



Kot Bhalwal, Jammu

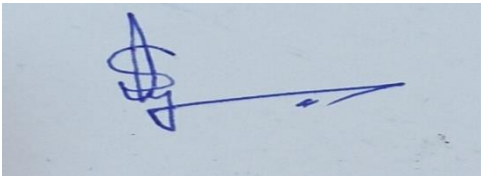


Model Institute of Engineering
& Technology (Autonomous)
Dr. Arun K. Gupta Teaching-Learning Centre

Department of Civil Engineering

Details of Lesson Plan

S.No.	Particulars	Details
1.	Course Name	Structural Analysis-II
2.	Course Code	CE-401
3.	Academic Year	2024-25
4.	Semester	4 th
5.	Number of Lesson plans	38
6.	Faculty Assigned	Mr.Iliyas Khaleel



Faculty Signature



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Lesson Plan No. 1	Course Name: Structural Analysis-II Topic: Introduction of Slope Deflection method	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: <ol style="list-style-type: none"> Understand the concepts of simple stresses and strains. Explain Hooke's Law and its applications. Calculate stress and strain in various materials. Analyze the behavior of materials under different types of loading.
Teaching Aids (if any)	<ol style="list-style-type: none"> Stress-strain diagrams. Interactive simulations for stress and strain calculation.
Teaching Development	<p>Introduction (5 minutes)</p> <ul style="list-style-type: none"> Engage students with questions about material deformation under load. Discuss the significance of understanding stresses and strains in structural analysis. <p>Development (30 minutes)</p> <ul style="list-style-type: none"> Define stress and strain and explain their types. Introduce Hooke's Law and its mathematical formulation. Explain the relationship between stress, strain, and Young's modulus. Provide examples and numerical practice problems. <p>Exercise (5 minutes) – Calculate stress and strain for a given material under specific loading conditions. Problem: A steel rod with a diameter of 10 mm and a length of 1 m is subjected to a tensile force of 20 kN. Calculate the stress and strain in the rod. (Young's modulus for steel = 200 GPa)</p>
Closure	<ol style="list-style-type: none"> Summarize the Lesson Learning Outcomes and get affirmation from students on these. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ Homework A cylindrical metal rod is subjected to a tensile force. Calculate the stress and Given: <ul style="list-style-type: none"> Length of the rod, $L=2$ meters Diameter of the rod, $d=10$ mm Applied tensile force, $F=5000$ N Young's modulus of the material, $E=200$ GPa
Evaluation	<ol style="list-style-type: none"> Slope and deflection equations, fixing moment equations Allow students to answer and discuss. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 2	Course Name: Structural Analysis-II Topic: Analysis of continuous beams when supports are at same level.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concept of composite sections. b. Analyze the behavior of composite sections under different loading conditions. c. Calculate stress and strain in composite sections. d. Explain the applications of composite sections in engineering.
Teaching Aids (if any)	a. Visual aids for composite sections. b. Interactive simulations for composite section analysis
Teaching Development	Introduction (5 minutes) -Engage students with questions about the use of different materials in a single section. - Discuss the importance of composite sections in structural design. Development (30 minutes) <ul style="list-style-type: none">Define composite sections and explain their significance.Explain the analysis of composite sections under different loading conditions.Provide examples and numerical practice problems. Exercise (5 minutes) – Analyze a composite section and calculate stress and strain. Problem: A composite section consists of a steel plate (200 mm wide, 10 mm thick) bonded to a concrete slab (200 mm wide, 50 mm thick). If a tensile force of 50 kN is applied, calculate the stress in both materials. (Young's modulus for steel = 200 GPa, for concrete = 25 GPa)
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ 3. Homework A composite beam is constructed by bolting together a steel plate and a timber beam, as shown in the figure below. The steel plate is 200 mm wide and 10 mm thick, and the timber beam is 200 mm wide and 150 mm high. The modulus of elasticity for steel (E_s) is 200 GPa, and for timber (E_t) it is 10 GPa. The composite beam is subjected to a uniformly distributed load of 5 kN/m over a span of 4 meters.
Evaluation	1. Slope and deflection equations, fixing moment equations Allow students to answer and discuss. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 3	Course Name: Structural Analysis-II Topic: Analysis of continuous beams when supports are at different level.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: <ol style="list-style-type: none"> Understand the concept of strain energy. Calculate strain energy in materials under different types of loading. Analyse the impact of gradually and suddenly applied loads on strain energy. Explain the applications of strain energy in engineering.
Teaching Aids (if any)	<ol style="list-style-type: none"> Visual aids for strain energy demonstration. Interactive simulations for strain energy calculation.
Teaching Development	<p>Introduction (5 minutes)</p> <ul style="list-style-type: none"> -Engage students with questions about energy absorption in materials. - Discuss the importance of understanding strain energy in structural analysis. <p>Development (30 minutes)</p> <p>Define strain energy and explain its significance.</p> <ul style="list-style-type: none"> - Explain how to calculate strain energy under different types of loading. - Discuss the impact of gradually and suddenly applied loads on strain energy. - Provide examples and numerical practice problems. <p>Exercise (5 minutes) – Calculate strain energy for a given material under specific loading conditions.</p> <p>Problem: A steel rod with a diameter of 10 mm and a length of 1 m is subjected to a gradually applied tensile load of 20 kN. Calculate the strain energy stored in the rod. (Young's modulus for steel = 200 GPa)</p>
Closure	<ol style="list-style-type: none"> Summarize the Lesson Learning Outcomes and get affirmation from students on these. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ Homework A simply supported beam with a span of 4 meters is subjected to a central point load of 10 kN. The beam has a rectangular cross-section with a width of 50 mm and a height of 150 mm. The modulus of elasticity (E) is 200 GPa. Calculate the strain energy stored in the beam due to bending.
Evaluation	<ol style="list-style-type: none"> Slope and deflection equations, fixing moment equations Allow students to answer and discuss. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 4	Course Name: Structural Analysis-II Topic: Analysis of simple frames by slope deflection method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concepts of shear force and bending moment. b. Analyze shear force and bending moment in simply supported beams. c. Draw shear force and bending moment diagrams. d. Apply the concepts to solve numerical problems.
Teaching Aids (if any)	a. Visual aids for shear force and bending moment diagrams. b. Interactive simulations for shear force and bending moment calculation.
Teaching Development	Introduction (5 minutes) -Engage students with questions about forces and moments in beams. - Discuss the importance of understanding shear force and bending moment in structural analysis. Development (30 minutes) -Define shear force and bending moment and explain their significance. - Explain how to calculate shear force and bending moment in simply supported beams. - Demonstrate how to draw shear force and bending moment diagrams. - Provide examples and numerical practice problems. Exercise (5 minutes) – Draw shear force and bending moment diagrams for a given simply supported beam. Problem: A simply supported beam with a span of 6 meters carries a point load of 10 kN at the mid-span. Draw the shear force and bending moment diagrams for the beam.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ 3. Homework A simply supported beam with a length of 6 meters is subjected to the following loading conditions: Point Load: A point load of 10 kN is applied at 2 meters from the left support. Uniformly Distributed Load (UDL): A uniformly distributed load of 5 kN/m is applied over the entire length of the beam.
Evaluation	1. Slope and deflection equations, fixing moment equations Allow students to answer and discuss. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 5	Course Name: Structural Analysis-II Topic: Analysis of symmetrical portal frames by slope deflection method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the behavior of cantilevers and fixed beams. b. Analyze shear force and bending moment in cantilevers and fixed beams. c. Draw shear force and bending moment diagrams for these beams. d. Apply the concepts to solve numerical problems.
