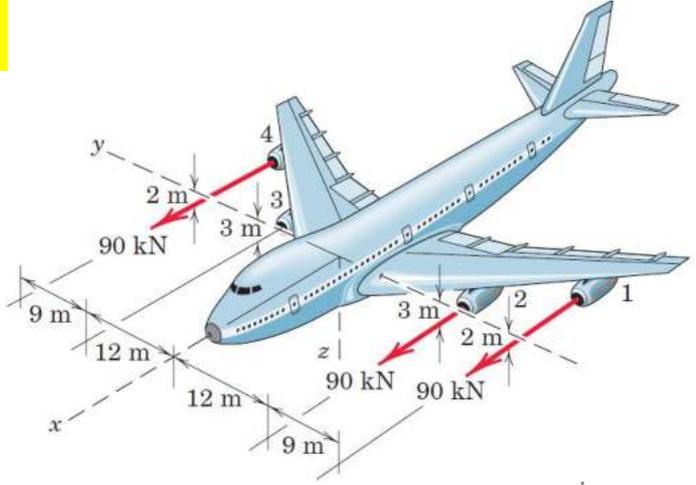
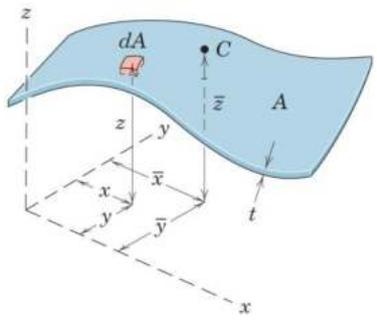
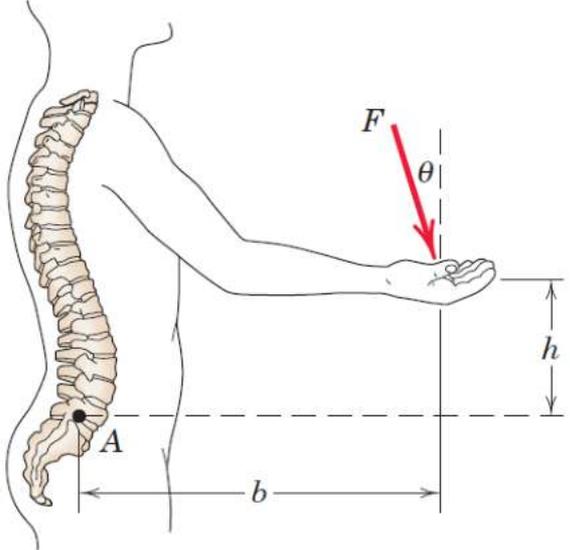
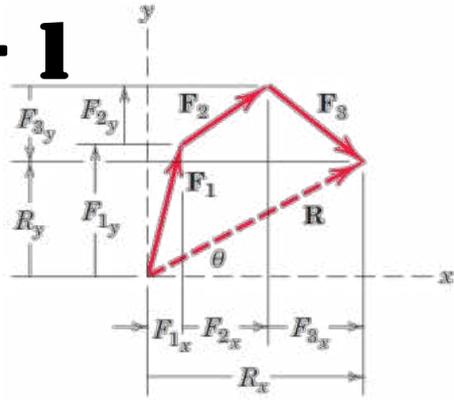
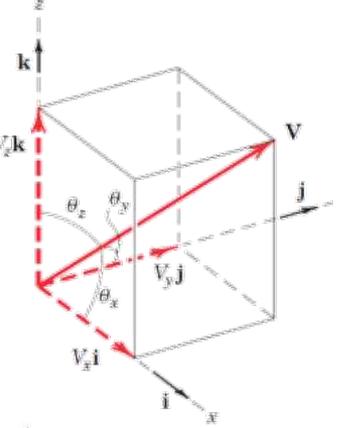


