Solution 1: Basics of Matrix analysis

1. **State some assumptions made in the matrix analysis of structures. Also specify their implications or limitations (if any) in your point of view**

   - Material obeys Hooks Law implies that linear relationship exists between load and displacement. This has a limitation that material nonlinearity is unaccounted for in such analysis. Hence it is good for elastic analysis. In case you have to consider material nonlinearity also, possibly one should perform finite element analysis.

   - Stress values are within elastic limits. This implies that the stiffness matrix generated shall be only the initial stiffness and not the secant stiffness accounting for nonlinear stress-strain behaviour.

   - Principle of super-position valid. This makes the analysis easier, comparatively simpler and valid for elastic analysis. Initially when computer algorithms were not developed, matrix method was considered to be the systematic and faster methods of structural analysis. Even today, most of the standard software employs matrix method (Stiffness method, in particular).

   - P-delta effect is small compared to the original geometry and hence negligible. This implies a disadvantage that geometric nonlinearity is not accounted in matrix methods. Hence this method cannot readily be used for solving large deflection problems. However, can be used with some modifications.

2. **What do you understand by static and kinematic indeterminacy? Differentiate them in simple terms.**

   - By definition, Static indeterminacy (SI) is the number of actions (like shear force, bending moment, axial force etc) external or internal, that must be released in order to transform the structure to a stable and statically determinate one. Whereas kinematic indeterminacy (KI) refers to the number of independent joint displacements (rotations, translations (vertical or horizontal)) that are required to describe the response of the structure for a given load. It is the number of unrestrained joint displacements of the structure.

   - SI deals with action (forces) whereas KI deals with displacements. For a given structure, displacements at the supports (or nodes) are identifiable without much discrepancy and easy to locate whereas actions to be considered depends on one's choice. For example, one may not like to consider axial forces into account by allowing rigid body motion in the analysis. In such case, the number of actions (which govern SI) will vary for different problem. In particular, SI of a structure can have two different answers, one without considering the axial forces and one with considering them.

   - SI is the number of forces to be released to make the given structure determinate whereas KI deals with the degree of freedom each joint has to express the response of the structure to a given load.

3. **State the differences between stiffness and flexibility methods of matrix analysis. Also explain their suitability in context of indeterminate structural analysis**

   - In simple terms, Stiffness method [K] deals with the KI of the structure whereas Flexibility method [f] deals with SI of the structure. i.e. in stiffness method, we have displacements (both horizontal and vertical) and rotations at joints as unknowns (which will

be called as degree-of-freedom later) whereas in flexibility method, the unknowns are forces like bending moment, shear force, axial force etc.

- Flexibility method has more choice of selection of these unknowns, like one may consider axial forces into account or not whereas stiffness method has no such choice. In particular, refer to the Table below.

Type of support	Rotation	Translation		Total dof	
				Restrained	Unrestrained
		Horizontal	vertical		
Roller 	Yes	Yes	No	1	2
Hinged 	Yes	No	No	2	1
Fixed 	No	No	No	3	Nil

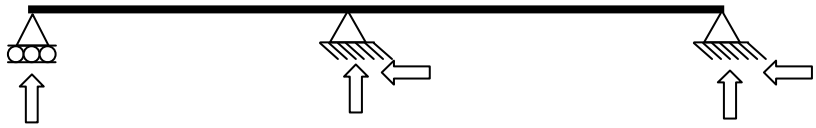
- Flexibility method, as the name implies is flexible to choose the unknowns (forces) but stiffness method has no such choice. This further makes flexibility method as problem specific (load specific and geometric specific). The analyst has a choice to solve the problem by considering different set of forces for a specific problem he is solving. This implies in stating that this method of analysis does not prescribe a general procedure and therefore cannot be programmed in the computer. On the other hand, stiffness method has no such choice (because as seen in the above table, displacements to be considered in each type of support is almost freezed) making it more generalized. This is one of the major advantage making it easily programmable in computer.

- Also, while designing the structures followed by analysis, though one will be mainly interested to know the bending moment and shear force values as a result of the analysis (so that actual stress values obtained on the cross section can be limited to the permissible values), but it is important to know also the displacements (to meet the serviceability criteria) and rotations (if one is interested in checking the rotation capacity) making stiffness method more practical.

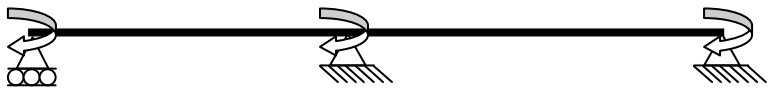
- However, it is fundamentally to be appreciated that [K] is the inverse of [f] .

4. Find the static and kinematic degree of indeterminacy of the following with suitable explanations (Neglect axial deformations)

Fig. 1

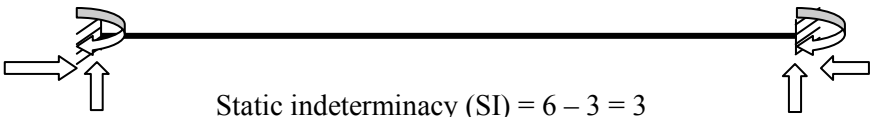


Static indeterminacy (SI) = 5 – 3 = 2



Kinematic indeterminacy (KI) = 3

Fig. 2



Static indeterminacy (SI) = 6 – 3 = 3

Kinematic indeterminacy (KI) = zero (as there are no unrestrained joint displacement possible at both the supports)