Teaching Aids (if any)	a. Visual aids for shear force and bending moment diagrams. b. Interactive simulations for beam analysis.
Teaching Development	Introduction (5 minutes) -Engage students with questions about cantilevers and fixed beams. - Discuss the importance of analyzing these beams in structural design. Development (30 minutes) - Define cantilevers and fixed beams and explain their significance. - Explain how to calculate shear force and bending moment in these beams. - Demonstrate how to draw shear force and bending moment diagrams. - Provide examples and numerical practice problems. Exercise (5 minutes) - Draw shear force and bending moment diagrams for a given simply supported beam. Problem: A cantilever beam with a length of 4 meters is subjected to a uniformly distributed load of 2 kN/m. Draw the shear force and bending moment diagrams for the beam.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ 3. Homework A cantilever beam of length L is subjected to a point load P at the free end. 1. Draw the shear force and bending moment diagrams for the beam. 2. Determine the maximum shear force and bending moment.
Evaluation	1. Slope and deflection equations, fixing moment equations Allow students to answer and discuss. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 6	Course Name: Structural Analysis-II Topic: Influence Lines for Statically Determinate Structures	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concept of influence lines. b. Analyze influence lines for statically determinate structures. c. Draw influence lines for reactions, shear forces, and bending moments. d. Apply the concepts to solve numerical problems.
Teaching Aids (if any)	a. Visual aids for influence line diagrams. b. Interactive simulations for influence line analysis.
Teaching Development	Introduction (5 minutes) -Engage students with questions about moving loads and their impact on structures. -Discuss the importance of influence lines in structural analysis. Development (30 minutes) - Define influence lines and explain their significance. - Explain how to analyze influence lines for statically determinate structures. - Demonstrate how to draw influence lines for reactions, shear forces, and bending moments. - Provide examples and numerical practice problems. Exercise (5 minutes) - Draw influence lines for a given simply supported beam subjected to a moving load. Problem: Draw the influence lines for the reaction at the left support, shear force at the mid-span, and bending moment at the mid-span for a simply supported beam with a span of 8 meters.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ 3. Homework Consider a simply supported beam AB with a span length of 12 meters. The beam is subjected to a moving point load of P. Determine and draw the influence lines for the following quantities: <ul style="list-style-type: none">• Reaction at support A (R_A)• Reaction at support B (R_B)• Shear force at a section C located 4 meters from support A• Bending moment at a section D located 6 meters from support A
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 7	Course Name: Structural Analysis-II Topic: Analysis of asymmetrical portal frames by slope deflection method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the theory of simple bending. b. Derive the bending equation. c. Apply the bending equation to calculate bending stress. d. Analyze the implications of bending stress on beam design.
Teaching Aids (if any)	a. Visual aids for demonstrating bending stress. b. Interactive simulations for bending stress calculation.
Teaching Development	Introduction (5 minutes) -Engage students with questions about bending in beams. - Discuss the importance of understanding bending stress in structural analysis. Development (30 minutes) - Explain the theory of simple bending and its assumptions. - Derive the bending equation ($M/I = \sigma/y = E/R$). - Demonstrate how to calculate bending stress in beams using the bending equation. - Provide examples and numerical practice problems. Exercise (5 minutes) - Calculate bending stress in a given beam using the bending equation. Problem: A simply supported beam with a span of 6 meters carries a uniform load of 5 kN/m over the entire span. Calculate the maximum bending stress if the cross-section of the beam is a rectangle 200 mm wide and 300 mm deep.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ 3. Homework A simply supported beam with a span of 6 meters is subjected to a uniform distributed load of 10 kN/m. Calculate the maximum bending stress in the beam if the beam has a rectangular cross-section with a width of 150 mm and a height of 300 mm.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 8	Course Name: Structural Analysis-II Topic: Analysis of continuous beams by moment distribution method when supports are at same level.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concept of the neutral axis. b. Analyze bending stress distribution in beams. c. Explain the relationship between the neutral axis and bending stress. d. Determine the location of the neutral axis in various beam sections.
Teaching Aids (if any)	a. Visual aids for demonstrating the neutral axis. b. Interactive simulations for bending stress distribution.
Teaching Development	Introduction (5 minutes) -Engage students with questions about stress distribution in beams. -Discuss the importance of the neutral axis in beam analysis. Development (30 minutes) - Define the neutral axis and its significance. - Explain how to analyze bending stress distribution in beams. - Discuss the relationship between the neutral axis and bending stress. - Provide examples and numerical practice problems. Exercise (5 minutes) - Analyze bending stress distribution in a given beam Problem: A rectangular beam section 150 mm wide and 300 mm deep is subjected to a bending moment of 45 kNm. Determine the maximum bending stress and the location of the neutral axis.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ 3. Homework A simply supported beam with a length of 6 meters carries a uniformly distributed load (UDL) of 10 kN/m over its entire length. The beam has a rectangular cross-section with a width of 200 mm and a height of 400 mm.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 9	Course Name: Structural Analysis-II Topic: Analysis of continuous beams by moment distribution method when supports are at different level.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: <ol style="list-style-type: none"> Understand the concept of shear stresses in beams. Calculate shear stress distribution in beams. Explain the relationship between shear force and shear stress. Determine shear stress in different beam sections.
Teaching Aids (if any)	<ol style="list-style-type: none"> Visual aids for demonstrating the neutral axis. Interactive simulations for bending stress distribution.
Teaching Development	<p>Introduction (5 minutes)</p> <ol style="list-style-type: none"> Engage students with questions about shear forces in beams. Discuss the significance of shear stress analysis in beam design. <p>Development (30 minutes)</p> <ul style="list-style-type: none"> - Define shear stress in beams and its importance. - Explain how to calculate shear stress distribution in beams. - Discuss the relationship between shear force and shear stress. - Provide examples and numerical practice problems. <p>Exercise (5 minutes) - A simply supported beam with a span of 4 meters is subjected to a point load of 20 kN at the mid-span. The cross-section of the beam is a T-section with a flange 200 mm wide and 20 mm thick, and a web 150 mm deep and 10 mm thick. Determine the maximum shear stress in the beam.</p>
Closure	<ol style="list-style-type: none"> Summarize the Lesson Learning Outcomes and get affirmation from students on these. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/ Homework A simply supported beam of length 6 meters is subjected to a uniformly distributed load (UDL) of 5 kN/m across its entire length. The cross-section of the beam is rectangular with a width of 150 mm and a height of 300 mm. <ul style="list-style-type: none"> • Calculate the maximum shear force in the beam. • Determine the shear stress distribution across the depth of the beam. • Calculate the maximum shear stress in the beam.
Evaluation	<ol style="list-style-type: none"> Slope deflection equations, Distribution factors, Fixing moment equations. Nearpod Quiz on Cloud Computing <p>Spend 5 minutes to evaluate student assimilation of the lesson contents</p>