# ENGINEERING MECHANICS - 1

## ENG 203

# CHAPTER - 4

# Structures



# CHAPTER OUTLINE

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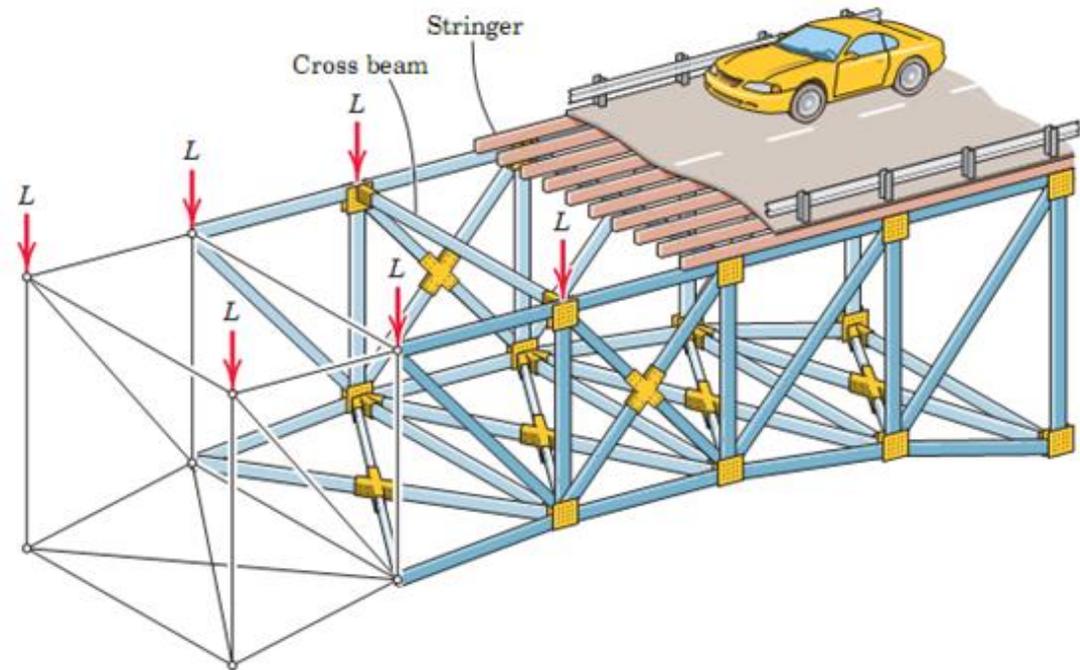
✓ *Introduction*

✓ *Method of Joints*

# Introduction

✓ An engineering structure is any connected system of members built to support or transfer forces and to safely withstand the loads applied to it.

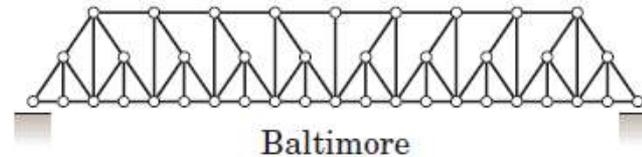
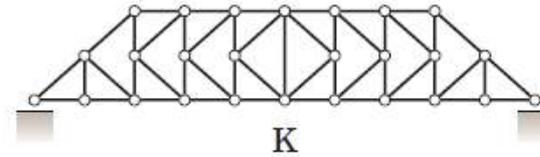
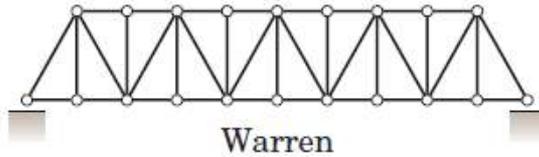
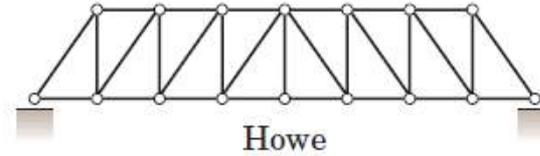
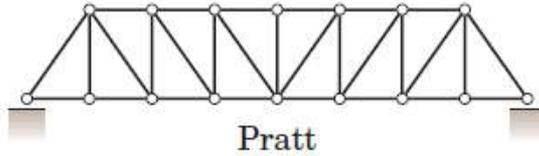
✓ To determine the forces internal to an engineering structure, we must dismember the structure and analyze separate free-body diagrams of individual members or combinations of members.



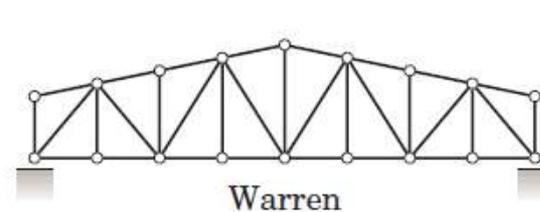
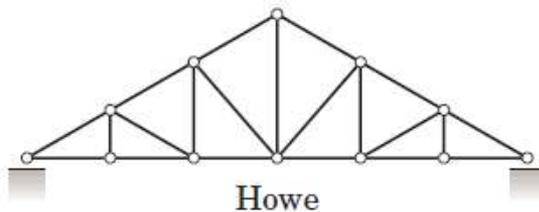
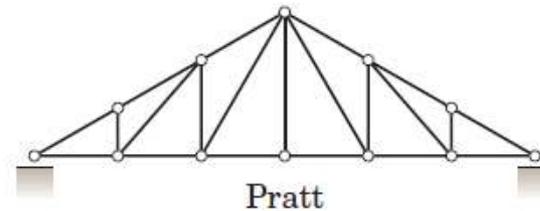
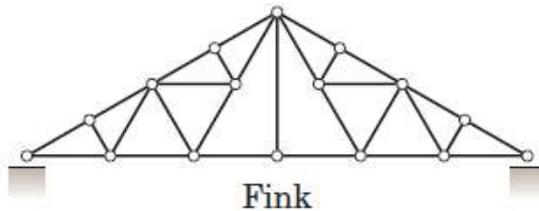
✓ This analysis requires careful application of **Newton's third law**, which states that each action is accompanied by an equal and opposite reaction.

