STRUCTURAL ANALYSIS

www.gatemastersacademy.com

Head Office:

HYDERABAD

GATE MASTER'S ACADEMY
3rd Floor, S.S. Towers, Beside Kamala Hospital,
Dilsukhnagar, Hyderabad.
Tel: 040-6662 3032
Mobile:+91 8125303032

GM Publications

Address : #303, 3rd Floor, SS Towers, Beside Kamala Hospital,
Dilsukh Nagar, Hyderabad - 60
Phone : 040-66623032
Mobile : +91 8125303032
e-mail : info.gmpublication@gmail.com
web : www.gatemasterspublication.com

Authors

Subject Experts of Gate Master's Academy, Hyderabad.

While every effort has been made to avoid any mistake of omission, the publishers do not owe any responsibility for any damage or loss to any person on account of error or omission in this publication. Mistakes if any may be brought to the notice of the publishers, for further corrections in forthcoming editions to the following e-mail id:

e-mail : info.gmpublication@gmail.com

Editions:

First Edition - 2007
Fourth Edition - 2010
Ninth Edition - 2015
Fourteenth Edition - 2020
Sixteenth Edition - 2022

INDEX

Structural Analysis

TSPSC AEE SYLLABUS

Direct and bending stresses; Columns and Struts; Strain energy method; Moving loads and influence lines; Arches and Suspension Bridges; Static and Kinematic Indeterminacy; Moment Distribution, Slope Deflection, and Kani's Methods Applied to Continuous Beam and Portal Frames; Column Analogy and Matrix Methods of Analysis.

APPSC AEE SYLLABUS

General theorems : theorems relating to elastic structures, principles of virtual work, strain energy in elastic structures, complementary energy ,Castigliano's theorem ,Betti's and Maxwell's reciprocal theorems. Analysis of determinate structures –Deflection of determinate beams by double integration maculay's movement area and conjugate beam methods, Analysis of indeterminate skeletal frames-Moment distribution, Slope deflection, Kani's, Stiffness and force methods, Energy methods, Plastic analysis of indeterminate beams and simple portal frames..

1 DETERMINACY AND INDETERMINACY

INTRODUCTION

- The aim of structural analysis is to evaluate the external reactions, the deformed shape and internal stresses in the structure. If this can be accomplished by the equations of equilibrium, then such structures are known as determinate structures. However, in many structures it is not possible to determine either reactions (or) internal stresses (or) both using equilibrium equations alone. Such structures are known as the statically indeterminate structures. In this chapter, we differentiate between statically determinate and statically indeterminate structures and also calculate the degree of static and kinematic indeterminacy of given structures such as beams, trusses and frames.

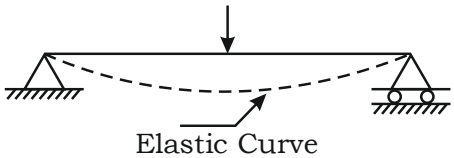
Structure

- A structure refers to a system of connected parts used to support a load. A few examples of civil engineering include buildings, bridges, towers and in other branches of engineering, ship and aircraft frames, tanks, pressure vessels etc.

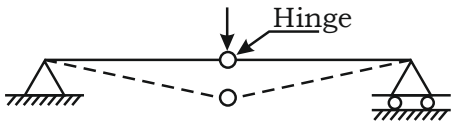
Statically determinate structures	Statically indeterminate structures
1. Conditions of equilibrium are sufficient to analyse the structure fully. 2. The bending moment at a section (or) the force in any member is independent of the material of the components of the structure. 3. No stresses are caused due to temperature changes 4. No stresses are caused due to lack of fit. Ex :Cantilever beam, simply supported beam	1. Conditions of equilibrium are insufficient to analyses the structure fully. 2. The bending moment at a section (or) the force in a member depends upon the material of the components of the structure. 3. Stresses are generally caused due to temperature variations. 4. Stresses are caused due to lack of fit. Ex :Fixed beam, Continous beam

Stable Structure

- When any elastic body is subjected to a system of load, deformation takes place and the resistance is set up against the deformation, the elastic body is said to be 'stable structure'

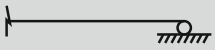
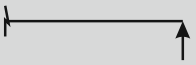
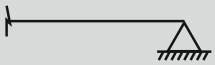
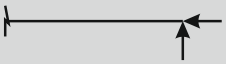
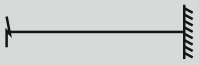
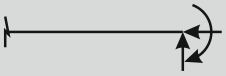
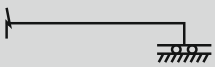
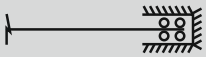
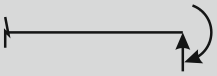
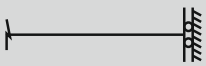
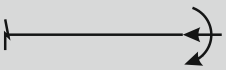


- If there is no resistance is set-up in the body against the deformation, then it is said to be mechanism (or) unstable structure



Important Information

Type of joint	No. of equilibrium equations
1. Pin jointed plane frame	2
2. Rigid jointed plane frame	3
3. Pin jointed space frame	3
4. Rigid jointed space frame	6

