Gyanmanjari Innovative University

Syllabus
Gyanmanjari Institute of Technology
Semester-3 (B. Tech)

Subject: Structural Performance and Analysis Studies– BET2CV13304

Type of course: Professional Core

Prerequisite: Knowledge of Engineering Insights into Material Strength

Rationale: This subject is conceptual applications of principles of mechanics of rigid and deformable bodies in Engineering. This subject helps in determining response of statically determinate framed structures. In addition to this, the topics related to stability checks for structure subjected to lateral loads, buckling behavior will also help the students in developing the basic concepts of structural analysis. Considering the importance of computer analysis, use of professional software in structural analysis is also kept in the syllabus.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks		Total Marks
CI	T	P	C	SEE	CCE	
4	0	2	5	100	50	150

Legends: CI-Classroom Instructions; T-Tutorial; P -Practical; C –Credit; SEE -Semester End Evaluation; CCE-Continuous and Comprehensive Evaluation

Course Content:

Sr. No.	Course Content	Hrs.	% Weightage
1	**Fundamentals of Statically Determinate Structures** ***Theory Topics:*** Introduction to Statically Determinate Structures, Classification of Determinate and Indeterminate Structures, Static Indeterminacy, Kinematic Indeterminacy, Stability of Structures, Principle of Superposition, Maxwell's Reciprocal Theorem, Analysis of Plane Trusses, Analysis of Frames, Analysis of Grids, Computation of Internal Forces in Framed Structures, Introduction to Arches, Three-Hinged Circular Arches, Three-Hinged Parabolic Arches, Analysis of Arches under Various Loading Conditions, Introduction to Cables, Force Analysis in Cables, Thin Cylinders under Internal Pressure, Thin Spherical Vessels under Internal Pressure, Stress Analysis in Pressure Structures.		

Practical:

1. Identify and classify different types of structures based on their form, support conditions, and load-resisting mechanisms.
2. Determine the degree of static indeterminacy of beams, trusses, and frames using standard analytical methods.
3. Analyze simple trusses using the method of joints to determine member forces.
4. Analyze plane frames to evaluate support reactions and internal forces under various loading conditions.
5. Study the behavior of three-hinged arches and cables under different loading conditions and determine the resulting forces.
6. Demonstrate the principle of superposition and verify Maxwell's reciprocal theorem through analytical methods.
7. Solve numerical problems related to thin cylinders and spherical vessels to determine stresses and pressure effects.
8. Perform force analysis of cable structures and study their load-carrying behavior.
9. Compare the structural response of trusses, frames, arches, and cables under different loading scenarios.
10. Conduct a case study of real-life framed structures to understand structural behavior, load transfer, and design considerations.

Evaluation Method:

20 | 20 %

Sr. No.	Evaluation Methods	SEE	CCE
1	**Structural Analysis Challenge** Students will be assessed through a structured problem-solving task demonstrating their understanding of statically determinate structures. The challenge will require students to classify structures, determine static and kinematic indeterminacy, and solve numerical problems related to trusses, frames, arches, and cables under various loading conditions and perform basic analysis of thin cylinders. Students may also be required to apply principles such as superposition and Maxwell's reciprocal theorem. The assessment will focus on conceptual clarity, accuracy of calculations, logical approach to problem solving, and clear presentation of solutions.	20	

	2	**Active Learning Assignment: Foreflow Lab: Trace & Analyze Load Transfer in Structures:** Students will study real structures such as trusses, frames, and arches, trace the flow of forces from load application to supports, and analyze internal force distribution. Students will present their findings with diagrams and explanations in a structured PDF for submission on the GMIU Web Portal.		10		
		Total	**20**	**10**		

Examination Style:

Structural Analysis Challenge (20 Marks)
Students will be assessed through a problem-based and analytical evaluation designed to test their ability to apply structural analysis concepts in practical scenarios. The examination will require students to solve numerical problems related to trusses, frames, arches, and cables, determine the degree of static and kinematic indeterminacy, and interpret structural behavior under various loading conditions. Students may also be required to apply principles such as superposition and Maxwell's reciprocal theorem in solving problems. The assessment will focus on accuracy of calculations, logical problem-solving approach, application of engineering concepts, and clear and structured presentation of solutions.