# Several Examples of Commonly Used Trusses

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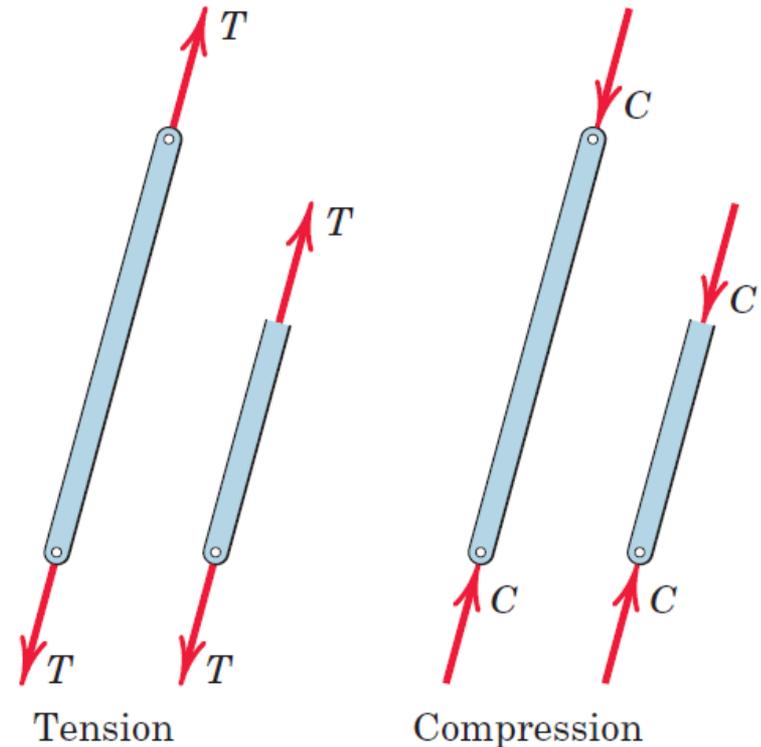


Commonly Used Bridge Trusses



# Two-Force Members

- ✓ The two forces are applied at the ends of the member and are necessarily equal, **opposite**, and **collinear** for equilibrium.
- ✓ The member may be in **tension** (T) or **compression** (C), as shown in Fig.
- ✓ We assume here that the weight of the member is small compared with the force it supports.



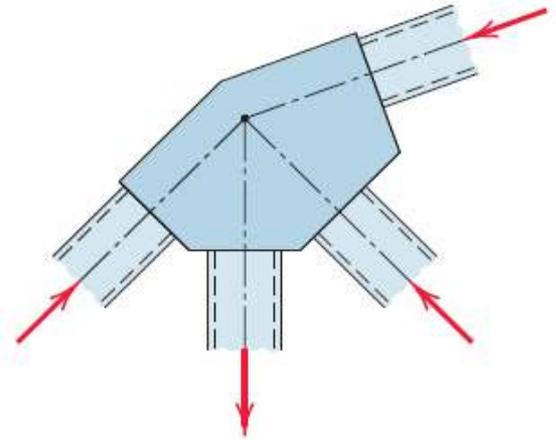
Two-Force Members

**Tension T / Compression C**

# Truss Connections & Supports

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- ✓ We may usually assume that the connection is a **Pin Joint** if the centerlines of the members are concurrent at the joint as in figure.
- ✓ For large trusses, a **Roller**, **Rocker**, or some kind of slip joint is used at one of the supports to provide for **expansion** and **contraction** due to temperature changes and for deformation from applied loads.



- ✓ **Two methods for the force analysis of simple trusses:**
  - I. *Method of Joints.*
  - II. *Method of Sections.*

