5 CHAPTER

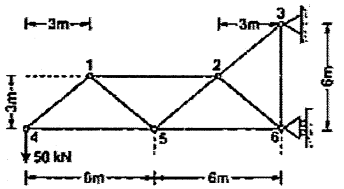
# Trusses

**Q.1** The method of joints in the analysis of trusses gives
(a) uncoupled equations.
(b) coupled or uncoupled equations.
(c) direct solution.
(d) coupled equations only.

**Q.2** Consider the following assumptions in the analysis of a plane truss:
1. The individual members are straight.
2. The individual members are connected by frictionless hinges.
3. The loads and reactions act only at the joints.

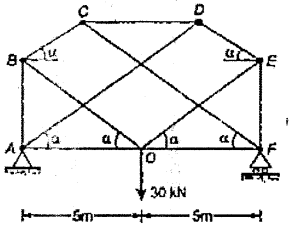
Which of these assumptions are valid?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

**Q.3** Axial forces in the members 1-2 and 1-5 of the truss shown in the given figure are respectively



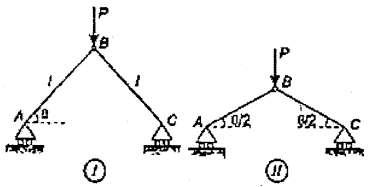

(a) 50 kN (compressive) and 25 kN (tensile)
(b) 25 kN (tensile) and $\frac{50}{\sqrt{2}}$ kN (compressive)
(c) 100 kN (tensile) and $50\sqrt{2}$ (compressive)
(d) 25 kN (compressive) and $\frac{50}{\sqrt{2}}$ k (tensile)

**Q.4** Axial force in the member BC of the truss shown in the given figure is (where $\alpha = 30°$)



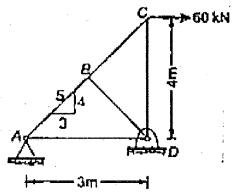

(a) 15 kN (b) $10\sqrt{3}$kN
(c) $15\sqrt{3}$kN (d) 30 kN

**Q.5** Which one of the following is the correct statement regarding the force and deflection at point *B* in trusses I and II shown in the figure?



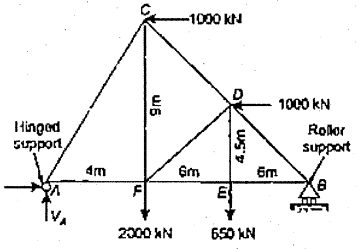

(a) I will have less member force and less deflection at B compared to II
(b) I will have less member force and more deflection at B compared to II
(c) I will have more member force and deflection at B compared to II
(d) I will have more member force and less deflection at B compared to II

**Q.6** Due to horizontal pull of 60 kN at *C*, what is the force induced in the member *AB*?



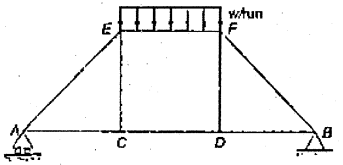

(a) 0 (b) 40 kN
(c) 80 kN (d) 100 kN

**Q.7** A truss *ABC* carries two horizontal and two vertical loads, as shown in the figure. The horizontal and vertical components of reactions at *A* will be



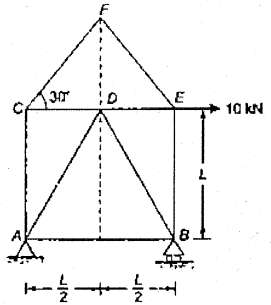

(a) $H_A$ = 1000 kN; $V_A$ = 1706.25 kN
(b) $H_A$ = 2000 kN; $V_A$ = 2550 kN
(c) $H_A$ = 1000 kN; $V_A$ = 2350 kN
(d) $H_A$ = 2000 kN; $V_A$ = 1706.25 kN

**Q.8** A truss consists of horizontal members and vertical members having length '*l*' each. The members *AE* and *BF* are inclined at 45° to the horizontal. For the uniformly distributed load '*w*' per unit length on the member *EF* of the truss shown in the figure the force in member *CD* is