Force Flow Lab: Trace & Analyze Load Transfer in Structures (10 Marks)
Students will be assessed through application-based and analytical evaluation focusing on their understanding of load transfer in structural systems. The examination will require students to trace the flow of forces in structures such as trusses, frames, and arches from the point of load application to supports, and analyze internal force distribution. Students may be given diagrams or real-life scenarios and asked to interpret structural behavior, identify critical members, and explain load paths. The assessment will focus on conceptual understanding, visualization of force flow, analytical ability, and clarity in explanation and presentation.

2	**Statically Determinate Structures** ***Theory Topics:*** Introduction to Strain Energy, Strain Energy in Structural Members, Resilience and Proof Resilience, Modulus of Resilience, Strain Energy Due to Axial Loads, Impact Loads on Structures, Sudden Loads and Their Effects, Deflection of Statically Determinate Beams, Differential Equation of the Elastic Curve, Relationship Between Bending Moment, Slope	20	20 %

and Deflection, Macaulay's Method for Beam Deflection, Moment Area Method, Conjugate Beam Method, Analysis of Beam Deformation, Slope and Deflection of Beams Under Various Loading Conditions.

Practical:

11. Solve numerical problems on strain energy and resilience, and calculate strain energy in axially loaded members.
12. Analyze the effects of impact loads and sudden loads on bars and compare them with gradually applied loads.
13. Derive and apply elastic curve equations to determine slope and deflection in beams.
14. Determine beam deflection using Macaulay's Method and interpret the results.
15. Determine beam deflection using the Moment Area Method and analyze beam behavior.
16. Determine beam deflection using the Conjugate Beam Method and compare the results with other methods.
17. Compare different beam deflection methods based on procedure, accuracy, and applicability.
18. Solve numerical problems involving slope and deflection relationships in beams under various loading conditions.
19. Analyze beam deformation behavior through practical examples and engineering applications.
20. Conduct a case study on deformation and deflection of beams in real structures and evaluate their serviceability performance.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Deflection and Strain Energy Challenge** Students will be assessed through a structured analytical and numerical problem-solving task demonstrating their understanding of strain energy and beam deflection concepts in statically determinate structures. The challenge will require students to solve problems related to resilience, strain energy due to axial loads, impact and sudden loads, and determine slope and deflection in beams using Macaulay's method, Moment Area Method, and Conjugate Beam Method. Students may also be required to compare different deflection methods and interpret	20	

		structural behavior under various loading conditions. The assessment will focus on conceptual clarity, method selection, accuracy of calculations, logical problem-solving approach, and effective presentation of solutions.			
	2	**Active Learning Assignment: Analyze Strain Energy & Beam Deformation** Students will prepare simple beam models using scales or plastic strips beams and apply different types of loads to observe deformation and deflection behavior. They will measure the deflection, compare experimental observations with theoretical concepts of strain energy and analyze the relationship between bending moment and beam deflection. The activity will help students understand Macaulay's Method, Moment Area Method, and Conjugate Beam Method through practical visualization and engineering applications. Students will compile their calculations, diagrams, observations, and interpretations into a structured PDF for submission on the GMIU Web Portal.		10	
		Total	**20**	**10**	

Examination Style:

Deflection and Strain Energy Challenge (20 Marks)
Students will be assessed through a structured analytical and numerical evaluation focusing on strain energy and beam deflection concepts in statically determinate structures. The examination will require students to solve problems related to resilience, strain energy due to axial loads, impact and sudden loads, and determine slope and deflection in beams using Macaulay's method, Moment Area Method, and Conjugate Beam Method. Students may also be required to compare different analytical methods and interpret deformation behavior under various loading conditions. The assessment will emphasize conceptual understanding, appropriate method selection, accuracy of calculations, analytical reasoning, and effective presentation of solutions in engineering applications.