# Method of Joints

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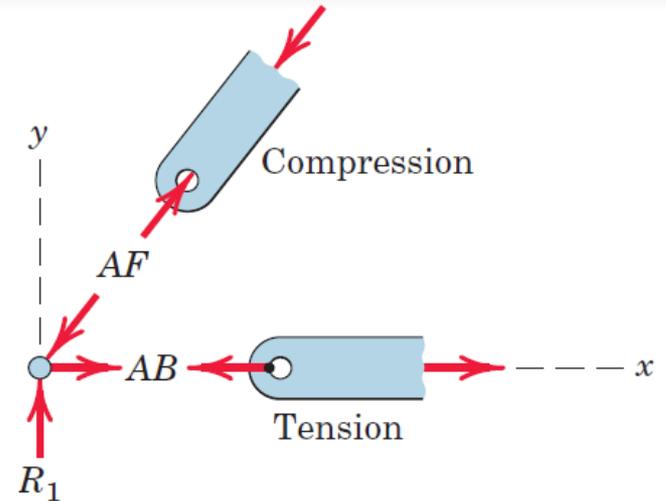
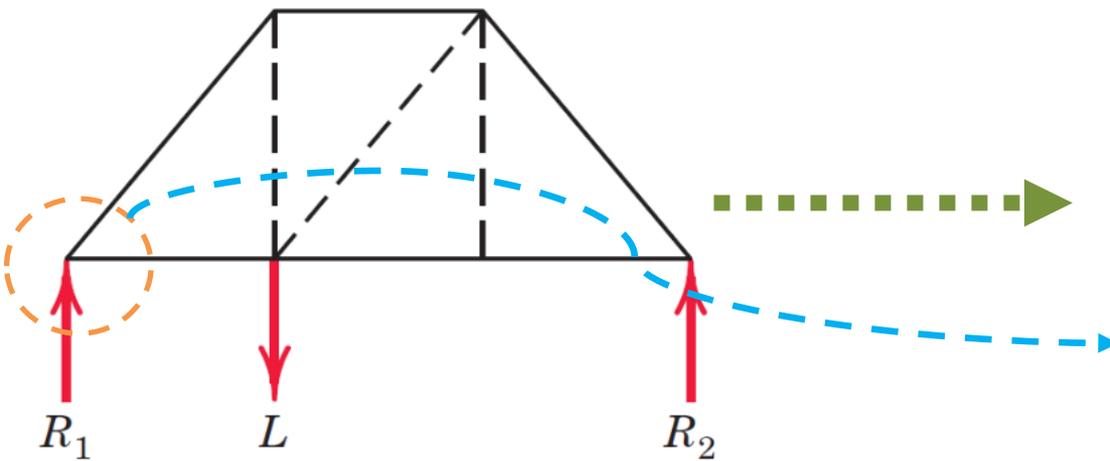
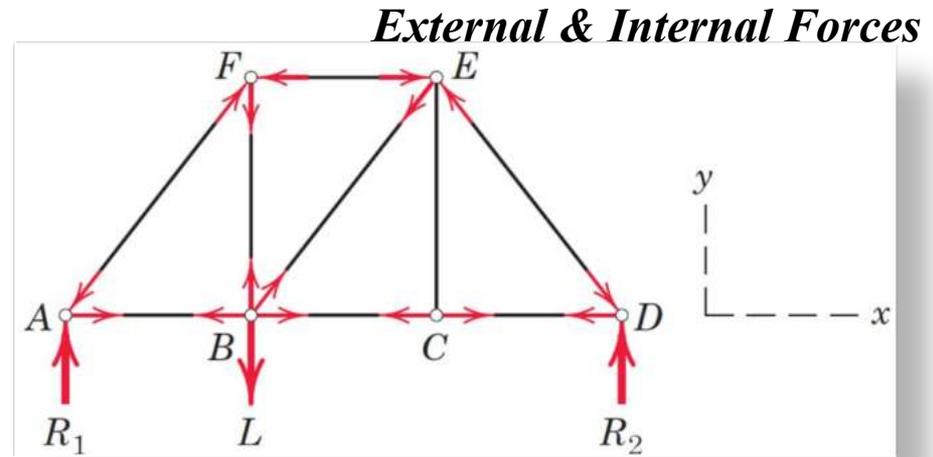
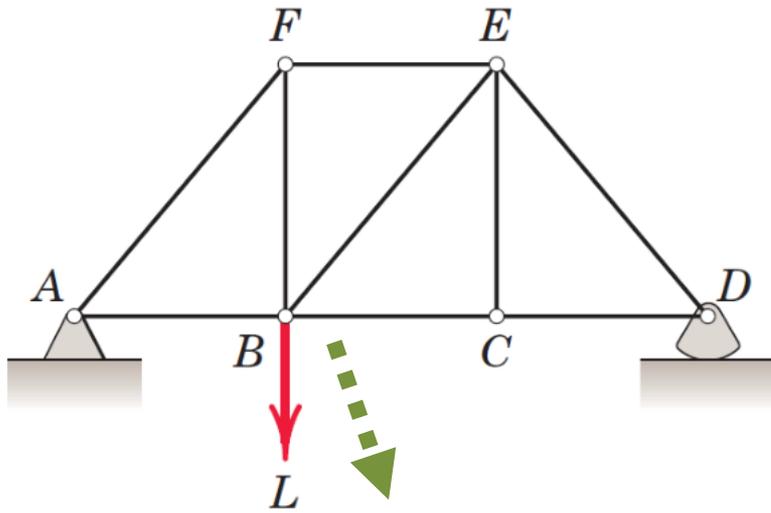
Method for finding the forces in the members of a truss:

1. The free-body diagram (F. B. D.) of the truss as a whole.
2. Applying the equilibrium equations to the truss as a whole to calculate the External Reactions.
3. We begin the analysis with any Joint where at least one known load exists and where not more than two unknown forces are present.