Lesson Plan No. 10	Course Name: Structural Analysis-II Topic: Analysis of simple frames by moment distribution method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concepts of unsymmetrical bending and shear center. b. Analyze beams for unsymmetrical bending. c. Determine the shear center for various beam sections. d. Explain the implications of unsymmetrical bending and shear center in beam design.
Teaching Aids (if any)	a. Visual aids for unsymmetrical bending and shear center. b. Case studies of beams under unsymmetrical bending.
Teaching Development	Introduction (5 minutes) -Engage students with examples of beams subjected to unsymmetrical bending. - Discuss the importance of analyzing unsymmetrical bending and shear center. Development (30 minutes) - Define unsymmetrical bending and shear center. - Explain how to analyze beams for unsymmetrical bending and determine the shear center. - Discuss the implications of unsymmetrical bending and shear center in beam design. - Provide examples and numerical practice problems. Exercise (5 minutes) - Analyze a beam for unsymmetrical bending and determine its shear center. Problem: A channel section with a flange width of 100 mm, a web depth of 200 mm, and a flange and web thickness of 10 mm is subjected to an eccentric load causing unsymmetrical bending. Determine the location of the shear center and the maximum bending stress.
Closure	<ol style="list-style-type: none">1. Summarize the Lesson Learning Outcomes and get affirmation from students on these.2. Suggested Reading https://archive.nptel.ac.in/courses/105/101/105101085/3. Homework A structural engineer is designing a steel channel section to be used as a beam in a construction project. The channel section is not symmetric with respect to both the x-axis (horizontal axis) and the y-axis (vertical axis). The dimensions of the channel are as follows:<ul style="list-style-type: none">• Flange width: 100 mm• Flange thickness: 10 mm• Web height: 200 mm• Web thickness: 10 mm



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Evaluation

1. Slope deflection equations, Distribution factors, Fixing moment equations.



Lesson Plan No. 11	Course Name: Structural Analysis-II Topic: Muller Breslau's principle and Rolling loads introduction.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concept of beam deflection. b. Calculate deflection for different types of beams and loading conditions. c. Derive and apply the slope-deflection formula. d. Use Macaulay's method for deflection calculations.
Teaching Aids (if any)	a. Visual aids for deflection diagrams. b. Interactive simulations for deflection calculations.
Teaching Development	Introduction (5 minutes) - Engage students with questions about the behavior of beams under load. - Discuss the importance of understanding beam deflection in structural design. Development (30 minutes) - Define deflection and explain its significance. - Explain how to calculate deflection using different methods. - Derive the slope-deflection formula. - Introduce Macaulay's method and its application in deflection calculations. - Provide examples and numerical practice problems Exercise (5 minutes) – Calculate the deflection of a simply supported beam using Macaulay's method. Problem: A simply supported beam of length 5 meters carries a point load of 10 kN at its mid-span. Calculate the deflection at the center of the beam. (Use Macaulay's method for calculation.)
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ 3. Homework simply supported beam of length $L=6$ meters is subjected to a central point load $P=20$ kN. The beam has a moment of inertia $I=50 \times 10^6 \text{ mm}^4$ and a modulus of elasticity $E=200$ GPa. Calculate the deflection at the center of the beam using the following methods: • Double Integration Method • Moment-Area Theorem
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 12	Course Name: Structural Analysis-II Topic: Slope, Deflection, and Radius of Curvature	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: <ol style="list-style-type: none"> Understand the concepts of slope, deflection, and radius of curvature. Calculate slope and deflection using differential equations. Derive and apply the formula for the radius of curvature. Analyze the effect of loading conditions on slope and curvature.
Teaching Aids (if any)	<ol style="list-style-type: none"> Visual aids for slope and curvature diagrams. Interactive simulations for slope and curvature calculations.
Teaching Development	<p>Introduction (5 minutes)</p> <ul style="list-style-type: none"> - Engage students with questions about beam bending and its effects. - Discuss the importance of understanding slope and curvature in beam design. <p>Development (30 minutes)</p> <ul style="list-style-type: none"> - Define slope, deflection, and radius of curvature. - Explain how to calculate slope and deflection using differential equations. - Derive the formula for the radius of curvature. - Provide examples and numerical practice problems. <p>Exercise (5 minutes) – Calculate the radius of curvature for a given beam under specific loading conditions.</p> <p>Problem: For a simply supported beam with a length of 6 meters and a uniform load of 5 kN/m, calculate the radius of curvature at the center of the beam. (Assume EI is constant.)</p>
Closure	<ol style="list-style-type: none"> Summarize the Lesson Learning Outcomes and get affirmation from students on these. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ Homework A simply supported beam of length L is subjected to a central point load P. The beam has a modulus of elasticity E and a moment of inertia I. Calculate the following: <ol style="list-style-type: none"> Slope at the supports (θ_A and θ_B). Maximum deflection at the center of the beam (δ_{max}). Radius of curvature at the center of the beam (R).
Evaluation	<ol style="list-style-type: none"> Slope deflection equations, Distribution factors, Fixing moment equations. Nearpod Quiz on Cloud Computing <p>Spend 5 minutes to evaluate student assimilation of the lesson contents</p>