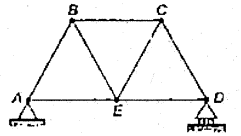

(a) $\frac{wl}{2}$ (b) $wl$
(c) zero (d) $\frac{2wl}{3}$

**Q.9** The strain energy stored in the member *AD* of the pin jointed truss shown below is



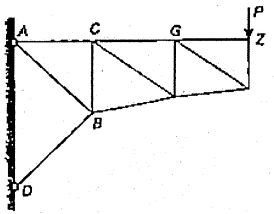

(a) $\frac{125\sqrt{5}\,L}{2AE}$ (b) $\frac{100\sqrt{5}\,L}{2AE}$
(c) $\frac{125\sqrt{5}\,L}{4AE}$ (d) $\frac{100\sqrt{5}\,L}{4AE}$

**Q.10** Length of each member of the truss shown in figure is 3 m. Members *AB* and *CD* are subjected to a temperature rise of 30°C and coefficient of thermal expansion is $12 \times 10^{-6}$/°C. The vertical deflection at joint *E* is




(a) 3 mm (b) 1.25 mm
(c) 2.5 mm (d) 1 mm

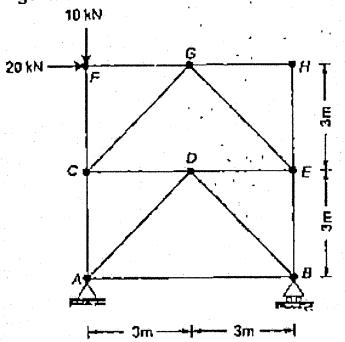
**Q.11** A cantilever pin-jointed truss carries one load *P* at the point *Z* as shown in the given figure. The hinges in the vertical wall are at *A* and *D*. The truss has only three horizontal members *AC*, *CG* and *GZ*.




The nature of force in member *AB*

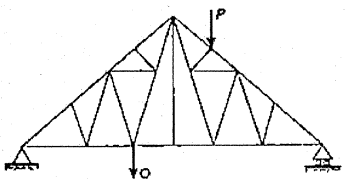
(a) is tensile.
(b) is zero.
(c) is compressive.
(d) cannot be predicted.

Q.12 A loaded pin-jointed truss is shown in the given figure. The force in member *AC* is




(a) $10\sqrt{2}$ kN (Tensile)
(b) $10\sqrt{2}$ kN (Compressive)
(c) Zero
(d) 10 kN (Tensile)

Q.13 For the plane truss shown in the figure, the number of zero force members for the given loading is

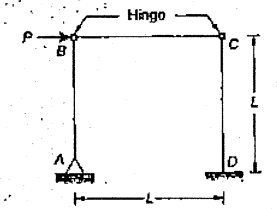



(a) 8 (b) 10
(c) 11 (d) 13

Q.14 In an indeterminate structure, when there is no lack of fit, the partial derivative of strain energy with respect to any of the redundant

(a) is zero.
(b) will give deflection in the direction of redundant.
(c) will give slope in the direction of redundant.
(d) is maximum.

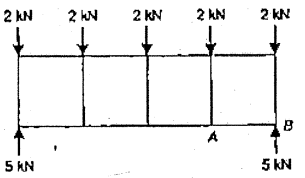
Q.15 For the structure shown below, magnitude of horizontal reaction at *A* and moment at *D* will respectively be




(a) $\frac{P}{2}, \frac{PL}{2}$ (b) $0, \frac{PL}{2}$

(c) $\frac{PL}{2}, PL$ (d) $0, PL$

Q.16 In the figure shown below, the force in member *AB* is

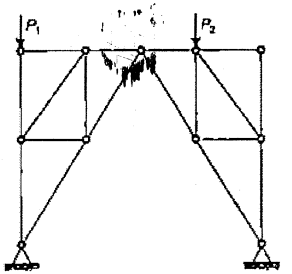



(a) 5 kN compression
(b) 2 kN compression
(c) 7 kN compression
(d) Zero

Q.17 An indeterminate building frame may be converted to a determinate one by assuming