→ Sometimes we cannot initially assign the correct direction of one or both of the unknown forces acting on a given pin. If so, we may make an arbitrary assignment.

→ A negative computed force value indicates that the initially assumed direction is incorrect.

# Method of Joints



1. *F. B. D. (whole).*

2. *External Reactions (whole).*

3. *F. B. D. and Applying Equilibrium Equations for each Joint*

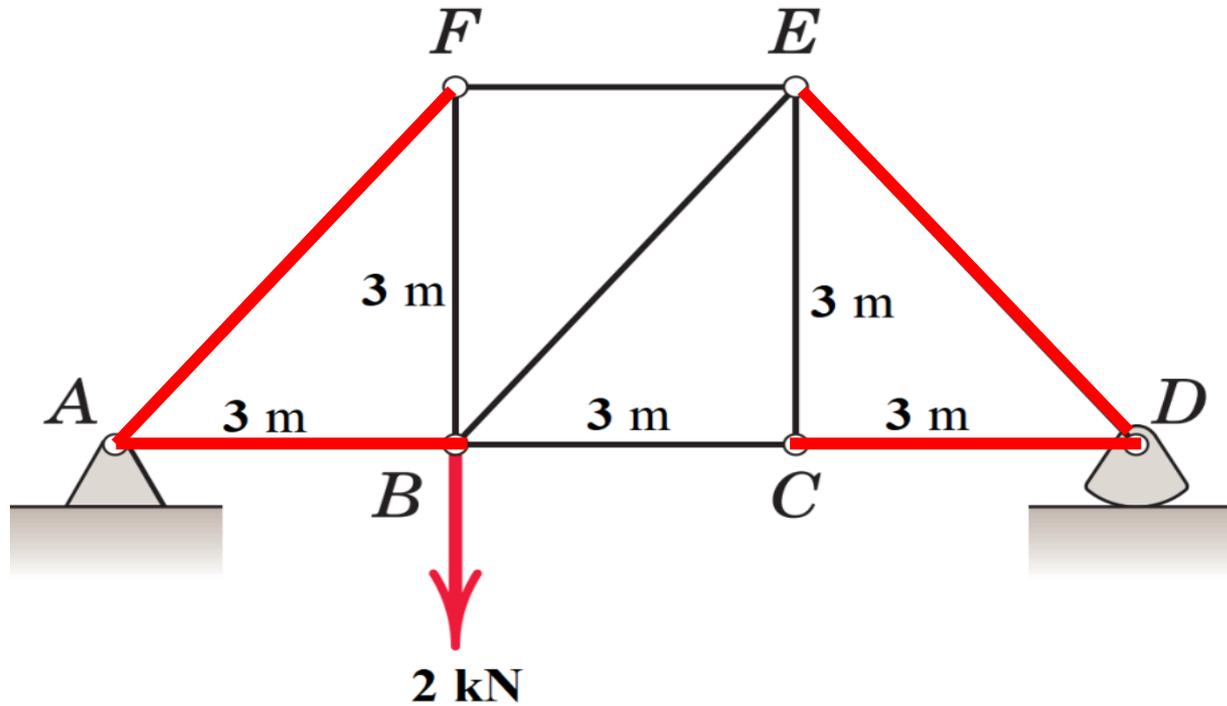
$$\Sigma F_x = 0 \quad \Sigma F_y = 0$$

# **Exercises**

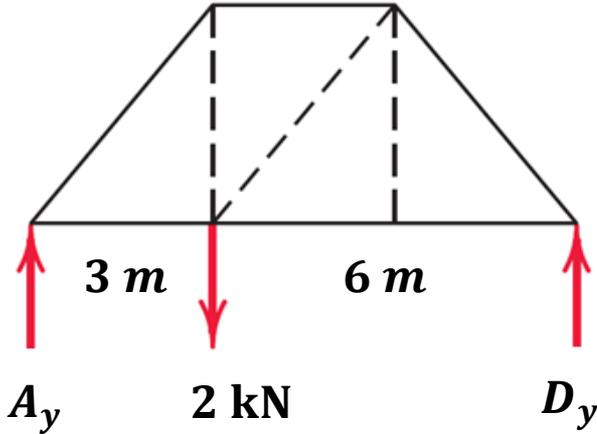
# Exercise – 1

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Using method of joints, calculate the force only in the members **AB**, **AF**, **CD** and **DE** of the loaded truss.



