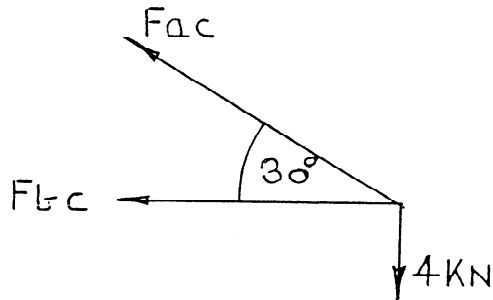
$$F_{ac} \sin 30 = 4$$

$$\therefore F_{ac} = 8 \text{ kN (tension)}$$

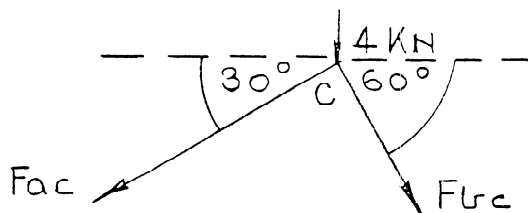
Resolving forces horizontally

$$F_{ac} \cos 30 + F_{bc} = 0$$

$$F_{bc} = -6.928 \text{ (compression)}$$



- 3b. Assume all unknown internal forces are in tension and consider the equilibrium of joint C.



Joint C

Resolving horizontally

$$F_{ac} \cos 30 = F_{bc} \cos 60$$

$$F_{ac} = 0.5774 F_{bc}$$

1

Resolving vertically

$$4 + F_{ac} \sin 30 + F_{bc} \sin 60 = 0$$

$$\text{or } 4 = -0.5 F_{ac} - 0.866 F_{bc}$$

2

Substitute 1 into 2

$$4 = -0.2887 F_{bc} - 0.866 F_{bc}$$

$$\therefore F_{bc} = -3.464 \text{ kN (compression)}$$

3

Substitute 3 into 1

$$F_{ac} = -2 \text{ kN (compression)}$$

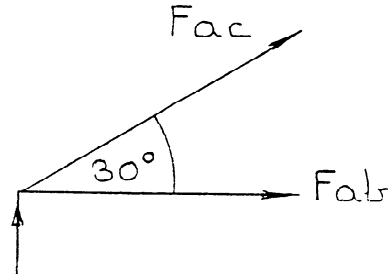
4

Consider Joint A

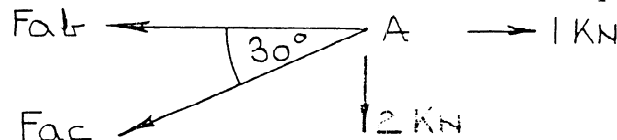
Resolve horizontally

$$F_{ac} \cos 30 + F_{ab} = 0$$

$$F_{ab} = -F_{ac} \cos 30 = 1.732 \text{ kN (tension)}$$



4. Assume all unknown forces are in tension, and consider equilibrium of Joint A.



Resolving vertically

$$F_{ac} \sin 30 = 2 = 0$$

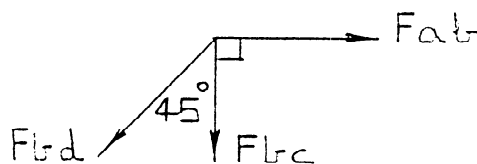
$$F_{ac} = -4 \text{ kN (compression)}$$