Lesson Plan No. 13	Course Name: Structural Analysis-II Topic: Derivation of Slope-Deflection Formula	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the slope-deflection formula. b. Derive the slope-deflection formula from basic principles. c. Apply the slope-deflection formula to analyze beams. d. Solve numerical problems involving slope and deflection using the formula.
Teaching Aids (if any)	a. Visual aids for slope-deflection derivation. b. Interactive simulations for formula application
Teaching Development	Introduction (5 minutes) - Engage students with questions about beam deflection and slope. - Discuss the importance of the slope-deflection formula in structural analysis. Development (30 minutes) - Define the slope-deflection formula and its components. - Derive the formula step-by-step from basic principles. - Explain how to apply the formula to analyze beams. - Provide examples and numerical practice problems. Exercise (5 minutes) – Apply the slope-deflection formula to a given beam problem. Problem: A simply supported beam of length 4 meters is subjected to a point load of 12 kN at the midpoint. Derive the slope-deflection equations and calculate the deflection at the midpoint.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ 3. Homework Consider a simply supported beam of length L with a point load PPP located at a distance a from the left support and b from the right support (where $a+b=L$). Derive the slope-deflection equations for this beam and find the reactions at the supports.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 14	Course Name: Structural Analysis-II Topic: Single concentrated load	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand Macaulay's method for beam deflection. b. Apply Macaulay's method to solve deflection problems. c. Analyze complex loading conditions using Macaulay's method. d. Solve numerical problems involving Macaulay's method.
Teaching Aids (if any)	a. Visual aids for Macaulay's method steps. b. Interactive simulations for deflection calculations.
Teaching Development	Introduction (5 minutes) -Engage students with questions about different methods for deflection calculation. - Discuss the importance and advantages of Macaulay's method. Development (30 minutes) - Define Macaulay's method and its application. - Explain the steps involved in using Macaulay's method for deflection calculations. - Provide examples and numerical practice problems. Exercise (5 minutes) – Solve a deflection problem using Macaulay's method Problem: A simply supported beam of length 8 meters carries a uniformly distributed load of 4 kN/m over the entire span. Use Macaulay's method to calculate the deflection at a point 3 meters from the left support.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ 3. Homework A simply supported beam of length L has a point load P applied at a distance a from the left support. The beam has a uniform flexural rigidity EI. Determine the deflection at the point of load application and the maximum deflection of the beam using Macaulay's method.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 15	Course Name: Structural Analysis-II Topic: Effect of UDL longer than span rolling loads and draw its influence line diagram	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concepts of principal stresses and strains. b. Calculate principal stresses and strains from given data. c. Analyze stress and strain in materials using principal values. d. Solve numerical problems involving principal stresses and strains.
Teaching Aids (if any)	a. Visual aids for stress and strain calculations. b. Interactive simulations for principal stress analysis.
Teaching Development	Introduction (5 minutes) - Engage students with questions about material failure and stress analysis. - Discuss the significance of principal stresses and strains in engineering design. Development (30 minutes) - Define principal stresses and strains. - Explain how to calculate principal stresses and strains from given data. - Provide examples and numerical practice problems. Exercise (5 minutes) – Calculate the principal stresses and strains for a given material under specific loading conditions. Problem: A material experiences normal stresses of 50 MPa and 30 MPa along two perpendicular axes and a shear stress of 20 MPa. Calculate the principal stresses and strains.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ 3. Homework A component is subjected to a two-dimensional stress state with the following normal and shear stresses: • $\sigma_x = 80$ MPa • $\sigma_y = 30$ MPa • $\tau_{xy} = 40$ MPa Tasks: Calculate the principal stresses (σ_1 and σ_2). Determine the maximum shear stress (τ_{max}). Find the orientation of the principal axes (θ_p) relative to the x-axis.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 16	Course Name: Structural Analysis-I Topic: UDL shorter than span	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concept of Mohr's Circle for stress analysis. b. Construct Mohr's Circle for given stress states. c. Use Mohr's Circle to determine principal stresses and maximum shear stresses. d. Solve numerical problems involving Mohr's Circle.
Teaching Aids (if any)	a. Visual aids for Mohr's Circle construction. b. Interactive simulations for stress analysis.
Teaching Development	Introduction (5 minutes) -Engage students with questions about stress transformations and their importance. -Discuss the role of Mohr's Circle in stress analysis. Development (30 minutes) - Define Mohr's Circle and its application. - Explain how to construct Mohr's Circle for given stress states. - Use Mohr's Circle to determine principal stresses and maximum shear stresses. - Provide examples and numerical practice problems. Exercise (5 minutes) – Construct Mohr's Circle and find principal stresses and maximum shear stresses. Problem: Given normal stresses of 60 MPa and 40 MPa along perpendicular axes with a shear stress of 25 MPa, construct Mohr's Circle and determine the principal stresses and maximum shear stress.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ 3. Homework A rectangular metal plate is subjected to the following strains: $\epsilon_x = 0.002$, $\epsilon_y = -0.001$, $\gamma_{xy} = 0.0015$ Tasks: 1. Construct Mohr's Circle for the given strain state. 2. Determine the principal strains (ϵ_1 and ϵ_2). 3. Calculate the maximum shear strain (γ_{max}). 4. Find the orientation of the principal strain planes (θ_p) relative to the x-axis.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 17	Course Name: Structural Analysis-II Topic: Graphical and Analytical Methods for Principal Stresses	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: <ol style="list-style-type: none"> Understand graphical and analytical methods for determining principal stresses. Apply graphical methods to solve stress problems. Solve principal stress problems using analytical methods. Compare the results from graphical and analytical methods.
Teaching Aids (if any)	<ol style="list-style-type: none"> Visual aids for graphical methods. Interactive simulations for stress calculations.
Teaching Development	<p>Introduction (5 minutes)</p> <ul style="list-style-type: none"> -Engage students with questions about different methods of stress analysis. -Discuss the importance of graphical and analytical methods. <p>Development (30 minutes)</p> <ul style="list-style-type: none"> - Define graphical and analytical methods for determining principal stresses. - Explain how to apply graphical methods (e.g., Mohr's Circle) and analytical methods. - Provide examples and numerical practice problems. <p>Exercise (5 minutes) – Solve a stress problem using both graphical and analytical methods.</p> <p>Problem: Given normal stresses of 70 MPa and 50 MPa with a shear stress of 30 MPa, determine the principal stresses using both graphical (Mohr's Circle) and analytical methods, and compare the results.</p>
Closure	<ol style="list-style-type: none"> Summarize the Lesson Learning Outcomes and get affirmation from students on these. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ Homework <ol style="list-style-type: none"> Graphical Methods: Given a stress element with $\sigma_x = 50$ MPa, $\sigma_y = -30$ MPa, and $\tau_{xy} = 40$ MPa: <ul style="list-style-type: none"> Construct Mohr's circle. Determine the principal stresses and the maximum shear stress. Find the orientation of the principal planes. Analytical Methods: Stress Transformation Equations- A material element is subjected to $\sigma_x = 100$ MPa, $\sigma_y = 50$ MPa, and $\tau_{xy} = 25$ MPa. <ul style="list-style-type: none"> Use stress transformation equations to find the normal and shear stresses on a plane oriented at 30 degrees to the x-axis. Verify the results using Mohr's circle.
Evaluation	<ol style="list-style-type: none"> Reflective Questions (What, why, Who?). Allow students to answer and discuss.