	Type of support	Representation	No of unknown reaction
Free			0
Roller			1 (R_v)
Hinged			2 (R_v, H)
Fixed			3 (R_v, H, M)
Guided support			
Horizontal Roller			2 (R_v, M)
Vertical Roller			2 (H, M)

Statically Determinate Structure

- Any structure that can be analysed with help of equilibrium equations alone is called statically determinate structure.
- Condition, the number of unknown reactions forces = no of equilibrium equations

Ex: Simply supported beam, cantilever beam, three hinged arch, suspension cable

Statically Indeterminate Structure (or) Redundant Structure

- Any structure whose reaction components can not be established by using equilibrium equations alone
- Condition, the no of unknown forces/reaction > no of equilibrium equation

Ex:- Fixed beam, two-hinged arch, continous beam, propped cantilever beam

Degree of Static Indeterminacy/Degree of Redundancy (D_s)

- No of equations necessary in addition to equilibrium equations to completely analyse statically indeterminate structure

D_S = No of unknown reactions - equilibrium equations

D_S = r - 3, for plane structure

= r - 6 for space structure

D_S = 0, statically determinate structure

D_S > 0, statically indeterminate structure

D_S < 0, Mechanism (or) unstable structure

Formulation of D_S for frames

$D_S = D_{si} + D_{se}$

D_{se} = External Indeterminacy

= r - 3, for plane frame

= r - 6, for space frame

Where, r = no of unknown reactions

D_{si} = Internal Indeterminacy

= m-(2j-3), plane truss

= 3C, for plane frame

= m-(3j-6), for space truss

= 6C, for space frame

Where C = no of cuts necessary to open the box (or) loop

= no of boxes (or) loops

j = no of joints

m = no of members

Note :

Equilibrium equations deals with forces, where as compatibility equations deals with displacements

Simplified Formulae

D_S = m - (2j-r) $\rightarrow$ plane truss

= m - (3j-r) $\rightarrow$ space truss

= 3m - (3j-r) $\rightarrow$ plane frame

= 6m - (6j-r) $\rightarrow$ space frame

Where r = no of raction components

Degree of Static Indeterminacy for Hybrid Type Structures

- Skeletal structure having some of the joints as pin connected and other as rigid.
- To determine the degree of static indeterminary of these hybrid type of structure, the pin joints may in the first instance by replaced by rigid joints.
- $D_S = D_{si} + D_{se}$ - Force releases

Restraining Member / Joints

Plane frame (2-D):

- Number of restraining moments required at a joint where 'n' members meet = (n-1)

Space frame (3-D):

- Number of restraining moment required at a joint where 'n' members meet = 3 (n-1)

KINEMATIC INDETERMINACY (DEGREE OF FREEDOM)

- The no. of independent components of joint displacements with respect to a specified set of axes.
- The number of unrestrained components of joint displacements.

Kinematically Determinate Structure

- If the displacement components of the joints of a skeletal structure can be determined by compatibility equations alone

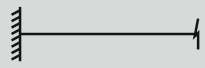
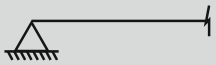
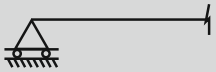
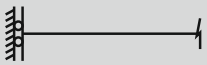
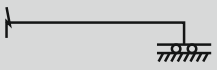
Kinematically Indeterminate Structure

- If the displacement components of the joints of a skeletal structure can not be determined by compatibility equations alone
- Number of unknown joint displacement components is greater than the number of compatibility equations

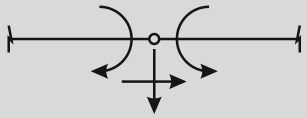
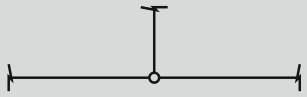
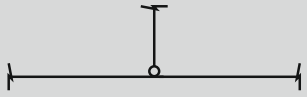
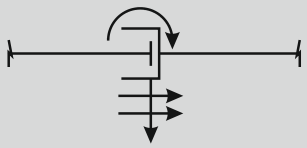
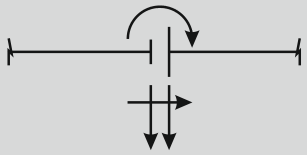
Degree of Freedom for Different Types of Joints

Type of joints	Degree of Freedom
Pin jointed plane frame	2 (δ_x , δ_y)
Rigid jointed plane frame	3 (δ_x , δ_y , θ)
Pin jointed space frame	3 (δ_x , δ_y , δ_z)
Rigid jointed space frame	6 (δ_x , δ_y , δ_z , θ_x , θ_y , θ_z)

Degree of Freedom for Different Type of Supports

Type of support	Figure	D.O.F
Fixed		0
Free		3 (δ_x , δ_y , θ)
Hinged		1 (θ)
Roller		2 (δ_x , θ)
Vertical guided roller		1 (δ_y)
Horizontal guided reller		1 (δ_x)