Resolving horizontally

$$F_{ab} + F_{ac} \cos 30 = 1$$

$$F_{ab} = 1 - 0.866 F_{ac} = 4.464 \text{ kN (tension)}$$

Joint B



Resolving horizontally

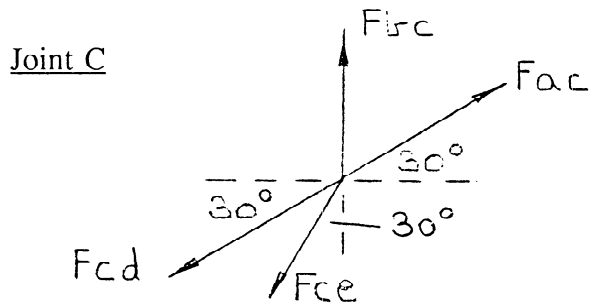
$$F_{bd} \cos 45 = F_{ab}$$

$$F_{bc} = 6.31 \text{ kN (tension)}$$

Resolving vertically

$$F_{bc} + F_{bd} \cos 45 = 0$$

$$F_{bd} = -4.464 \text{ kN (compression)}$$



Resolving Horizontally

$$F_{ac} \cos 30 = F_{cd} \cos 30 + F_{ce} \cos 60$$

$$F_{cd} = F_{ac} - 0.5774 F_{ce}$$

$$F_{cd} = -4 - 0.5774 F_{ce} \quad 1$$

Resolving vertically

$$F_{bc} + F_{ac} \sin 30 = F_{cd} \sin 30 + F_{ce} \sin 60$$

$$-4.464 - 2 = 0.5 F_{cd} + 0.866 F_{ce} \quad 2$$

Substitute 1 into 2

$$-6.464 = -2 - 0.289 F_{ce} + 0.866 F_{ce}$$

$$F_{ce} = -7.737 \text{ kN (compression)} \quad 3$$

Substituting 3 into 1

$$F_{cd} = 0.467 \text{ kN (tension)}$$

Joint E

Resolving horizontally

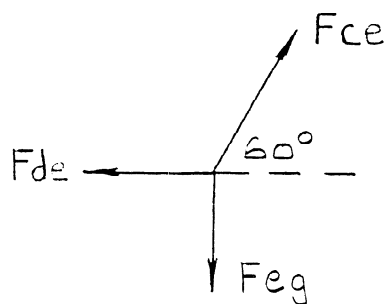
$$F_{ce} \cos 60 = F_{de}$$

$$F_{de} = -3.87 \text{ (compression)}$$

Resolving vertically

$$F_{ce} \sin 60 = F_{eg}$$

$$F_{eg} = -6.7 \text{ kN (compression)}$$



### Joint D

#### Resolving horizontally

$$F_{bd} \cos 45 + F_{cd} \cos 30$$

$$+ F_{de} + F_{dg} \cos 45 = 0$$

$$6.31 \times 0.707 + 0.467 \times 0.866 - 3.87 + 0.707 F_{dg} = 0$$

$$F_{dg} = -1.41 \text{ kN (compression)}$$

#### Resolving vertically

$$F_{bd} \sin 45 + F_{cd} \sin 30 = F_{dg} \sin 45 + F_{df}$$

$$6.31 \times 0.707 + 0.467 \times 0.5 = -1.41 \times 0.707 + F_{df}$$

$$F_{df} = 5.7 \text{ kN (tension)}$$

### Joint G

#### Resolving horizontally

$$- F_{dg} \times 0.707 = F_{gf}$$

$$F_{gf} = 1.0 \text{ kN (tension)}$$

#### Resolving vertically

$$F_{ge} + F_{dg} \times 0.707 = F_{gj}$$

$$-6.7 - 1.41 \times 0.707 = F_{gj}$$

$$F_{gj} = -7.7 \text{ kN (compression)}$$

### Joint F

#### Resolving horizontally

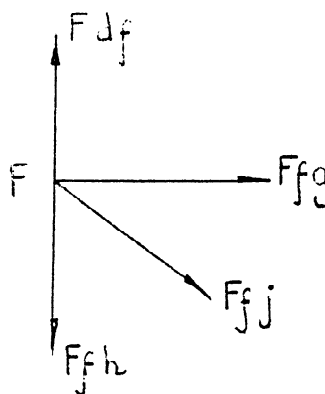
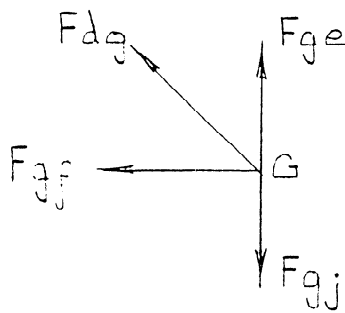
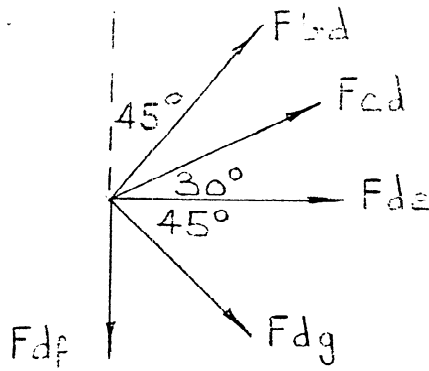
$$- F_{fj} \times 0.707 = F_{fg}$$