Lesson Plan No. 18	Course Name: Structural Analysis-II Topic: Strain Energy in Terms of Principal Stresses	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand strain energy concepts in terms of principal stresses. b. Calculate strain energy for different loading conditions. c. Apply strain energy principles to solve practical problems. d. Analyze the relationship between strain energy and material properties.
Teaching Aids (if any)	a. Visual aids for strain energy calculations. b. Interactive simulations for strain energy analysis.
Teaching Development	Introduction (5 minutes) -Engage students with questions about energy concepts in structural analysis. -Discuss the importance of strain energy in engineering design.. Development (30 minutes) - Define strain energy and its relationship with principal stresses. - Explain how to calculate strain energy using principal stress values. - Provide examples and numerical practice problems. Exercise (5 minutes) – Calculate the strain energy for a given material under specified loading conditions. Problem: A material experiences principal stresses of 80 MPa and 40 MPa. Calculate the strain energy per unit volume for this material if Young's modulus is 200 MPa.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ 3. Homework 1) A rectangular bar of width b , thickness t , and length L is subjected to a tensile load P along its length. The material of the bar has Young's modulus E and Poisson's ratio ν . <ul style="list-style-type: none"> • Determine the principal stresses in the bar. • Calculate the strain energy stored in the bar. 2) A simply supported beam of length L , width b , and depth d is subjected to a central load P . The material of the beam has Young's modulus E . <ul style="list-style-type: none"> • Determine the maximum principal stresses in the beam. • Calculate the strain energy stored in the beam.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 19	Course Name: Structural Analysis-II Topic: Ellipse of Strain	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concept of the ellipse of strain. b. Construct the ellipse of strain for given stress states. c. Analyze the effects of strain on material behavior. d. Solve numerical problems involving the ellipse of strain.
Teaching Aids (if any)	a. Visual aids for ellipse of strain diagrams. b. Interactive simulations for strain analysis.
Teaching Development	Introduction (5 minutes) -Engage students with questions about strain and its effects on materials. -Discuss the significance of the ellipse of strain in material analysis. Development (30 minutes) -Define the ellipse of strain and its construction. - Explain how to construct and analyze the ellipse of strain for given stress states. - Provide examples and numerical practice problems. Exercise (5 minutes) – Construct the ellipse of strain for a given material under specific loading conditions. Problem: Given normal strains of 0.002 and 0.0015 along two perpendicular axes and a shear strain of 0.001, construct the ellipse of strain and determine the major and minor axes.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ 3. Homework Problem: Basic Construction of the Strain Ellipse Given: • Normal strains in the x and y directions: $\epsilon_x=0.005$, $\epsilon_y=0.002$ • Shear strain in the xy-plane: $\gamma_{xy}=0.003$ Tasks: 1. Construct the strain ellipse using the given strains. 2. Determine the principal strains. 3. Find the orientation of the principal strain axes.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 20	Course Name: Structural Analysis-II Topic: Thin Cylinders: Circumferential and Longitudinal Stresses	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the stress distribution in thin cylinders. b. Calculate circumferential and longitudinal stresses in thin cylinders. c. Apply these calculations to practical engineering problems. d. Solve numerical problems involving thin cylinders under different loading conditions.
Teaching Aids (if any)	a. Visual aids for stress distribution in thin cylinders. b. Interactive simulations for stress calculations.
Teaching Development	Introduction (5 minutes) -Engage students with questions about the behavior of thin cylinders under load. -Discuss the importance of understanding circumferential and longitudinal stresses. Development (30 minutes) -Define circumferential and longitudinal stresses in thin cylinders. - Explain how to calculate these stresses using appropriate formulas. - Provide examples and numerical practice problems. Exercise (5 minutes) – Calculate circumferential and longitudinal stresses for a given thin cylinder problem. Problem: A thin cylindrical shell with a radius of 1 meter and wall thickness of 5 mm is subjected to an internal pressure of 2 MPa. Calculate the circumferential and longitudinal stresses in the cylinder.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/112/107/112107146/ 3. Homework Internal Pressure Given: A thin-walled cylindrical vessel with an internal radius $r = 500$ mm and a wall thickness $t = 10$ mm. The vessel is subjected to an internal pressure $p = 2$ MPa. Calculate: 1. The hoop stress (circumferential stress). 2. The longitudinal stress.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 21	Course Name: Structural Analysis-II Topic: Introduction of Kanis method	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the basic concepts of columns and struts. b. Differentiate between short and long columns. c. Recognize the importance of columns and struts in structural design.
Teaching Aids (if any)	a. Diagrams showing different types of columns and struts. b. Interactive simulation to visualize column buckling.
Teaching Development	Introduction (5 minutes) • Discuss the role of columns and struts in structures. • Engage students with questions about the behavior of columns under load. Development (30 minutes) • Define columns and struts. • Explain the difference between short and long columns. • Discuss the factors affecting the behavior of columns. Exercise (5 minutes) – Identify and classify given examples as short or long columns. Problem: A 3-meter-long steel column with a cross-sectional area of 1500 mm ² is subjected to an axial load of 250 kN. Determine whether the column should be considered short or long, given that the critical slenderness ratio for the material is 50.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 3. Homework Identify different types of columns and struts in a building near you.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 22	Course Name: Structural Analysis-II Topic: Analysis of continuous beams when supports are at same level.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand Euler's theory of columns. b. Apply Euler's formula to calculate critical loads for different types of columns.
Teaching Aids (if any)	a. Graphical representation of buckling modes. b. Derivation of Euler's formula on the board.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Review the concept of long columns.Introduce Euler's theory as a fundamental concept in column analysis. Development (30 minutes) <ul style="list-style-type: none">Derive Euler's formula for critical load.Explain the assumptions and limitations of Euler's theory.Solve examples of critical load calculations using Euler's formula. Exercise (5 minutes) – Calculate the critical load for a given column using Euler's formula. Problem: Determine the critical load for a steel column with an effective length of 4 meters and a radius of gyration of 50 mm. The modulus of elasticity of steel is 200 GPa.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/111/107/111107103/ 3. Homework Derive Euler's formula for different boundary conditions.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 23	Course Name: Structural Analysis-II Topic: Analysis of continuous beams when supports are at different level	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the concept of effective length. b. Determine the effective length for different column boundary conditions.
Teaching Aids (if any)	a. Charts showing effective lengths for various boundary conditions. b. Visual aids for different column end conditions.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap Euler's formula.Introduce the concept of effective length in columns. Development (30 minutes) <ul style="list-style-type: none">Explain effective length and its significance.Discuss different end conditions and their impact on effective length.Solve examples to calculate effective length for various cases. Exercise (5 minutes) – Calculate the effective length for a column with given end conditions. <ul style="list-style-type: none">Pinned-Pinned (Hinged-Hinged)Fixed-FixedPinned-Fixed (Hinged-Fixed)Fixed-Free (Cantilever) Problem: A column with a length of 6 meters is pinned at both ends. Calculate its effective length and determine the critical load using Euler's formula, given that the column has a radius of gyration of 70 mm and the modulus of elasticity is 210 GPa.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 3. Homework Determine the effective length for columns with different end conditions in a building.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 24	Course Name: Structural Analysis-II Topic: Analysis of simple frames by Kanis method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: <ol style="list-style-type: none"> Understand the concept of effective length. Determine the effective length for different column boundary conditions.
Teaching Aids (if any)	<ol style="list-style-type: none"> Derivation of empirical formulae on the board. Examples of empirical formulae application in industry.
Teaching Development	<p>Introduction (5 minutes)</p> <ul style="list-style-type: none"> Review effective length and critical load. Introduce the need for empirical formulae in column design <p>Development (30 minutes)</p> <ul style="list-style-type: none"> Discuss various empirical formulae like Rankine's formula. Explain the assumptions and limitations of each formula. Provide examples and solve numerical problems using empirical formulae. <p>Exercise (5 minutes) – Calculate the critical load for a given column in a 10-storey building using an empirical formula. The column has the following parameters: length = 3 meters per floor (total length = 30 meters), cross-sectional area = 0.5 square meters, moment of inertia = 0.02 m⁴, and modulus of elasticity = 25 GPa. Assume the column is pinned at both ends.</p> <p>Problem: A column has an effective length of 5 meters and a cross-sectional area of 2000 mm². The column is made of steel with a yield strength of 250 MPa and a modulus of elasticity of 200 GPa. Using Rankine's formula with an empirical constant (α) of 1/1600, calculate the critical load for the column.</p>
Closure	<ol style="list-style-type: none"> Summarize the Lesson Learning Outcomes and get affirmation from students on these. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ Homework Apply an empirical formula to solve a practical problem involving columns.
Evaluation	<ol style="list-style-type: none"> Slope deflection equations, Distribution factors, Fixing moment equations. Nearpod Quiz on Cloud Computing <p>Spend 5 minutes to evaluate student assimilation of the lesson contents</p>