Degree of Freedom for Internal Hinge

Internal Hinge	D.O.F
	4 (δ_x , δ_y , 2θ's)
	5 (δ_x , δ_y , 3θ's)
	4 (δ_x , δ_y , 2θ)
	4 ($2\delta_x$, δ_y , θ)
	4 (δ_x , $2\delta_y$, θ)

Degree of Kinematic Indeterminacy for Frames

D_K = NJ-C

Where, N = no. of degrees of freedom of joint

N = 3 → plane frame

= 2 → plane truss

= 6 → space frame

= 3 → space truss

J = no, of joints

C = r, if the members are extensible

= (m + r), if the members are inextensible

For Plane Frame

D_K = 3j - r, if member are extensible

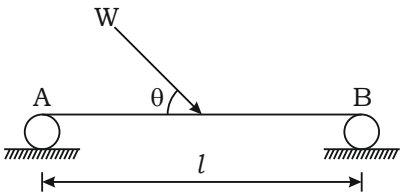
D_K = 3j - (m + r) → if members are inextensible

For Plane Truss

D_K = 2j - r

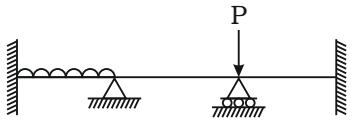
CLASSWORK

1. The simply supported beam shown in the figure is



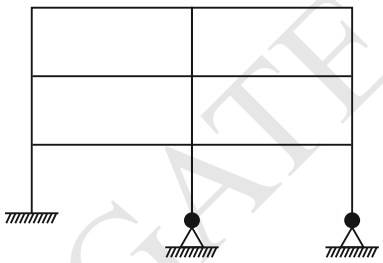
a) determinate and stable
b) determinate and unstable
c) indeterminate and stable
d) indeterminate and unstable

2. What is the total degree of indeterminacy in the continuous prismatic beam shown in the figure below?



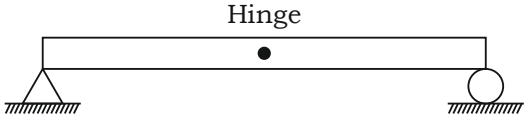
a) 1 b) 2 c) 3 d) 4

3. The total (both internal and external) degree of static indeterminacy of the plane frame shown in the given figure is



a) 18 b) 16 c) 14 d) 13

4. A prismatic beam is shown in the figure given below



Consider the following statements:
1. The structure is unstable
2. The bending moment is zero at supports and internal hinge
3. It is a mechanism
4. It is statically indeterminate

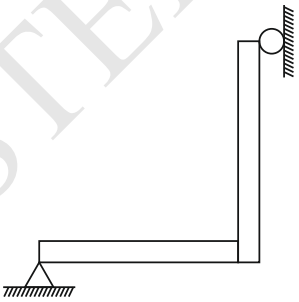
Which of these statements are correct?
a) 1,2,3 and 4 b) 1,2 and 3
c) 1 and 2 d) 3 and 4

5. The degree of static indeterminacy of the beam given below is

a) zero b) one c) two d) three

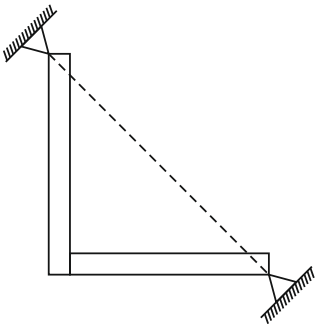
6. Which one of the following structures is statically determinate and stable?

a)

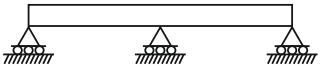


b)

c)



d)



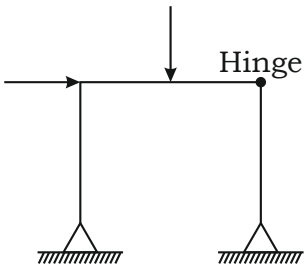
7. Consider the following statements:
1) A properly constrained rigid system has several degrees of freedom
2) The number of degrees of freedom of a locomotive moving on a railway track is only two

3) A floating ship has six degrees of freedom

Which of these statements is/are correct?

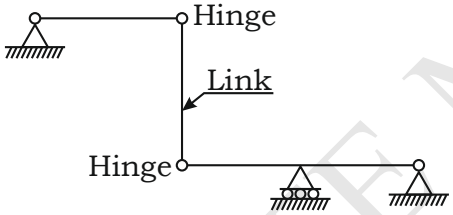
a) 1, 2 and 3 b) 3 only
c) 2 only d) 1 only

8. The plane frame shown in figure is



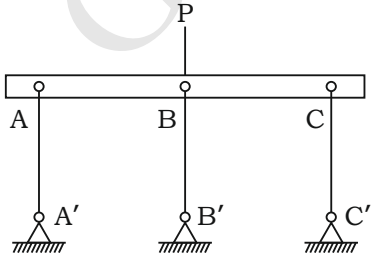
a) stable and statically determinate
b) unstable and statically determinate
c) stable and statically indeterminate
d) unstable and statically indeterminate