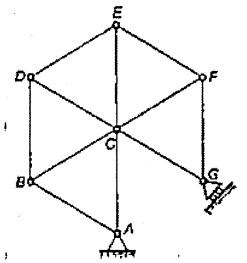
(a) hinges at mid-height of columns
(b) hinges at mid-span of the beams
(c) hinges at both mid-height of columns and mid-span of beams
(d) none of these

Q.18 For the truss frame shown below, how many members will definitely have zero force under the given loadings $P_1$ and $P_2$?




(a) 2 (b) 3
(c) 4 (d) 5

Q.19 A pin jointed frame is as shown in the figure below.



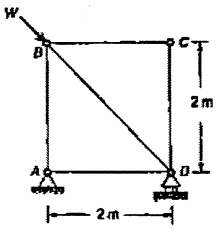

Consider the following statements regarding the above frame:

1. Frame is externally statically determinate.
2. Frame is internally stable.

Which of the above statement(s) is(are) correct?

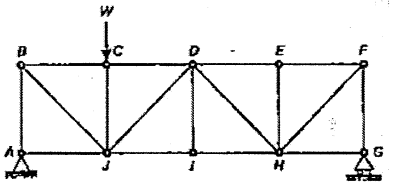
(a) 1 only (b) Both 1 and 2
(c) 2 only (d) None of these

Q.20 Force in the member *AD* of the frame shown in the given figure will be



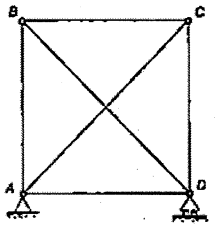

(a) Zero
(b) $\frac{W}{\sqrt{2}}$ (Tension)
(c) $\frac{W}{\sqrt{2}}$ (Compression)
(d) $W\sqrt{2}$ (Compression)

Q.21 For the truss shown in figure, members having zero forces are



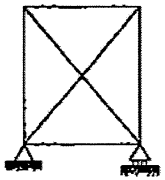

(a) 4 (b) 5
(c) 7 (d) 10

Q.22 A square truss shown below is to be constructed in field but while fabricating the members in the factory, member *AC* was defectively fabricated, a bit too short. Stress developed in the member *BD*, immediately after constructing the truss by force, would be



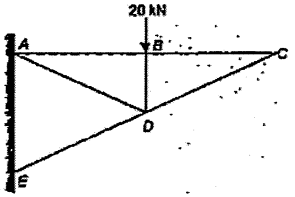

(a) Compressive (b) Tensile
(c) Zero (d) Can't say

**Q.23** The truss is



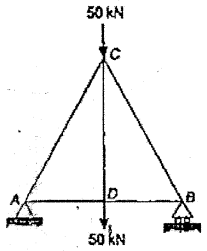
(a) Perfect (b) Deficient
(c) Redundant (d) None

**Q.24** For the truss shown in figure, which one of the following member has zero force induced in it?



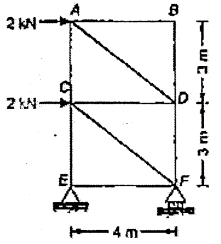

(a) BC (b) AD
(c) DE (d) BD

**Q.25** The force induced in the vertical member *CD* of the symmetrical plane truss shown in the figure is




(a) 50 kN (tension) (b) 100 kN (tension)
(c) 50 kN (comp.) (d) Zero

**Q.26** A pin-jointed tower turss is loaded as shown in the figure. The force induced in the member *DF* is




(a) 1.5 kN (tension) (b) 4.5 kN (tension)
(c) 1.5 kN (comp.) (d) 4.5 kN (comp.)