Lesson Plan No. 25	Course Name: Structural Analysis-II Topic: Analysis of symmetrical portal frames by Kanis method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the behavior of eccentrically loaded columns. b. Calculate stress distribution in eccentrically loaded columns.
Teaching Aids (if any)	a. Diagrams illustrating eccentric loading. b. Stress distribution charts for eccentrically loaded columns.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap previous lessons on columns.Introduce eccentric loading and its impact on column behavior. Development (30 minutes) <ul style="list-style-type: none">Explain eccentric loading and its effects.Discuss the calculation of stress distribution in eccentrically loaded columns.Solve numerical examples involving eccentrically loaded columns. Exercise (5 minutes) – Calculate the stress distribution for a given eccentrically loaded column (take any example from textbook) Problem: A steel column with a cross-sectional area of 1800 mm^2 and a length of 4 meters is subjected to an axial load of 300 kN with an eccentricity of 50 mm. Calculate the maximum and minimum stress in the column section.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 3. Homework Analyze a real-world column subjected to eccentric loading.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 26	Course Name: Structural Analysis-II Topic: Analysis of asymmetrical portal frames by Kanis method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the behavior of laterally loaded columns. b. Apply relevant equations to calculate deflection and stress.
Teaching Aids (if any)	a. Diagrams showing lateral loads on columns. b. Derivation of deflection equations on the board.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">• Discuss different loading conditions for columns.• Introduce lateral loads and their significance. Development (30 minutes) <ul style="list-style-type: none">• Explain the behavior of columns under lateral loads.• Derive equations for deflection and stress in laterally loaded columns.• Solve numerical examples involving lateral loads. Exercise (5 minutes) – Calculate the deflection of a laterally loaded column subjected to the following load conditions: <ul style="list-style-type: none">• Load: $P = 10 \text{ kN}$• Length of the column: $L = 4 \text{ m}$• Moment of inertia of the column's cross-section: $I = 200 \text{ cm}^4$• Modulus of elasticity: $E = 200 \text{ GPa}$ Determine the maximum deflection of the column at the point of loading. Problem: A column with a height of 5 meters is subjected to a lateral load of 15 kN at its midpoint. The column has a moment of inertia of $100 \times 10^6 \text{ mm}^4$ and a modulus of elasticity of 210 GPa. Calculate the maximum deflection of the column.
Closure	<ol style="list-style-type: none">1. Summarize the Lesson Learning Outcomes and get affirmation from students on these.2. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/3. Homework "Given a column with a height of 4 meters, a moment of inertia of $1 \times 10^{-6} \text{ m}^4$ and subjected to a lateral load of 500 N at the top, calculate the deflection of the column at the top under the given load, assuming it is fixed at the base."
Evaluation	<ol style="list-style-type: none">1. Slope deflection equations, Distribution factors, Fixing moment equations.2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 27	Course Name: Structural Analysis-II Topic: Analysis of three hinged parabolic arches.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the principle of virtual work. b. Apply the principle to calculate deflections in structural systems.
Teaching Aids (if any)	a. Visual aids illustrating the principle of virtual work. b. Step-by-step derivation of virtual work equations.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap basic concepts in structural analysis.Introduce the principle of virtual work and its relevance. Development (30 minutes) <ul style="list-style-type: none">Explain the principle of virtual work in detail.Derive equations for calculating deflections using virtual work.Solve examples involving the application of virtual work to calculate deflections. Exercise (5 minutes) – Calculate the deflection of a truss joint using the principle of virtual work. Problem: Calculate the vertical deflection at the joint of a simple determinate truss using the principle of virtual work. The truss is loaded with a vertical force of 10 kN at the joint. The length of each member is 4 meters, and the modulus of elasticity is 200 GPa.
Closure	<ol style="list-style-type: none">Summarize the Lesson Learning Outcomes and get affirmation from students on these.Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/Homework To illustrate the application of the principle of virtual work to analyze a frame, let's consider a simple example. Assume we have a frame with the following configuration: Frame Description: <ul style="list-style-type: none">Frame Type: Simply supported at A and B.Dimensions: Length of the horizontal beam = L, height of the vertical member = h.Loads:<ul style="list-style-type: none">Vertical point load PPP applied at the midpoint of the beam.Vertical point load FFF applied at the top of the vertical member.E: Young's modulus of the material.I: Moment of inertia of the beam. Determine the deflection at the point of load PPP using the principle of virtual work