9. Degree of static indeterminacy of the structure as shown in the figure is



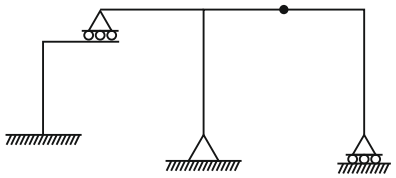
a) 0 b) 1 c) 2 d) 3

10. The beam supported by 3 links and loaded as shown in the figure is



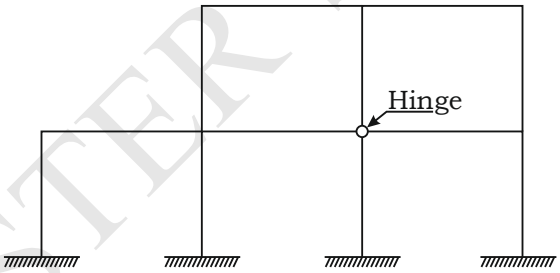
a) stable and determinate
b) unstable
c) stable and indeterminate
d) unstable but determinate

11. A plane structure shown in the figure is



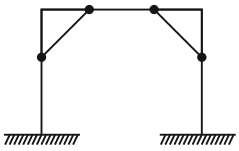
a) stable and determinate
b) stable and indeterminate
c) unstable and determinate
d) unstable and indeterminate

12. Total degree of indeterminacy (both internal and external) of the plane frame shown in the given figure is



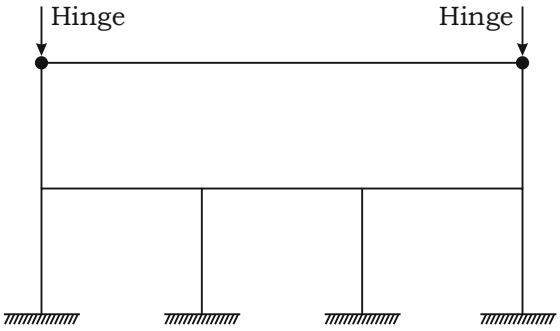
a) 10 b) 11 c) 12 d) 15

13. The degree of static indeterminacy for the rigid frame as shown below is



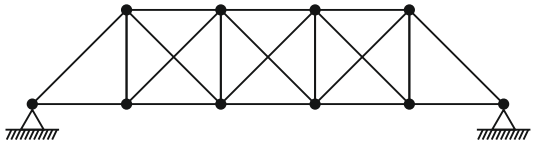
a) 3 b) 4 c) 5 d) 6

14. What is the total degree of static indeterminacy, both internal and external of the plane frame shown below?



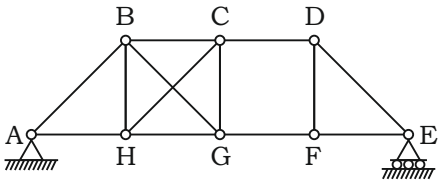
a) 10 b) 11 c) 12 d) 14

15. The total degree of static indeterminacy (both internal and external) for the bridge truss shown in the given figure is



a) 4 b) 5 c) 6 d) 3

16. Which one of the following statements is correct for the pin-jointed truss shown in the figure?



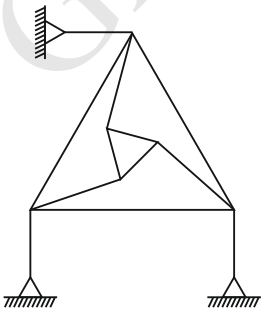
a) The truss is externally determinate but internally indeterminate.

b) The truss is both externally and internally determinate.

c) The truss is externally determinate and internally indeterminate and is unstable.

d) The truss is externally determinate and internally indeterminate and is stable.

17. The following two statements are made with reference to the plane truss shown below.



I. The truss is statically determinate

II. The truss is kinematically determinate

With reference to the above statements which of the following applies?

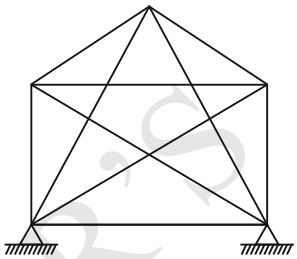
a) Both statements are true

b) Both statements are false

c) II is true but I is false

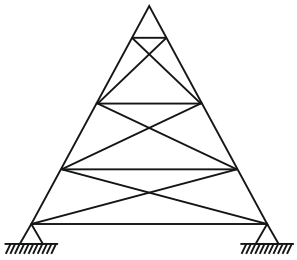
d) I is true but II is false

18. What is the degree of static indeterminacy of the plane structure as shown in the figure below?



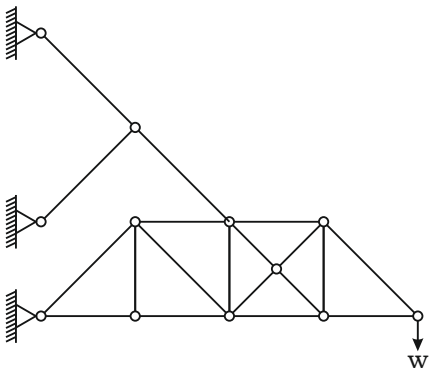
a) 3 b) 4 c) 5 d) 6

19. What is the total degree of static indeterminacy (both internal and external) of the triangular planar truss shown in the figure below?