	Analyze Strain Energy & Beam Deformation (10 Marks) Students will be evaluated based on their ability to conduct the experiment, analyze the observed beam behavior, and relate practical results to theoretical concepts. The assessment may include measurement of beam deflection under different loading conditions, calculation of strain energy and resilience, interpretation of elastic curve behavior, and comparison of experimental results with analytical methods. Students will be required to explain the effect of various loads on beam deformation and justify the selection of appropriate beam deflection analysis methods. Evaluation will focus on conceptual understanding, experimental observations, analytical calculations, interpretation of results, problem-solving ability, and presentation of findings.		
3	**Combined Stresses, Columns and Struts** ***Theory Topics:*** Stress at a Point in Two-Dimensional Stress Systems, Principal Planes and Principal Stresses, Mohr's Circle for Stress Analysis, Ellipse of Stress and Its Applications, Direct and Bending Stresses, Eccentric Loading on Structural Members, Middle Third Rule, Kernel of Section, Analysis of Chimneys Under Wind Pressure, Retaining Walls Subjected to Earth Pressure, Dams Subjected to Hydraulic Pressure, Introduction to Columns and Struts, Buckling of Columns, Effective Length of Columns for Different End Conditions, Radius of Gyration and Least Radius of Gyration, Euler's Column Theory, Rankine's Formula for Columns, Columns with Initial Curvature, Columns Subjected to Eccentric Loading, Columns Under Lateral Loading, Design Applications of Columns and Struts. ***Practical:*** 21. Solve numerical problems on principal stresses and principal planes, and interpret the state of stress at a point. 22. Construct and interpret Mohr's Circle and Stress Ellipse for graphical analysis of stresses. 23. Analyze members subjected to eccentric loading and combined stresses using numerical methods. 24. Study the behavior of engineering structures such as chimneys, retaining walls, and dams under wind, earth, and hydraulic pressures. 25. Determine the effective length of columns for different end conditions and study its influence on buckling. 26. Perform Euler's column buckling calculations and analyze the critical load of columns. 27. Apply Rankine's formula for the design and analysis of columns under compressive loading. 28. Compare Euler's and Rankine's column theories based on assumptions, applicability, and results. 29. Solve numerical problems on columns subjected to eccentric and lateral loading conditions.	20	20%

30. Conduct a case study on buckling failure of structural members and evaluate the factors affecting column stability.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Combined Stress and Column Stability Challenge:** Students will be assessed through a structured analytical and numerical problem-solving task demonstrating their understanding of combined stresses, bending stresses, and column stability concepts. The challenge will require students to solve problems related to principal stresses, Mohr's circle, eccentric loading, bending stresses, and buckling behavior of columns under different end conditions using Euler's and Rankine's formulae. Students may also be required to apply and analyze practical applications such as chimneys, retaining walls, and dams subjected to external forces. The assessment will focus on conceptual clarity, analytical reasoning, accuracy of calculations, method selection, and effective presentation of engineering solutions.	20	
2	**Active Learning Assignment: Analyze, Visualize & Interpret Structural Stress Behavior:** Students will analyze the stability behavior of columns subjected to axial compressive loads under different end conditions. The activity will involve studying column buckling behavior and determining critical loads using Euler's and Rankine's theories. Students will compare the results obtained from both approaches, interpret the effect of slenderness ratio and end conditions on column stability, and present their observations through		10

		calculations, diagrams, and engineering interpretations. The findings shall be compiled into a structured PDF report and submitted through the GMIU Web portal.			
		Total	**10**	**10**	

Examination Style:

Combined Stress and Column Stability Challenge (20 Marks)

Students will be assessed through a structured analytical and numerical evaluation focusing on combined stresses, bending stresses, and stability behavior of columns and struts. The examination will require students to solve problems related to principal stresses, principal planes, Mohr's circle, eccentric loading, and direct and bending stresses in structural members. Students may also be required to analyze buckling behavior of columns under different end conditions using Euler's and Rankine's formulae and interpret engineering applications such as chimneys, retaining walls, and dams subjected to external forces. The assessment will emphasize conceptual understanding, analytical reasoning, method selection, accuracy of calculations, and effective presentation of engineering solutions.

Analyze, Visualize & Interpret Structural Stress Behavior (10 Marks)

Students will be assessed through analytical and application-based evaluation demonstrating their understanding of column stability and buckling concepts. The examination will require students to solve numerical problems related to Euler's critical load, Rankine's formula, effective length calculations, and buckling behavior of columns with different end conditions. Students may also be required to compare theoretical approaches and interpret the influence of column dimensions and support conditions on stability. The assessment will focus on conceptual understanding, accuracy of calculations, analytical thinking, method selection, interpretation of results, and clear presentation of solutions.