■■■■

## Answers Trusses

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. (b) | 2. (d) | 3. (c) | 4. (d) | 5. (d) | 6. (d) | 7. (b) | 8. (a) | 9. (c) | 10. (b) |
| 11. (c) | 12. (c) | 13. (a) | 14. (a) | 15. (d) | 16. (d) | 17. (c) | 18. (b) | 19. (a) | 20. (b) |
| 21. (a) | 22. (b) | 23. (c) | 24. (a) | 25. (a) | 26. (c) | | | | |

## Explanations Trusses

1. (b)
Method of joints gives $\Sigma F_x = 0$, $\Sigma F_y = 0$, but some times only one equation gives the solution.

2. (d)
For plane truss assumptions are:
(i) Weight of all members are neglected. All members are straight.
(ii) All connections are smooth with frictionless pins.
(iii) External loads are applied directly to the pin joints.
(iv) All frames are perfect, hence statically determinate.

3. (c)
Cutting a section through 1–2; 2–5; and 5–6.
Taking moment of left part about 5.

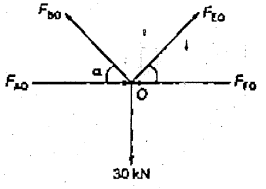
$$F_{1\text{-}2} = \frac{50 \times 6}{3} = 100 \text{ kN (Tensile)}$$

Cut a section through 1–2, 1–5 and 4–5 and balance vertical force for left part only

$$\frac{F_{1\text{-}5}}{\sqrt{2}} = 50$$

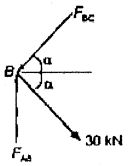
$$\therefore F_{1\text{-}5} = 50\sqrt{2}\text{kN (Compressive)}$$

4. (d)
The given truss is symmetrical. So force in members *BO* and *EO* will be same in magnitude and nature both. Joint equilibrium at *O*.




$$F_{bo} = \frac{15}{\sin 30^\circ} = 30\text{kN}$$

Joint equilibrium at *B*.




$\therefore F_{BC} = 30$ kN

5. (d)
Force in *AB* or *AC*
Consider joint *B*.

Case-I: $F_{AB}$ or $F_{AC} = \frac{P}{2}\sin\theta$

Case-II: $F_{AB}$ or $F_{AC} = \frac{P}{2}\sin\left(\frac{0}{2}\right)$

As $\sin\theta > \sin\frac{\theta}{2}$, so in case-I force in members will be more than that in case-II.

From symmetry, there will be only vertical dellection of joint *B*.

$$U = U_{AB} + U_{BC} = \frac{F^2 l}{2AE} \times 2 = \frac{F^2 l}{AE}$$

$$U_I = \frac{P^2 l}{4AE\sin^2\theta}$$

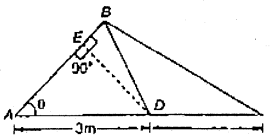
$$\Delta_I = \frac{\delta U_I}{\delta P} = \frac{Pl}{2AE\sin^2\theta}$$

$$\Delta_{II} = \frac{Pl}{2AE\sin^2\left(\frac{\theta}{2}\right)}$$

Thus $\Delta_{II} > \Delta_I$

6. (d)
Cut a section through members *AB*, *BD* and *CD*, and take moment of upper part about D.

$$DE = AD\sin\theta = 3 \times \frac{4}{5} = \frac{12}{5}$$

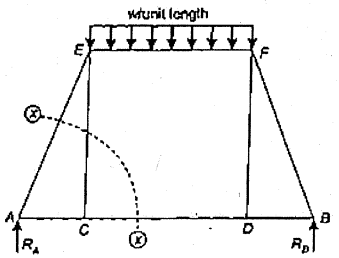


Taking moments about $D$,

$F_{AB}(DE) = 60 \times 4$

$$F_{AB} = \frac{60 \times 4 \times 5}{12} = 100 \text{ kN}$$

8. (a)