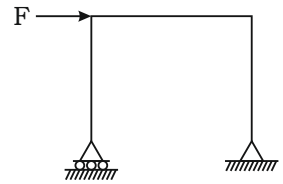
a) 2 b) 4 c) 5 d) 6

20. The total (both external and internal) degrees of indeterminacy of the pin-jointed structure shown in the figure is



a) 4 b) 3 c) 2 d) 1

21. Considering beam as axially rigid, the degree of freedom of a plane frame shown below is



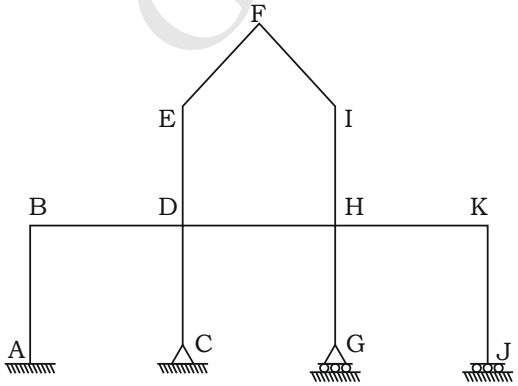
a) 9 b) 8 c) 7 d) 6

22. Consider the following statements:
    1. A statically indeterminate structure is not economical from the material stand-point in comparison to a statically determinate structure
    2. If 'n' redundants in a statically indeterminate structure of 'n' degree of static indeterminacy are removed, the structure will become statically determinate but unstable.
    3. In the rigid frame analysis, the axial effects are ignored as their influence is negligibly small compared to bending and shear effects.

    Which of these statements is/are correct?

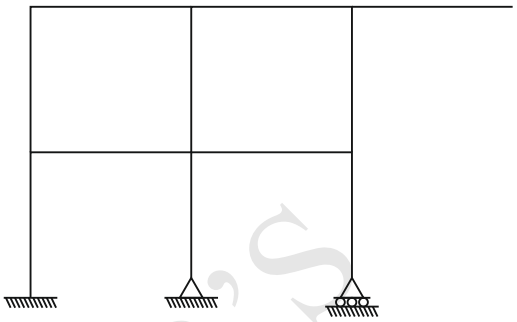
    a) 1 only b) 1 and 2
    c) 3 only d) 2 and 3

23. Neglecting axial deformation, the kinematic indeterminacy of the structure shown in the figure below is



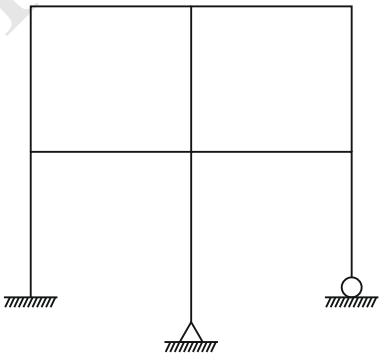
a) 12 b) 14 c) 20 d) 22

24. For the plane frame with an overhang as shown below, assuming negligible axial deformation, the degree of static indeterminacy, d, and the degree of kinematic indeterminacy, k, are



a) d = 3 and k = 10 b) d = 3 and k = 13
c) d = 9 and k = 10 d) d = 9 and k = 13

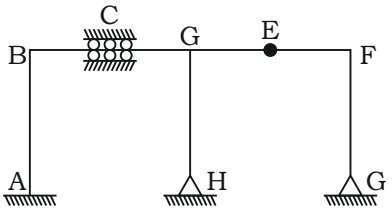
25. For a skeletal frame shown in the figure



Static and kinematic indeterminacies are

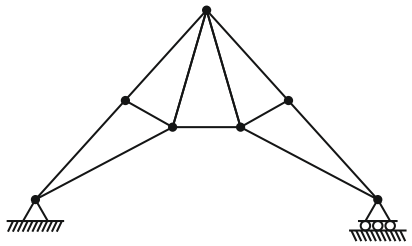
a) 3 and 11 b) 3 and 9
c) 3 and 6 d) 9 and 11

26. A plane frame ABCDEFGH shown in figure has clamp support at A, hinge supports at G and H, axial force release (horizontal sleeve) at C and moment release (hinge) at E. The static (D_s) and kinematic (D_k) indeterminacies are