4	**Influence Line Diagrams and Moving Load Analysis** ***Theory Topics:*** Introduction to Influence Line Diagrams (ILDs), Influence Line Diagrams for Support Reactions, Influence Line Diagrams for Shear Force, Influence Line Diagrams for Bending Moment, Moving Load Analysis on Beams, Beams Subjected to Point Loads, Beams Subjected to Uniformly Distributed Loads (UDLs), Maximum Shear Force Due to Moving Loads, Maximum Bending Moment Due to Moving Loads, Influence Line Diagrams for Statically Determinate Trusses, Analysis of Truss Member Forces Under Moving	20	20%

Loads, Trusses Subjected to Point Loads, Trusses Subjected to Uniformly Distributed Loads, Applications of Influence Line Diagrams in Bridge Engineering, Load Movement Effects in Transportation Structures

Practical:

31. Construct Influence Line Diagrams (ILDs) for support reactions in statically determinate beams and interpret their significance.
32. Construct Influence Line Diagrams for shear force and bending moment at selected sections of simply supported beams.
33. Determine maximum shear force in beams subjected to moving point loads and uniformly distributed loads using ILDs.
34. Determine maximum bending moment in beams subjected to moving loads and identify critical load positions.
35. Analyze simply supported beams subjected to moving point loads and uniformly distributed loads using Influence Line Diagrams.
36. Solve numerical problems related to moving load criteria for maximum reactions, shear forces, and bending moments.
37. Construct Influence Line Diagrams for member forces in statically determinate trusses.
38. Determine forces in truss members due to moving point loads and uniformly distributed loads using ILD concepts.
39. Compare the effects of different moving load systems on beams and truss members through analytical studies.
40. Conduct a case study on bridge structures subjected to moving loads and evaluate the structural response using Influence Line Diagram principles.

Evaluation Method:

Sr. No.	Evaluation Methods	SEE	CCE
1	**Moving Load Behavior and ILD Analysis:** Students will be assessed through a structured analytical and numerical problem-solving task demonstrating their understanding of Influence Line Diagrams and moving load analysis in statically determinate structures. The challenge will require students to construct ILDs for support reactions, shear force, and bending moment in beams, and determine maximum effects due to uniformly distributed and point loads. Students may also be required to	20	

	analyze statically determinate trusses subjected to moving loads and calculate member forces. The assessment will focus on conceptual understanding, accuracy in diagram construction and calculations, analytical reasoning, and interpretation of structural behavior under moving loads.			
2	**Interpret Structural Load Effects:** Students will analyze the effects of moving loads on beams and trusses using Influence Line Diagrams for support reactions, shear force, and bending moment. The activity will include determination of maximum load effects, analysis of truss member forces, and interpretation of structural behavior under moving load conditions. Students will compile their diagrams, calculations, observations, and analyses.		10	
	Total	**20**	**10**	

Examination Style:

Moving Load Behavior and ILD Analysis (20 Marks)

Students will be assessed through analytical and numerical evaluation demonstrating their understanding of Influence Line Diagrams and moving load analysis in statically determinate structures. The examination will require students to construct ILDs for support reactions, shear force, and bending moment in beams subjected to point loads and uniformly distributed loads, and determine maximum structural effects under different loading conditions. Students may also be required to analyze truss member forces due to moving loads and interpret structural behavior. The assessment will focus on conceptual understanding, accuracy in diagram construction and calculations, analytical reasoning, and effective presentation of engineering solutions.

Interpret Structural Load Effects (10 Marks)

Students will be assessed through application-based and analytical evaluation focusing on the interpretation of moving load effects on beams and trusses using Influence Line Diagrams. The examination will require students to analyze support reactions, shear force, and bending moment variations under moving load conditions and determine maximum load effects in structural members. Students may also be required to

	evaluate truss member forces and explain structural response through diagrams and calculations. The assessment will emphasize diagram interpretation, analytical skills, problem-solving ability, accuracy of calculations, and clarity in presenting engineering analysis.		
5	**Computer Applications in Structural Engineering** ***Theory Topics:*** Introduction to Computer Applications in Structural Engineering, Overview of Structural Analysis Software, Structural Modeling Techniques, Material Properties in Structural Software, Section Properties and Member Definition, Boundary Conditions and Support Modeling, Application of Loading Conditions, Structural Analysis of Framed Structures, Interpretation of Support Reactions, Analysis of Internal Forces, Deflection Analysis of Structures, Structural Response Evaluation, Post-Processing Tools in Structural Software, Interpretation of Software-Generated Results, Computer-Aided Structural Analysis and Design. ***Practical:*** 41. Develop beam and frame models in structural analysis software by defining geometry, material properties, section properties, supports, and loading conditions. 42. Perform structural analysis of beams and frames using software tools and interpret support reactions, internal forces, and structural behavior. 43. Analyze beam deflection and overall structural response using software and compare the results with theoretical principles. 44. Study waterproofing materials used in building construction and evaluate their properties, applications, and performance characteristics. 45. Study false ceiling materials and compare their features, advantages, limitations, and suitability for various building applications. **Evaluation Method:**	10	20 %