Evaluation

1. Slope deflection equations, Distribution factors, Fixing moment equations.
 2. Nearpod Quiz on Cloud Computing
- Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 28	Course Name: Structural Analysis-II Topic: Analysis of three hinged circular arches.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the principle of virtual work. b. Apply the principle to calculate deflections in structural systems.
Teaching Aids (if any)	a. Visual aids illustrating Maxwell's reciprocal theorem. b. Examples of reciprocal forces in structures.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap the principle of virtual work.Introduce Maxwell's reciprocal theorem and its application. Development (30 minutes) <ul style="list-style-type: none">Explain Maxwell's reciprocal theorem in detail.Derive relevant equations and apply them to solve structural deflection problems.Solve examples involving reciprocal forces. Exercise (5 minutes) –Analyze the deflection in a structure using Maxwell's reciprocal theorem. Problem: For a simple beam supported at both ends with a length of 6 meters, apply Maxwell's reciprocal theorem to calculate the deflection at the midpoint due to a 20 kN load applied 2 meters from one end.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 3. Homework Apply Maxwell's reciprocal theorem to analyze deflection in a truss.
Evaluation	1. Reflective Questions (What, why, Who?). Allow students to answer and discuss. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 29	Course Name: Structural Analysis-II Topic: Analysis of two hinged parabolic arches.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: a. Understand the first theorem of Castigliano. b. Apply Castigliano's theorem to calculate deflections in structures.
Teaching Aids (if any)	a. Visual aids illustrating Maxwell's reciprocal theorem. b. Examples of reciprocal forces in structures.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap previous methods for deflection calculation.Introduce Castigliano's first theorem. Development (30 minutes) <ul style="list-style-type: none">Explain the first theorem of Castigliano in detail.Derive relevant equations.Solve examples involving the application of the theorem to calculate deflections in trusses and frames. Exercise (5 minutes) –Apply Castigliano's theorem to solve a deflection problem in a given truss (Take an example of truss from a textbook) Problem: Using Castigliano's theorem, calculate the horizontal deflection at the top of a triangular truss subjected to a horizontal load of 15 kN at the top joint. The length of each truss member is 3 meters, and the modulus of elasticity is 210 GPa.
Closure	1. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 2. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 3. Homework Apply the first theorem of Castigliano to solve a deflection problem in a frame.
Evaluation	1. Slope deflection equations, Distribution factors, Fixing moment equations. 2. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 30	Course Name: Structural Analysis-II Topic: Analysis of frames by portal method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: d. Understand the basic concepts of columns and struts. e. Differentiate between short and long columns. f. Recognize the importance of columns and struts in structural design.
Teaching Aids (if any)	c. Diagrams showing different types of columns and struts. d. Interactive simulation to visualize column buckling.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">• Discuss the role of columns and struts in structures.• Engage students with questions about the behavior of columns under load. Development (30 minutes) <ul style="list-style-type: none">• Define columns and struts.• Explain the difference between short and long columns.• Discuss the factors affecting the behavior of columns. Exercise (5 minutes) – Identify and classify given examples as short or long columns. Problem: A 3-meter-long steel column with a cross-sectional area of 1500 mm ² is subjected to an axial load of 250 kN. Determine whether the column should be considered short or long, given that the critical slenderness ratio for the material is 50.
Closure	4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 6. Homework Identify different types of columns and struts in a building near you.
Evaluation	3. Slope deflection equations, Distribution factors, Fixing moment equations. 4. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 31	Course Name: Structural Analysis-II Topic: Analysis of frames by cantilever method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: c. Understand Euler's theory of columns. d. Apply Euler's formula to calculate critical loads for different types of columns.
Teaching Aids (if any)	c. Graphical representation of buckling modes. d. Derivation of Euler's formula on the board.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none"> Review the concept of long columns. Introduce Euler's theory as a fundamental concept in column analysis. Development (30 minutes) <ul style="list-style-type: none"> Derive Euler's formula for critical load. Explain the assumptions and limitations of Euler's theory. Solve examples of critical load calculations using Euler's formula. Exercise (5 minutes) – Calculate the critical load for a given column using Euler's formula. Problem: Determine the critical load for a steel column with an effective length of 4 meters and a radius of gyration of 50 mm. The modulus of elasticity of steel is 200 GPa.
Closure	4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/111/107/111107103/ 6. Homework Derive Euler's formula for different boundary conditions.
Evaluation	3. Slope deflection equations, Distribution factors, Fixing moment equations. 4. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No.32	Course Name: Structural Analysis-II Topic: Introduction to portal method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: c. Understand the concept of effective length. d. Determine the effective length for different column boundary conditions.
Teaching Aids (if any)	c. Charts showing effective lengths for various boundary conditions. d. Visual aids for different column end conditions.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap Euler's formula.Introduce the concept of effective length in columns. Development (30 minutes) <ul style="list-style-type: none">Explain effective length and its significance.Discuss different end conditions and their impact on effective length.Solve examples to calculate effective length for various cases. Exercise (5 minutes) – Calculate the effective length for a column with given end conditions. <ul style="list-style-type: none">Pinned-Pinned (Hinged-Hinged)Fixed-FixedPinned-Fixed (Hinged-Fixed)Fixed-Free (Cantilever) Problem: A column with a length of 6 meters is pinned at both ends. Calculate its effective length and determine the critical load using Euler's formula, given that the column has a radius of gyration of 70 mm and the modulus of elasticity is 210 GPa.
Closure	4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 6. Homework Determine the effective length for columns with different end conditions in a building.
Evaluation	3. Slope deflection equations, Distribution factors, Fixing moment equations. 4. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 33	Course Name: Structural Analysis-II Topic: Introduction to cantilever method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: c. Understand the concept of effective length. d. Determine the effective length for different column boundary conditions.
Teaching Aids (if any)	c. Derivation of empirical formulae on the board. d. Examples of empirical formulae application in industry.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Review effective length and critical load.Introduce the need for empirical formulae in column design Development (30 minutes) <ul style="list-style-type: none">Discuss various empirical formulae like Rankine's formula.Explain the assumptions and limitations of each formula.Provide examples and solve numerical problems using empirical formulae. Exercise (5 minutes) – Calculate the critical load for a given column in a 10-storey building using an empirical formula. The column has the following parameters: length = 3 meters per floor (total length = 30 meters), cross-sectional area = 0.5 square meters, moment of inertia = 0.02 m ⁴ , and modulus of elasticity = 25 GPa. Assume the column is pinned at both ends. Problem: A column has an effective length of 5 meters and a cross-sectional area of 2000 mm ² . The column is made of steel with a yield strength of 250 MPa and a modulus of elasticity of 200 GPa. Using Rankine's formula with an empirical constant (α) of 1/1600, calculate the critical load for the column.
Closure	4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 6. Homework Apply an empirical formula to solve a practical problem involving columns.
Evaluation	3. Slope deflection equations, Distribution factors, Fixing moment equations. 4. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 34	Course Name: Structural Analysis-II Topic: Introduction to Stiffness and Flexibility method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: c. Understand the behavior of eccentrically loaded columns. d. Calculate stress distribution in eccentrically loaded columns.
Teaching Aids (if any)	c. Diagrams illustrating eccentric loading. d. Stress distribution charts for eccentrically loaded columns.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap previous lessons on columns.Introduce eccentric loading and its impact on column behavior. Development (30 minutes) <ul style="list-style-type: none">Explain eccentric loading and its effects.Discuss the calculation of stress distribution in eccentrically loaded columns.Solve numerical examples involving eccentrically loaded columns. Exercise (5 minutes) – Calculate the stress distribution for a given eccentrically loaded column (take any example from textbook) Problem: A steel column with a cross-sectional area of 1800 mm ² and a length of 4 meters is subjected to an axial load of 300 kN with an eccentricity of 50 mm. Calculate the maximum and minimum stress in the column section.
Closure	4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 6. Homework Analyze a real-world column subjected to eccentric loading.
Evaluation	3. Slope deflection equations, Distribution factors, Fixing moment equations. 4. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 35	Course Name: Structural Analysis-II Topic: Analysis of continuous beams when supports are at same level.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: <ul style="list-style-type: none"> c. Understand the behavior of laterally loaded columns. d. Apply relevant equations to calculate deflection and stress.
Teaching Aids (if any)	<ul style="list-style-type: none"> c. Diagrams showing lateral loads on columns. d. Derivation of deflection equations on the board.
Teaching Development	<p>Introduction (5 minutes)</p> <ul style="list-style-type: none"> • Discuss different loading conditions for columns. • Introduce lateral loads and their significance. <p>Development (30 minutes)</p> <ul style="list-style-type: none"> • Explain the behavior of columns under lateral loads. • Derive equations for deflection and stress in laterally loaded columns. • Solve numerical examples involving lateral loads. <p>Exercise (5 minutes) – Calculate the deflection of a laterally loaded column subjected to the following load conditions:</p> <ul style="list-style-type: none"> • Load: $P = 10 \text{ kN}$ • Length of the column: $L = 4 \text{ m}$ • Moment of inertia of the column's cross-section: $I = 200 \text{ cm}^4$ • Modulus of elasticity: $E = 200 \text{ GPa}$ <p>Determine the maximum deflection of the column at the point of loading.</p> <p>Problem: A column with a height of 5 meters is subjected to a lateral load of 15 kN at its midpoint. The column has a moment of inertia of $100 \times 10^6 \text{ mm}^4$ and a modulus of elasticity of 210 GPa. Calculate the maximum deflection of the column.</p>
Closure	<ol style="list-style-type: none"> 4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 6. Homework "Given a column with a height of 4 meters, a moment of inertia of $1 \times 10^{-6} \text{ m}^4$ and subjected to a lateral load of 500 N at the top, calculate the deflection of the column at the top under the given load, assuming it is fixed at the base."
Evaluation	<ol style="list-style-type: none"> 3. Slope deflection equations, Distribution factors, Fixing moment equations. 4. Nearpod Quiz on Cloud Computing <p>Spend 5 minutes to evaluate student assimilation of the lesson contents</p>