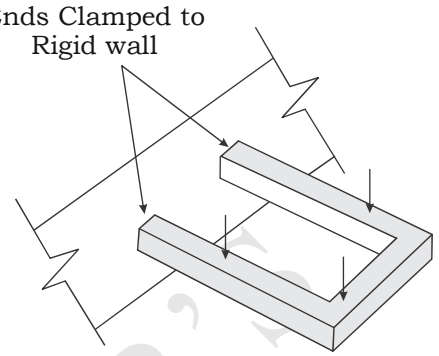
	D_s	D_k
a)	4	9
b)	3	11
c)	2	12
d)	1	14

27. The kinematic indeterminacy of the plane truss shown in the figure is



a) 11 b) 8 c) 3 d) 0

28. The degree of static indeterminacy of a rigidly jointed frame in a horizontal plane and subjected to vertical load only, as shown in figure below, is



a) 6 b) 4 c) 3 d) 1

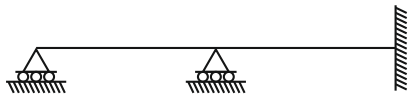
Practice Questions

Level - 1

1. A free body diagram is **(AEE 2003)**
   a) the structure with support removed
   b) an unstable structure
   c) the structure with loads removed
   d) a part of the structure with internal forces imposed.
2. The number of independent equations to be satisfied for static equilibrium in a space structure is **(AEE-2007)**
   a) 2 b) 3 c) 4 d) 6
3. Number of unknown internal force in each member of a rigid jointed plane frame is given by: **(SS-JE-2009)**
   a) 1 b) 2 c) 3 d) 4
4. Minimum number of equilibrium equation to be considered for a space truss is **(Lecturers - 2013)**
   a) 2 b) 3 c) 6 d) 9
5. Compatibility conditions satisfy **(AEE-2003)**
   a) equilibrium conditions of the structure
   b) displacement conditions
   c) equilibrium conditions of the free body
   d) symmetry conditions of the structure
6. A statically indeterminate building frame may be converted to a statically determinate one by assuming
   a) hinges at mid-height of columns
   b) hinges at the mid-span of the beams
   c) hinges at both mid-height of columns and mid-span of beams
   d) one support fixed at base and other support on rollers
7. A statically indeterminate structure is the one which **(APPSC AEE Mains-2016)**
   a) Can be analysed with the equations of statics alone
   b) Cannot be analysed using equations of statics alone
   c) Cannot be analysed at all
   d) Is not stable for general loading
8. A suspension bridge with a two-hinged stiffening girder is statically
   a) determinate
   b) indeterminate to 1 degree
   c) indeterminate to 2 degrees
   d) indeterminate to 3 degrees
9. A statically determinate structure
   a) cannot be analyzed without the correct knowledge of modulus of elasticity
   b) must necessarily have roller support at one of its ends
   c) requires only statical equilibrium equations for its analysis
   d) will have zero deflection at its ends
10. The degree of statical redundancy of a beam is the number of additional : **(AEE CE/ME-2008)**
    a) equations required in the analysis
    b) support forces required for the stability of the beam
    c) conditions in the analysis
    d) statical conditions required in the analysis
11. Which of the following makes statically determinate beams? **(AEE-2007)**
    a) Simply supported, cantilever and overhang beams
    b) Cantilever and fixed beams
    c) Continuous beams and beams carrying uniformly distributed loads
    d) Fixed beams and simply supported beams.
12. The static indeterminacy of a beam fixed at one end and hinged at the other end is equal to **(PH & Municipality 2001)**
    a) One b) Two c) Three d) Four
13. A beam fixed at the ends and subjected to lateral loads only is statically indeterminate and the degree of indeterminacy is

a) one b) two c) three d) four

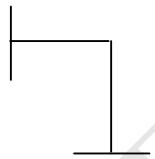
14. What is the number of independent degrees of freedom of the two-span continuous beam of uniform section shown in the figure below?



a) 1 b) 2 c) 3 d) 4

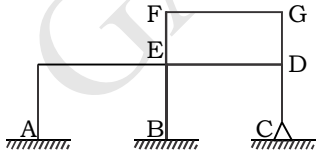
15. A beam is suppoted over three rollers lying in the same plane. The beam is stable ___. **(SS-JE-2016)**
a) For any general loading
b) For loading with no component in the direction of the beam
c) For loading with no component pependicular to the direction of beam
d) Only when no load except self-weight acts

16. What is the degree of static indeterminancy of the structure shown in figure ? **(AEE-2012)**



a) 1 b) 2 c) 3 d) 4

17. Degree of static redundancy of the structure given in figure below is : **(AEE-2008)**



a) 2 b) 4 c) 6 d) 8

18. What is the degree of indeterminancy of a two span continuous beam, if the end support is fixed and the other two supports are simply supported ? **(APGENCO Trainee AE - 2017)**
a) 1 b) 2 c) 3 d) 4

19. A beam is said to be in general stable and statically determinate for general loading when number of reaction components is **(AEE CE/ME-2004)**
a) greater than 3 b) 0
c) less than 3 d) 3

20. The number of joint equilibrium equations available for the analysis of plane trusses is
a) 3 b) 1 c) 2 d) zero

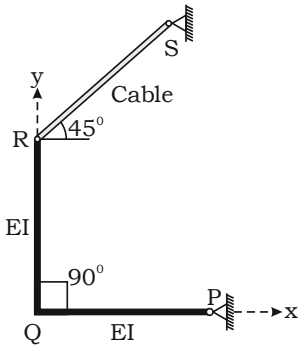
21. If we use a link suppot in a stuctural system, then how many unknowns would we have ? **(SS-JE-2017)**
a) 0 b) 1 c) 2 d) None of these