$$\therefore F_{fj} = -1.41 \text{ kN (compression)}$$

#### Resolving vertically

$$F_{df} = F_{fj} \times 0.707 + F_{fh}$$

$$F_{fh} = 5.7 + 1 = 6.7 \text{ kN (tension)}$$





Joint J

Resolving horizontally

$$- F_{jf} \times 0.707 = F_{jh}$$

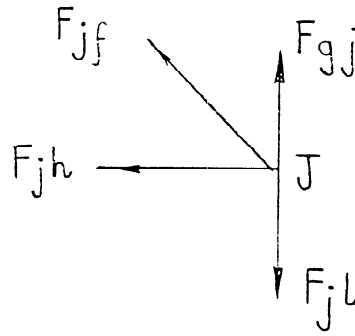
$$F_{jh} = 1.0 \text{ kN (tension)}$$

Resolving vertically

$$F_{gj} + F_{jf} \times 0.77 = F_{jl}$$

$$- 7.7 - 1.41 \times 0.707 = F_{jl}$$

$$F_{jl} = -8.7 \text{ kN (compression)}$$



Joint H

Resolving horizontally

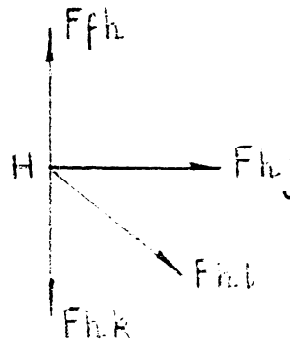
$$F_{hl} \cos 45 = - F_{hj}$$

$$\therefore F_{hl} = - 1.41 \text{ kN (compression)}$$

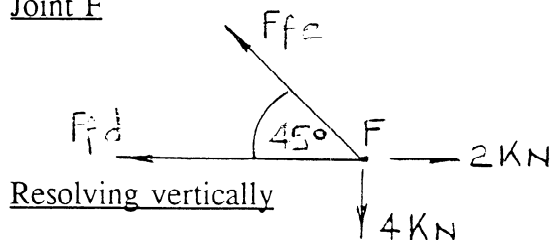
Resolving vertically

$$F_{th} = F_{hl} \times 0.707 + F_{hk}$$

$$\therefore F_{hk} = + 6.7 + 1 = 7.7 \text{ kN (tension)}$$



5. Joint F



Resolving vertically

$$F_{fe} \times 0.707 = 4$$

$$F_{fe} = 5.658 \text{ kN (tensile)}$$

Resolving horizontally

$$F_{fe} \times 0.707 + F_{fd} = 2$$

$$F_{fd} = 2 - 4 = -2 \text{ kN (compressive)}$$

Joint E

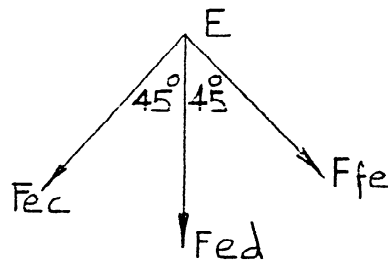
Resolving horizontally

$$F_{ec} = F_{fe} = 5.658 \text{ kN (tensile)}$$

Resolving vertically

$$F_{ec} \times 0.707 + F_{fe} \times 0.707 + F_{ed} = 0$$

$$F_{ed} = -8 \text{ kN (compressive)}$$



Joint C

Resolving horizontally

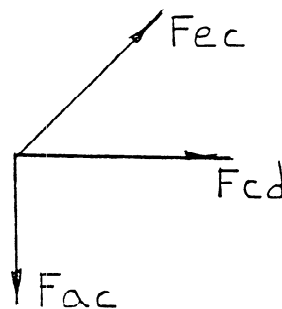
$$F_{ec} \times 0.707 + F_{cd} = 0$$

$$F_{cd} = -4 \text{ kN (compressive)}$$

Resolving vertically