Sr. No.	Evaluation Methods	SEE	CCE
1	**Structural Software Modeling and Analysis:** Students will be assessed through a practical and analytical task demonstrating their understanding of computer applications in structural engineering. The assessment will require students to create structural models using professional software, apply	20	

	material properties, supports, and loading conditions, and perform structural analysis. Students may also be required to interpret reactions, internal forces, and deflection results, and compare software outputs with analytical solutions. The assessment will focus on modeling accuracy, understanding of structural behavior, software operation skills, interpretation of results, and effective presentation of analysis.				
2	**Computer-Aided Structural Analysis of Framed Structures Using STAAD. Pro:** Students will develop and analyze a simple framed structure using STAAD. Pro software. The activity will include structural modeling, assignment of material and section properties, definition of supports and boundary conditions, and application of various loading conditions. Students will perform structural analysis to determine support reactions, internal forces, bending moments, shear forces, and deflections. They will interpret software-generated results, evaluate structural response, and prepare a concise report containing modeling procedures, analysis results, and engineering conclusions.		10		
	Total	**20**	**10**		

Examination Style:

Structural Software Modeling and Analysis (20 Marks)
Students will be assessed through conceptual and application-based evaluation demonstrating their understanding of interior and exterior finishing materials used in building construction. The examination will require students to identify materials such as paints, tiles, plaster, flooring, and cladding, explain their properties and uses, and analyze their suitability for different conditions. Students will also evaluate real-life scenarios and select appropriate materials for interior and

	exterior finishes based on durability, aesthetics, and environmental factors. The assessment will focus on conceptual clarity, practical application, material selection skills, and clear presentation of answers. **Struct Soft Lab: Model, Analyze & Interpret Structural Response (10 Marks)** Students will be assessed through a practical and application-based evaluation demonstrating their ability to use STAAD. Pro for structural analysis. The examination will require students to create a structural model, assign appropriate material and section properties, define support conditions, apply loads, and perform analysis. Students will be evaluated on their ability to interpret support reactions, internal force diagrams, and deflection results generated by the software. The assessment will focus on software proficiency, correctness of modeling, understanding of structural behavior, interpretation of results, analytical thinking, and presentation of findings.		

Suggested Specification table with Marks (Theory): 100

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage %	10%	20%	35%	20%	10%	5%

Course Outcome:

After learning the course, the students should be able to:	
CO1	Understand the fundamentals of statically determinate structures, stability, and structural behavior.
CO2	Apply strain energy principles and determine slope and deflection in beams using analytical methods.
CO3	Analyze combined stresses, direct and bending stresses, and buckling behavior of columns and struts.
CO4	Evaluate the effects of moving loads on beams and trusses using Influence Line Diagrams.
CO5	Perform structural modeling and analysis using professional software such as STAAD-Pro, SAP, and ETABS.

Instructional Method:

The course delivery method will depend upon the requirement of content and need of students.

A minimum of 20–30% of the course content shall be suggested to deliver through Flipped Learning, where students study digital learning resources before the classroom session. Classroom time shall be utilized for discussion, problem-solving, practical applications, and higher-order learning activities.

Students shall be encouraged to use AI-powered learning platforms, simulation software, virtual laboratories, digital libraries, research databases, online certification courses, NPTEL, SWAYAM, MOOCs, and other technology-enabled learning resources to strengthen conceptual understanding and practical competence.

Continuous assessment shall be conducted through Active Learning Assignments (ALAs), quizzes, skill demonstrations, presentations, practical exercises, projects, case studies, innovation activities, peer assessment, reflective learning, and industry-oriented tasks instead of relying primarily on conventional written assignments.

Reference Books:

[1] S.B. Junarkar and H.J. Shah, Mechanics of Structures Vol-I, Charotar Publishing House.
[2] R.K. Rajput, Strength of Materials, S. Chand Publications.
[3] B.C. Punmia, Strength of Materials and Theory of Structures, Laxmi Publications.
[4] S. Ramamrutham, Theory of Structures, Dhanpat Rai Publications.
[5] R.K. Bansal, Strength of Materials, Laxmi Publications