22. A shear hinge at a beam section releases : **(AEE CE/ME-2008)**
a) bending moment but transmits shear force
b) bending moment and shear force
c) axial force and bending moment but transmits shear forces
d) shear force but transmits bending moment and axial force

23. A simply supported beam with a hinge at mid-span is **(AEE - 1992)**
a) Statically determinate
b) Statically indeterminate
c) Unstable
d) Determinate and unstable

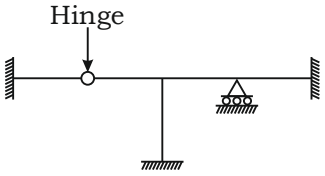
24. A perfect frame should satisfy the relation **(AE-2012, 2013, APPSC AE (Prelims) - 2016)**
a) m = 2j - 3 b) m = 2j - 4
c) m = 3j - 2 d) m = 3j - 3

25. The degree of static indeterminacy of a rigid jointed frame PQR supported as shown in figure is



a) zero b) one c) two d) unstable

26. The static indeterminacy of the frame shown below is



a) 4 b) 6 c) 8 d) 10

27. The degree of static indeterminacy of a rigid jointed space frame is **(AEE-2012)**

a) m + r - 2j b) m + r - 3j
c) 3m + r - 3j d) 6m + r - 6j

28. In the following question, j repesents no. of joints and r represents no. of extenal forces. If a structue has (2j-r) no. of membes, then it will be **(SS-JE-2017)**

a) Stable
b) Unstable
c) Depends upon structue
d) Depends upon magnitude of load

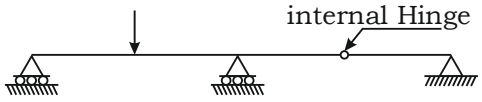
29. Degree of kinematic indeterminacy of a pin jointed plane frame is given by **(ISRO-15)**

a) 2j-r b) j-2r c) 3j-r d) 2j+r

30. A pin jointed frame with number of joints j, and number of members 'n' will be a perfect frame, if

a) n = (2j + 3) b) n > (2j - 3)
c) n < (2j - 3) d) n = (2j - 3)

31. The static indeterminacy of the two-span continuous beam with an internal hinge, shown below, is ____



32. A framed structure is perfect if it contains members equal to ____ where n = number of joints in a frame. **(APPSC AE (Prelims) - 2016)**

a) 2n - 3 b) n - 1 c) 2n - 1 d) n - 2

33. Match **List-I** (Type of structure) with **List-II** (Static indeterminacy) and select the correct answer using the codes given below the lists:

Number of members = m
Number of joints = n
Number of reaction elements = r

List-I	**List-II**
A) Plane frame	1. m+r-3n
B) Space truss	2. 6m+r-6n
C) Space frame	3. 6m+r-3n
	4. 3m+r-3n

Codes:

	A	**B**	**C**
a)	1	2	3
b)	4	3	2
c)	2	1	3
d)	4	1	2

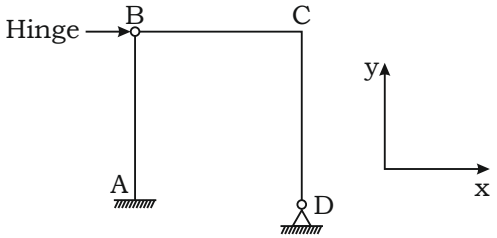
34. The kinematic indeterminacy of a structure is associated with **(AEE-1996)**

a) Degree of freedom
b) Equilibrium conditions
c) Additional special equilibrium conditions
d) Elastic deformations

35. The unknown joint displacements in a structure referred to as **(AEE-2006)**

a) static indeterminacy
b) kinematic indeterminacy
c) external indeterminacy
d) non-boundary displacements

36. The kinematic indeterminacy of the frame is



a) 4 b) 6 c) 8 d) 10

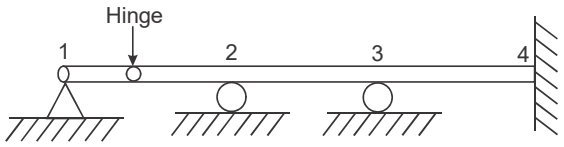
37. A support is said to be non-yielding if ____ **(SS-JE-2016)**

a) It can take any amount of reaction
b) It is frictionless
c) It holds the beam firmly
d) The beam has zero slope at the support

38. A single-bay, single - storied portal frame ABCD has its column ends fixed. If axial deformation is neglected, the kinematic indeterminacy is **(TSPSC-AEE-15)**