Pass a section $X$-$X$ cutting members $AE$, $CE$ and $CD$

$\Sigma M_E = 0$ from RHS of section gives

$$wl \times \frac{l}{2} - R_B \times 2l + F_{CD} \times l = 0$$

$$\Rightarrow \quad F_{CD} = 2R_B - \frac{wl}{2}$$

Now, $R_B = R_A = \frac{wl}{2}$

$$\therefore \quad F_{CD} = 2\frac{wl}{2} - \frac{wl}{2} = \frac{wl}{2}$$

9. (c)

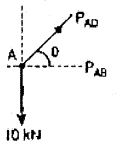
$\Sigma M_B = 0$

$\Rightarrow R_A \times L + 10 \times L = 0$

$R_A = -10$ kN (downward)

Force in member $FC$, $FE$, $CA$, $CD = 0$

Joint A




$$\tan\theta = \frac{L}{L/2} = 2$$

$$\Rightarrow \quad \cos\theta = \frac{1}{\sqrt{5}}$$

and $\sin\theta = \frac{2}{\sqrt{5}}$

$\Sigma F_y = 0$

$\Rightarrow P_{AD}\sin\theta = 10$

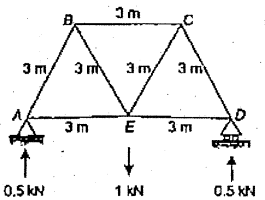
$\Rightarrow \quad P_{AD} = 5\sqrt{5}$ kN

$$L_{AD} = \sqrt{(L)^2 + \left(\frac{L}{2}\right)^2} = \frac{L\sqrt{5}}{2}$$

$$\therefore \quad U_{AD} = \frac{\left(5\sqrt{5}\right)^2 \cdot L\frac{\sqrt{5}}{2}}{2AE}$$

$$U_{AD} = \frac{125\sqrt{5}\,L}{4AE}$$

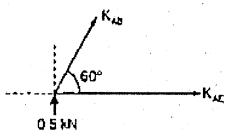
10. (b)




$\delta_E = \Sigma K \,.\, L\,\alpha\, l$

where $K$ is the force in truss members when a unit load is applied at $E$.

Considering joint $A$,




$\Sigma F_y = 0$

$$\Rightarrow \frac{1}{2} + K_{AB}\sin 60° = 0$$

$$\Rightarrow \frac{1}{2} + \frac{\sqrt{3}}{2}K_{AB} = 0$$

$$\Rightarrow K_{AB} = -\frac{1}{\sqrt{3}}$$

The member $CD$ will also have a compressive force of $\frac{1}{\sqrt{3}}$ kN, as the truss is symmetrical.

Now only member $AB$ and $CD$ are subjected to temperature change.

$$\therefore \quad \delta_0 = \Sigma KL\,\alpha\, l$$

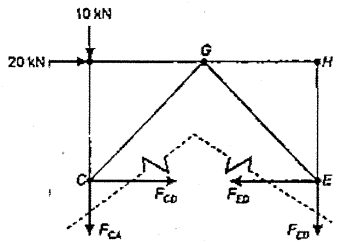
$$= \left(-\frac{1}{\sqrt{3}} \times 3 \times 12 \times 10^{-6} \times 30\right) + \left(-\frac{1}{\sqrt{3}} \times 3 \times 12 \times 10^{-6} \times 30\right)$$

$= -1.25 \times 10^{-3}$ m (–ve sign signifies that deflection is vertically upward)

$= 1.25$ mm (upwards)

12. (c)

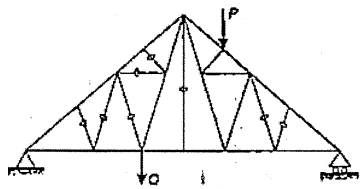
Cutting a section through members $CA$, $CD$, $DE$ and $EB$ and taking moment of the upper part about $E$.




$\therefore F_{CA} \times 6 + 10 \times 6 - 20 \times 3 = 0$

$\therefore F_{CA} = 0$

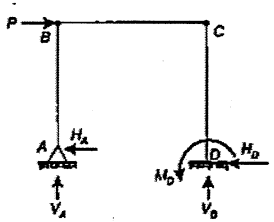
13. (a)




If three members meet at a joint and two of them are collinear, then the third member will carry zero force provided that there does not act any external load at the joint.