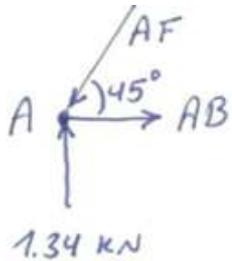
# Solution - Exercise - 1



$$\sum M_A = 0 \Rightarrow D_y * 9 - 2 * 3 = 0 \Rightarrow D_y = 0.66 \text{ kN}$$

$$\sum M_D = 0 \Rightarrow A_y * 9 - 2 * 6 = 0 \Rightarrow A_y = 1.34 \text{ kN}$$

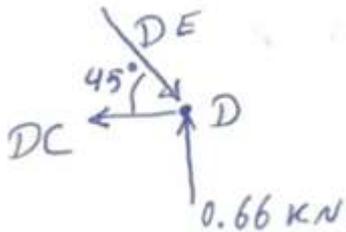
## “Joint A”



$$\sum F_y = 0 \Rightarrow 1.34 - AF \cos 45 = 0 \Rightarrow AF = 1.895 \text{ kN}$$

$$\sum F_x = 0 \Rightarrow AB - 1.895 \cos 45 = 0 \Rightarrow AB = 1.34 \text{ kN}$$

## “Joint D”

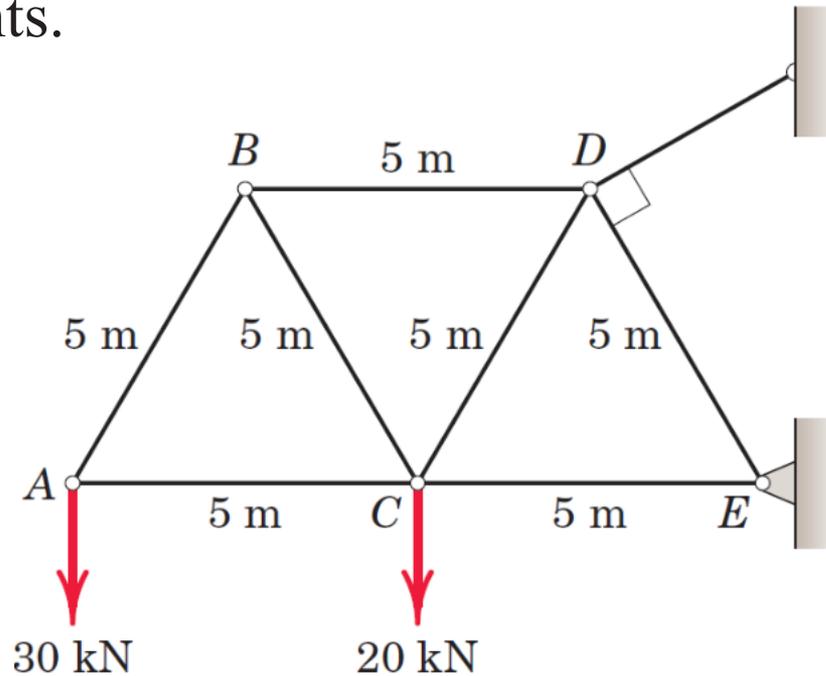


$$\sum F_y = 0 \Rightarrow 0.66 - DE \cos 45 = 0 \Rightarrow DE = 0.933 \text{ kN}$$

$$\sum F_x = 0 \Rightarrow -DC + 0.933 * \cos 45 = 0 \Rightarrow DC = 0.66 \text{ kN}$$

## Exercise – 2

Compute the force in each member of the loaded cantilever truss by the method of joints.



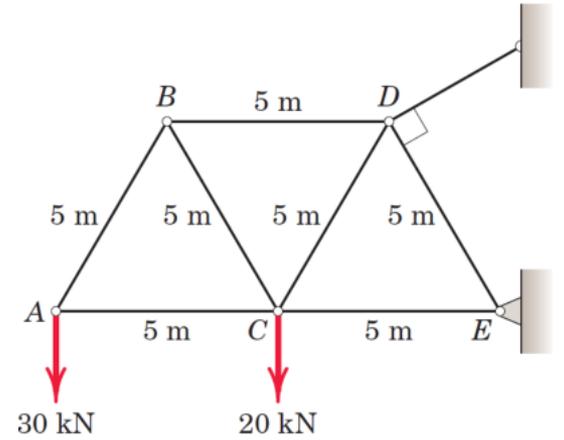
# Solution - Exercise – 2

## 1. F. B. D. & External Reactions at *D* and *E* (whole):

$$[\Sigma M_E = 0] \quad 5T - 20(5) - 30(10) = 0 \quad T = 80 \text{ kN}$$

$$[\Sigma F_x = 0] \quad 80 \cos 30^\circ - E_x = 0 \quad E_x = 69.3 \text{ kN}$$

$$[\Sigma F_y = 0] \quad 80 \sin 30^\circ + E_y - 20 - 30 = 0 \quad E_y = 10 \text{ kN}$$