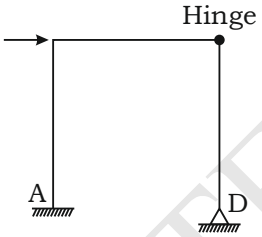
a) 3 b) 4 c) 2 d) 6

39. The kinematic indeterminacy of the beam is



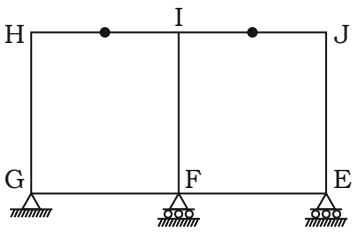
a) 5 b) 9 c) 14 d) 15

40. The kinematic indeterminacy of the plane frame shown in figure is (disregarding the axial deformation of the members)



a) 7 b) 5 c) 6 d) 4

41. The degree of static indeterminacy of the rigid frame having two internal hinges as shown in the figure below, is



a) 8 b) 7 c) 6 d) 5

42. Relation between number of joints "j" and number of members 'm' in pin jointed plane determinate truss is **(AE - 1993, AE-2013)**

a) m = 2j - 1 b) m = 2j - 3
c) m = 2j - 5 d) j = 2m - 3

43. Independent displacement components of each joint of a rigid-jointed plane frame are **(AEE-2007)**

a) Three linear movements
b) Two linear movements and one rotation
c) One linear movements and two rotation
d) Three rotations

44. Which one of the following is true example of a statically determinate beam?

a) One end is fixed and the other end is simply supported
b) Both the ends are fixed
c) The beam overhangs over two supports
d) The beam is supported on three suports

Level - 2

1. The analysis of a structure is

a) Deciding the material of the member
b) Deciding the dimensions of the member
c) Calculating the magnitude and nature of various straining actions at salient points of the structure.
d) Planning of the structure.

2. At a rigid joint in frame all the members have **(AEE-2003)**

a) same rotation but different displacements
b) same displacements but different rotations
c) different displacements and rotations
d) same displacements and rotations

3. In a rigid jointed frame, the joints are considered

a) to rotate only as a whole
b) not to rotate at all
c) that 50% of members rotate in clock wise direction and 50% in anti-clock wise direction

d) none of the above

4. In a semi-rigid connection: **(AEE-2008)**
   a) rotation is zero
   b) moment is zero
   c) restraining moment is proportional to rotation
   d) moments and shear are small

5. The correct combination of conditions that defines a rigid joint is ____
   i) All member meeting at the joint are rigid.
   ii) All deflections and rotations at the joint are zero.
   iii) All members meeting at the joint undergo same deflections at that joint.
   iv) All members meeting at the joint undergo same rotations at that joint.

   (TSPSC - HMWS & SB-15)

   a) iii, iv b) i, iii c) ii, iv d) i, ii

6. An orthogrid structure is one which satisfies following combinations of conditions ____
   i) A two dimensional framed structure consisting of members oriented in different directions
   ii) Loading plane perpendicular to the plane of structure.
   iii) Member end actions are the axial forces, shear forces and bending moments.
   iv) Angle between members is always 90^o
   v) Member end actions are the shear forces, torques and bending moments.

   (TSPSC-Manager HMWS & SB-15)

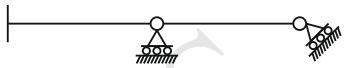
   a) i, ii, iv, v b) i, ii, iii, iv
   c) ii, iii, iv, v d) i, ii, iii, iv, v

7. When equations of statics are not sufficient to determine all the reactive forces at the supports, such beams are called as **(APPSC-AEE-MAINS-2016)**
   a) Defective
   b) Imperfect
   c) Statically indeterminate
   d) statically determinate

8. The number of unknown reactions to be found at a fixed support of a beam, during analysis **(TSPSC-AEE-15)**
   a) 1 b) 2 c) 3 d) 4

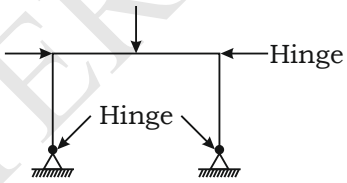
9. The static indeterminancy for the continuous beam shown in below figure is ____

   (TSPSC-Manager HMWS & SB-15)

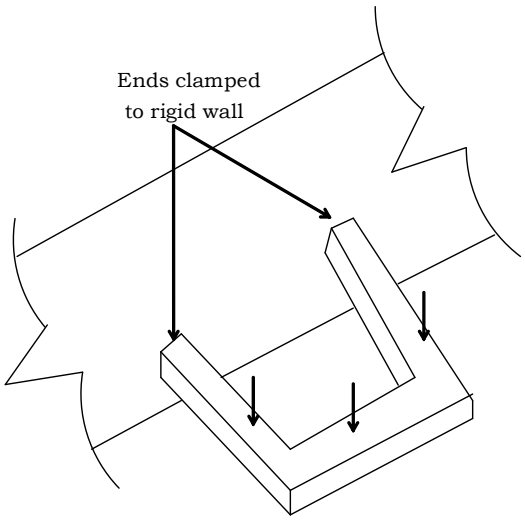
   a) 4 b) 3 c) 2 d) 6

10. The plane frame shown below is **(AEE-2006)**

    a) stable and statically determinate
    b) stable and statically indeterminate
    c) unstable and statically indeterminate
    d) unstable and statically determinate

11. The degree of static indeterminancy of rigidly jointed frame in a horizontal plane and subjected to vertical loads only, as shown in figure below is **(Research Assistant 2013)**

    a) 6 b) 4 c) 3 d) 1