Thus using above statement we arrive at eight zero force members which are highlighted by '0' sign.

15. (d)




$M_B = 0$

$\Rightarrow \quad H_A \times L = 0$

$\therefore \quad H_A = 0$

$\Sigma F_x = 0$

$\Rightarrow \quad P - H_A - H_D = 0$

$\Rightarrow \quad H_D = P$

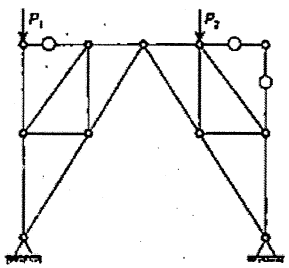
Since $M_C = 0$

$\Rightarrow \quad H_D \times L - M_D = 0$

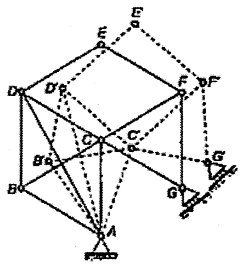
$\Rightarrow \quad M_D = H_D \,.\, L$

$\therefore \quad M_D = PL$

18. (b)




19. (a)



Number of members,

$m = 11$

Number of joints,

$j = 7$

Hence, $m = 2j - 3$ ...(i)

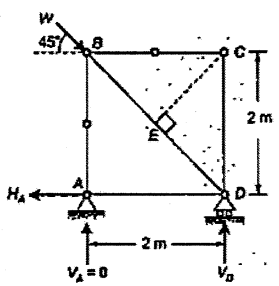
Equation (i) is satisfied.

However, the members are so arranged that the truss is not stable. For example, the distortion to the shape indicated by the dotted lines is possible without changing the length of any member.

The supports provide two reaction components at $A$ and $G$; hence the structure is externally statically determinate. However, static determinacy is irrelevant in this case, because the structure is not stable.

20. (b)

At joint $B$, load $W$ is in line with member $BD$




$\therefore \quad F_{BD} = W$ (Compression)

and $F_{AB} = F_{BC} = 0$

In $\Delta BCE$

Length $CE = 2\sin 45° = \sqrt{2}\,m$

Taking $\Sigma M_C = 0$

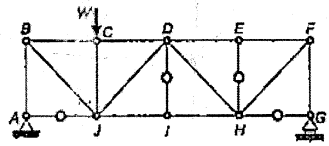
$\Rightarrow \quad W \times \sqrt{2} = H_A \times 2$

$\therefore \quad H_A = \dfrac{W}{\sqrt{2}}$

At joint $A$, reaction $H_A$ is in line with member $AD$.

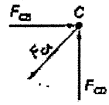
$\therefore \quad F_{AD} = \dfrac{W}{\sqrt{2}}$ (Tensile)

21. (a)

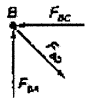



22. (b)

Stress developed in member $AC$ will be tensile. We can apply, method of joint at joint $C$ to get stress in member $BC$ which is compressive




Apply method of joint at joint $B$ to get stress in member $BD$ which is tensile.




23. (c)

$m = 6$

$j = 4$

$m = (2j - 3)$

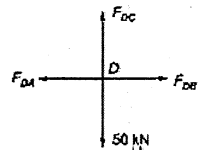
$\Rightarrow \quad = (2 \times 4 - 3) = 5$

$6 > 5$

$\therefore$ Redundant truss.

25. (a)

Consider joint $D$ and force equilibrium equation in the vertical direction.




$\Sigma F_y = 0$

$\Rightarrow \quad F_{DC} = 50$ kN (Tensile)

26. (c)

Cutting a section through $AC$, $CD$ & $DF$ and taking moment of upper portion about $C$. The forces in the members $AC$ and $CD$ meet at $C$ so they will not produce any moment. The force in member $DF$ is given by,

$$F_{DF} = \frac{2 \times 3}{4} = 1.5 \text{ kN (Comp.)}$$

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