THEORY OF STRUCTURES I

ENCE 202

Lecture : 3 **Year : II**
Tutorial : 2 **Part : I**
Practical : 2/2

Course Objectives:
The objective of this course is to develop concepts and analytical skills to compute structural responses (Stresses and deformations) in determinate structures subjected to static loads by manual calculation as well as matrix method of analysis using computer software.

1 Introduction (3 hours)

1.1 Types of structures based on analysis perspective
1.2 Idealization of structures, threats and responses
1.3 Review of determinacy, indeterminacy and stability of plane structures
1.4 Application of determinate systems in civil engineering infrastructures

2 Strain Energy Method (5 hours)

2.1 Work and complementary work
2.2 Strain energy and complementary strain energy
2.3 Strain energy due to axial, shear, bending and torsion
2.4 Deformation of beams and frames by real work method
2.5 Limitations of the real work method
2.6 Strain energy due to gradually and suddenly applied direct load: Dynamic multipliers

3 Virtual Work Method (6 Hours)

3.1 Introduction to virtual work
3.2 Derivation of virtual work equation
3.3 Displacements by the methods of virtual work
3.4 Direct axial, shear, bending and torsion effects
3.5 Deformation of trusses due to external loads, temperature effect and misfits
3.6 Deformation of beams and fames due to external loads and temperature effects
3.7 Deformation of beams and frames due to support settlements
3.8 Betti's law and Maxwell's reciprocal theorems
3.9 Application of different effects in beam, frame and truss

4 Deflection of Beams (7 hours)

4.1 Importance of deflection evaluation
4.2 Macaulay's method
4.3 Moment-area method: Derivation of theorems
4.4 Conjugate-beam method
4.5 Deflections by the method of superposition
4.6 Deflection evaluation of different determinate beams
4.7 Application of deflection

5 Influence Lines for Simple Structures (9 Hours)

5.1 Importance of influence lines
5.2 Concept of moving static loads and influence line diagrams (ILD)
5.3 Influence lines for support reactions and support moments
5.4 Influence lines for shear force and bending moment in beams
5.5 Influence lines for support reactions and member forces in trusses
5.6 ILD for indirect load applications (Panel loadings)
5.7 Qualitative ILD using Muller-Breslau principle
5.8 Use of influence line diagrams
  5.8.1 Determination of reactions, bending moments and shear forces (Structural quantity diagram) from ILD due to different loadings: Point load, distributed load, couple, standard load trains
  5.8.2 Most critical position of a loading system for maximum internal force/moment at a beam section
  5.8.3 Determination of most critical position of a loading system for absolute maximum internal forces

6 Statically Determinate Arches (6 hours)

6.1 Introduction and type of arches
6.2 Three-hinged structures with supports at the same and different levels
6.3 Determination of support reactions, shear forces, normal forces and bending moments
6.4 Analysis of three-hinged arches by the graphical method
6.5 Use of ILD for reactions, bending moments, radial shear forces and normal thrust

7 Suspension Cable Systems (7 hours)

7.1 Introduction and type
7.2 Funicular shape of cable
7.3 Catenary cables and general cable theorem
7.4 General cases of parabolic cables and their analysis

7.5 Elements of a simple suspended and suspension bridges
7.6 Analysis of three-hinged stiffening girder
7.7 Use of influence line diagrams
7.8 Basics of tower structures, wind cables and ties

8 Simple Space Truss (2 hours)

8.1 Introduction and importance of space truss
8.2 Boundary conditions and types of supports
8.3 Analysis of simple space truss by tension coefficient methods

Tutorial (30 hours)

1. Strain energy due to axial, shear, bending, and torsion
2. Deformation of beams and frames by real work method
3. Displacements by the methods of virtual work
4. Deformation of trusses due to external loads, temperature effect and misfits
5. Deformation of beams and fames due to external loads and temperature effects
6. Deformation of beams and frames due to support settlements
7. Deflection of beams by different methods
8. Influence line diagrams for support reactions, shear force and bending moment
9. Influence lines for support reactions and member forces in trusses
10. Determination of reactions, bending moments and shear forces (Structural quantity diagram) from ILD due to different loadings: Point load, distributed load, couple, standard load trains
11. Determination of support reactions, shear forces, normal forces and bending moments of three-hinged arches
12. ILD for reactions, bending moments, radial shear forces and normal thrust of three-hinged arches
13. Analysis of parabolic cables
14. Analysis of three-hinged stiffening girder
15. Analysis of simple space truss by tension coefficient methods

Practical (15 hours)

1. Deflection of beams and frames
2. Measurement of reactions in three-hinged arches under different loading arrangements
3. Analysis of plane truss under different loading arrangements
4. Experimental analysis of suspension bridges under different loading arrangements
5. Simulation of influence lines for beams, girders and frames under different loading arrangements
6. Simulation of displacement measurement in statically determinate plane frame

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	3	4
2	5	7
3	6	8
4	7	9
5	9	12
6	6	8
7	7	10
8	2	2
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Hibbler, R.C. (2008). Structural Analysis. Prentice Hall.
2. Norris, C.H. Wilbur, J.B., Utku S. (1977). Elementary structural Analysis. 3rd Edition. New York: McGraw-Hill Book Co.
3. Reddy, C.S. (2017). Basic Structural Analysis. Tata McGraw-Hill Education.
4. Wong Y. Yang et. al. (2005). Applied Numerical Methods using MATLAB. John Willey & Sons.
5. Parajuli H. R. and Ojha B. (2024). Structural Analysis-I, Determinate Structures. Kathmandu: Heritage Publishers & Distributors.
6. Darkov, A., Kuznetsov V. (2011). Structural Mechanics. Gordon and Breach 1969
7. West, H.H. (1980). Analysis of Structures. John Wiley & Sons Inc.
8. Devdas M. (2008). Structural Analysis. Narosa Publishing House.