## 2. F. B. D. & Equilibrium Equations for each Joint:

### “Joint A”

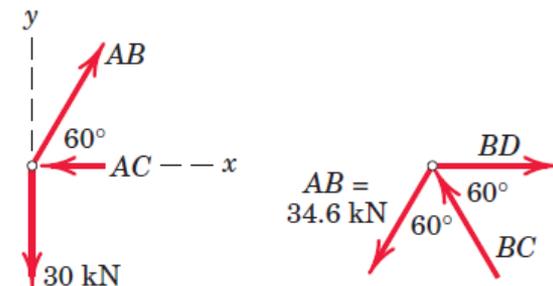
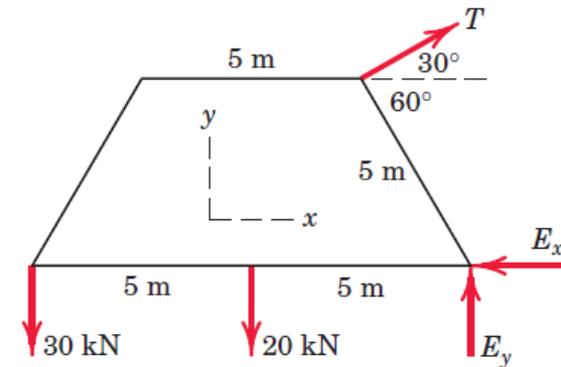
$$[\Sigma F_y = 0] \quad 0.866AB - 30 = 0 \quad AB = 34.6 \text{ kN } T \quad \text{Ans.}$$

$$[\Sigma F_x = 0] \quad AC - 0.5(34.6) = 0 \quad AC = 17.32 \text{ kN } C \quad \text{Ans.}$$

### “Joint B”

$$[\Sigma F_y = 0] \quad 0.866BC - 0.866(34.6) = 0 \quad BC = 34.6 \text{ kN } C \quad \text{Ans.}$$

$$[\Sigma F_x = 0] \quad BD - 2(0.5)(34.6) = 0 \quad BD = 34.6 \text{ kN } T \quad \text{Ans.}$$



Joint A

Joint B

## Solution - Exercise – 2

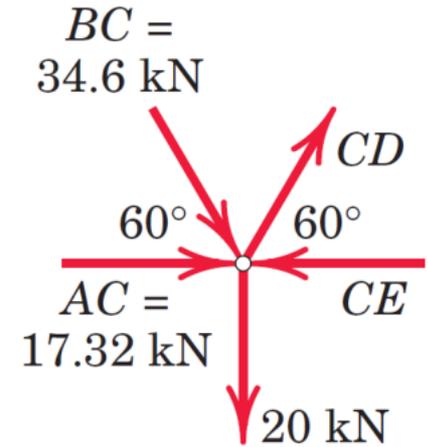
### “Joint C”