$$F_{ec} \times 0.707 = F_{ac}$$

$$F_{ac} = 4 \text{ kN (tensile)}$$



Joint D

Resolving horizontally

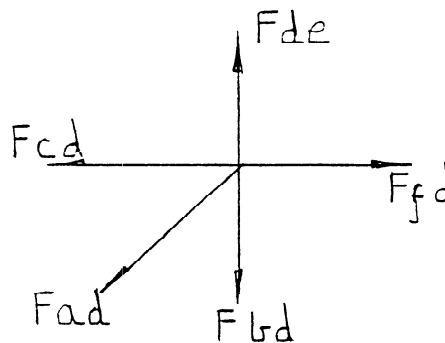
$$F_{fd} = F_{cd} + F_{ad} \times 0.707$$

$$F_{ad} = 2.828 \text{ kN (tensile)}$$

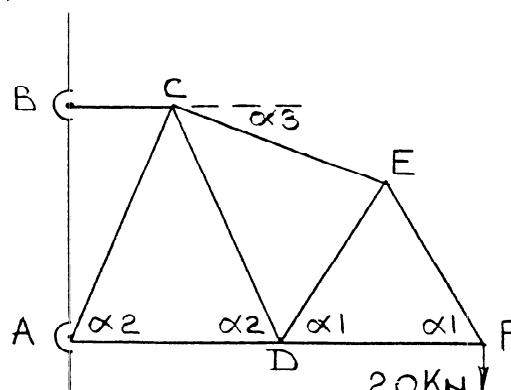
Resolving vertically

$$F_{de} = F_{bd} + F_{ad} \times 0.707$$

$$F_{bd} = -8 - 2 = -10 \text{ kN (compressive)}$$



6.  $\alpha_1 \tan^{-1} 3 = 71.565^\circ$   
 $\alpha_2 = \tan^{-1} 4 = 75.964^\circ$   
 $\alpha_3 = \tan^{-1} (1/2) = 26.565^\circ$



Joint F

Resolving vertically

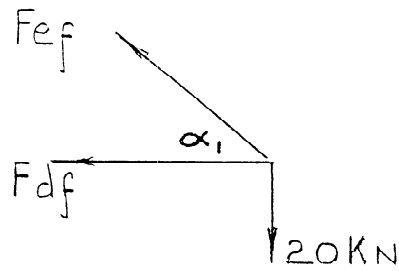
$$F_{ef} \sin \alpha_1 = 20$$

$$F_{ef} = 21.08 \text{ (tensile)}$$

Resolving horizontally

$$F_{df} + F_{ef} \cos \alpha_1 = 0$$

$$F_{df} = -6.667 \text{ kN (compressive)}$$



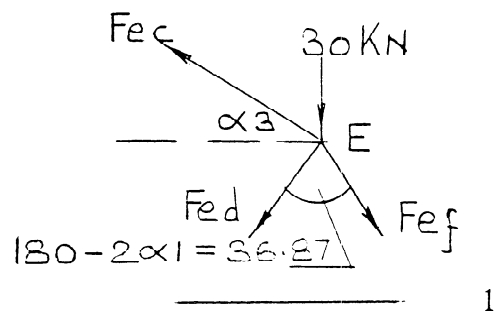
Joint E

Resolving vertically

$$F_{ec} \sin \alpha_3 = 30 + (F_{ed} + F_{ef}) \cos (18.435^\circ)$$

$$0.447 F_{ec} = 30 + 0.949 F_{ed} + 20$$

$$F_{ec} = 111.86 + 2.123 F_{ed}$$



Resolving horizontally

$$F_{ec} \cos \alpha_3 + F_{ed} \sin (18.435) = F_{ef} \sin (18.435)$$

$$0.894 F_{ec} + 0.316 F_{ed} = 6.667$$

Substitute 1 into 2

$$0.894 (111.86 + 2.123 F_{ed}) + 0.316 F_{ed} = 6.667$$

$$100 + 2.214 F_{ed} = 6.667$$

$$F_{ed} = -42.16 \text{ kN (compressive)}$$

Substituting 3 into 1

$$F_{ec} = 22.36 \text{ kN (tensile)}$$

Joint D

Resolving horizontally

$$F_{ad} + F_{cd} \cos \alpha_2$$

$$= F_{fd} + F_{cd} \cos \alpha_1$$