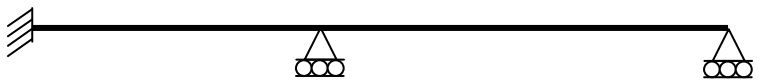
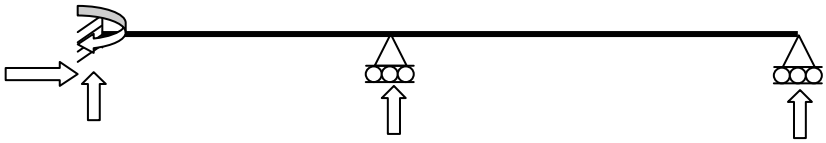
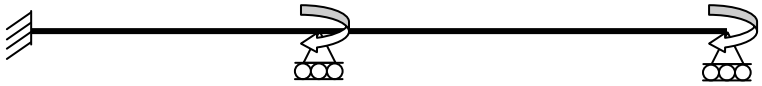


Fig. 3



Static indeterminacy (SI) = 5 – 3 = 2



Kinematic indeterminacy (KI) = 2

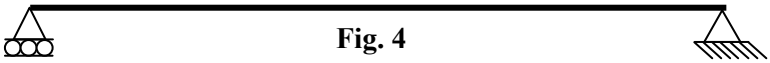
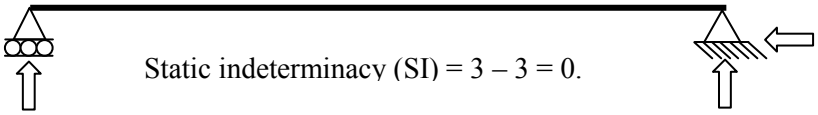
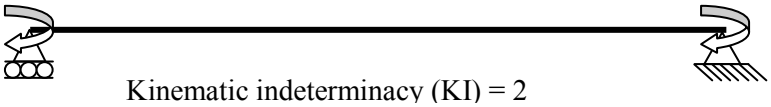


Fig. 4



Static indeterminacy (SI) = 3 – 3 = 0.



Kinematic indeterminacy (KI) = 2

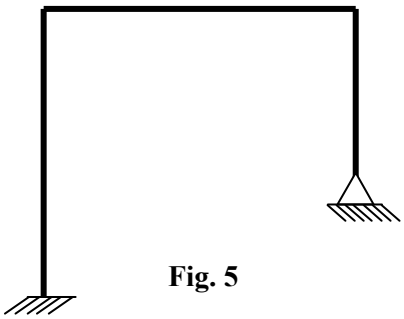


Fig. 5

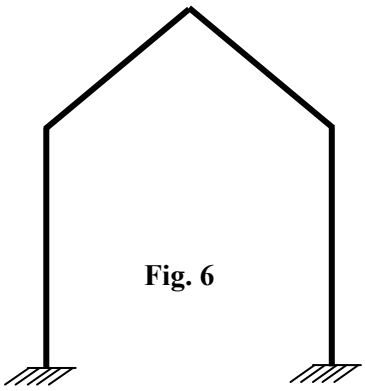
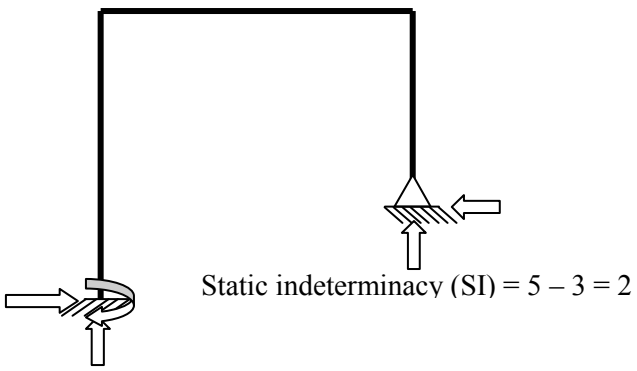
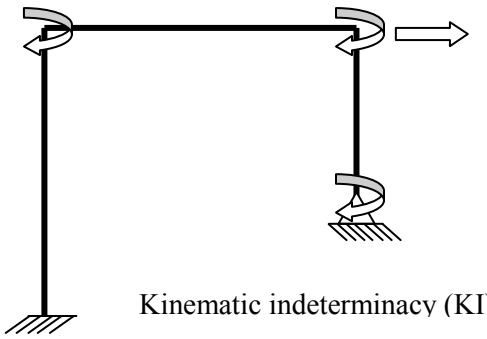


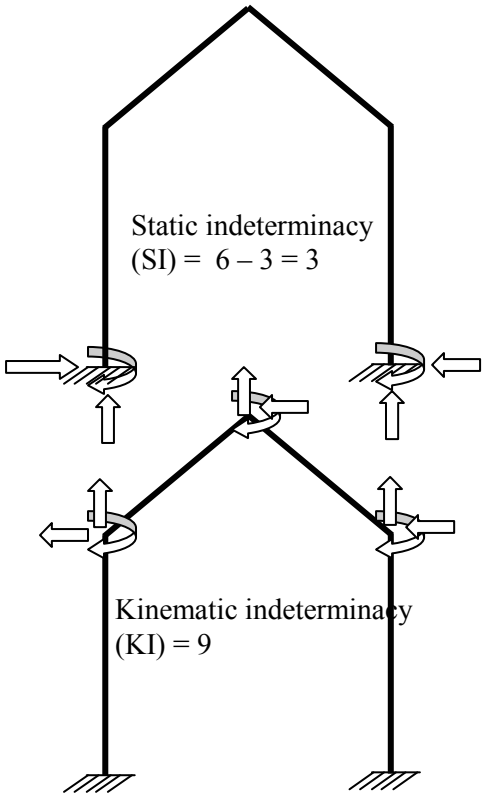
Fig. 6



Static indeterminacy (SI) = 5 – 3 = 2



Kinematic indeterminacy (KI) = 4



Static indeterminacy
(SI) = 6 – 3 = 3

Kinematic indeterminacy
(KI) = 9