$$[\Sigma F_y = 0] \quad 0.866CD - 0.866(34.6) - 20 = 0$$

$$CD = 57.7 \text{ kN } T$$

$$[\Sigma F_x = 0] \quad CE - 17.32 - 0.5(34.6) - 0.5(57.7) = 0$$

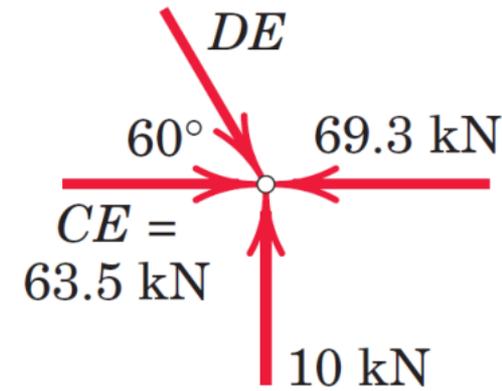
$$CE = 63.5 \text{ kN } C$$



Joint C

### “Joint E”

$$[\Sigma F_y = 0] \quad 0.866DE = 10 \quad DE = 11.55 \text{ kN } C$$

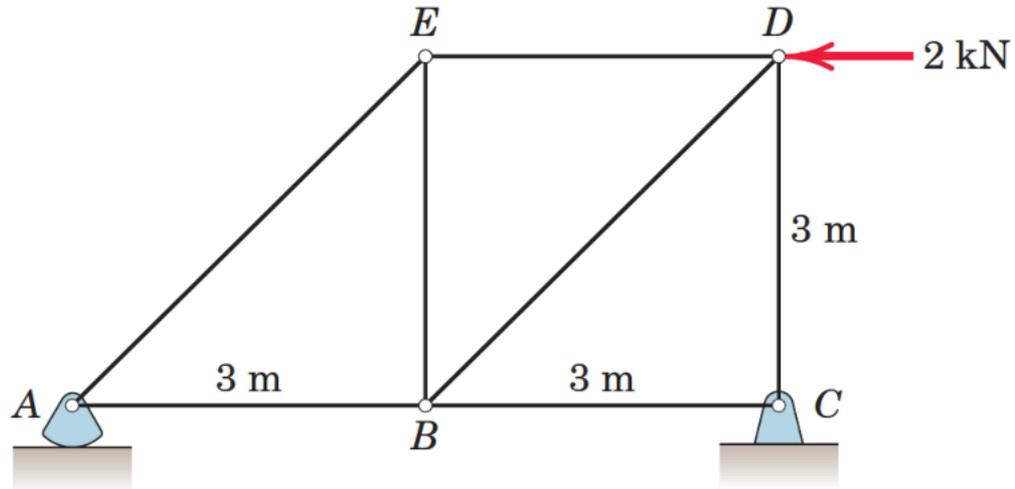


Joint E

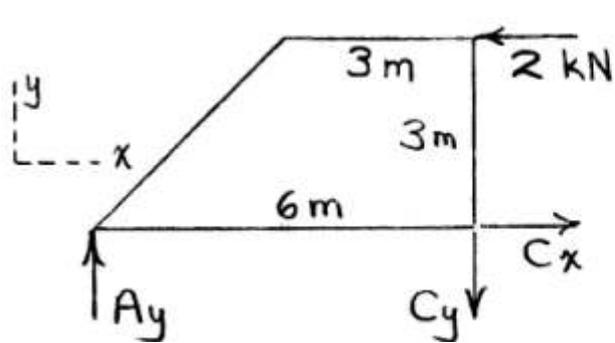
## Exercise – 3

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Calculate the force in each member of the loaded truss.



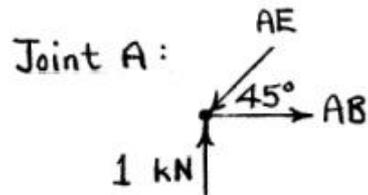
# Solution - Exercise - 3



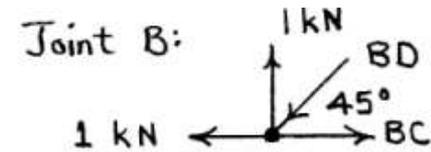
$$+\circlearrowleft \sum M_C = 0: 6A_y - 2(3) = 0$$

$$A_y = 1 \text{ kN}$$

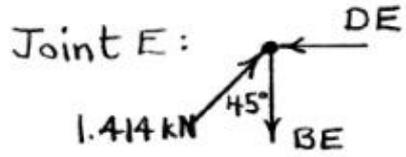
$$C_x = 2 \text{ kN}, C_y = 1 \text{ kN}$$



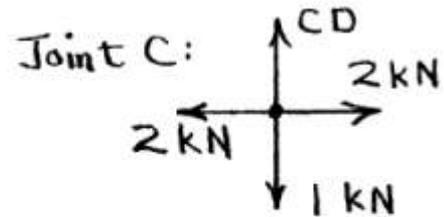
$$\begin{cases} \sum F_y = 0: 1 - AE \sin 45^\circ = 0 \\ \quad \quad \quad \underline{AE = 1.414 \text{ kN C}} \\ \sum F_x = 0: AB - 1.414 \cos 45^\circ = 0 \end{cases}$$



$$\begin{cases} \sum F_y = 0: 1 - BD \sin 45^\circ = 0 \\ \quad \quad \quad \underline{BD = 1.414 \text{ kN C}} \\ \sum F_x = 0: BC - 1.414 \cos 45^\circ - 1 = 0 \\ \quad \quad \quad \underline{BC = 2 \text{ kN T}} \end{cases}$$



$$\begin{cases} \sum F_x = 0: 1.414 \sin 45^\circ - DE = 0 \\ \quad \quad \quad \underline{DE = 1 \text{ kN C}} \\ \sum F_y = 0: 1.414 \cos 45^\circ - BE = 0 \\ \quad \quad \quad \underline{BE = 1 \text{ kN T}} \end{cases}$$



$$\sum F_y = 0: CD - 1 = 0$$

$$\underline{CD = 1 \text{ kN T}}$$

**(Joint D checks)**

## Exercise – 4

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Determine the force in each member of the loaded truss.