Lesson Plan No. 36	Course Name: Structural Analysis-II Topic: Analysis of symmetrical portal frames by Stiffness method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: c. Understand the principle of virtual work. d. Apply the principle to calculate deflections in structural systems.
Teaching Aids (if any)	c. Visual aids illustrating the principle of virtual work. d. Step-by-step derivation of virtual work equations.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap basic concepts in structural analysis.Introduce the principle of virtual work and its relevance. Development (30 minutes) <ul style="list-style-type: none">Explain the principle of virtual work in detail.Derive equations for calculating deflections using virtual work.Solve examples involving the application of virtual work to calculate deflections. Exercise (5 minutes) – Calculate the deflection of a truss joint using the principle of virtual work. Problem: Calculate the vertical deflection at the joint of a simple determinate truss using the principle of virtual work. The truss is loaded with a vertical force of 10 kN at the joint. The length of each member is 4 meters, and the modulus of elasticity is 200 GPa.
Closure	4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 6. Homework To illustrate the application of the principle of virtual work to analyze a frame, let's consider a simple example. Assume we have a frame with the following configuration: Frame Description: <ul style="list-style-type: none">Frame Type: Simply supported at A and B.Dimensions: Length of the horizontal beam = L, height of the vertical member = h.Loads:<ul style="list-style-type: none">Vertical point load PPP applied at the midpoint of the beam.Vertical point load FFF applied at the top of the vertical member.E: Young's modulus of the material.I: Moment of inertia of the beam. Determine the deflection at the point of load PPP using the principle of virtual work



Evaluation

3. Slope deflection equations, Distribution factors, Fixing moment equations.
 4. Nearpod Quiz on Cloud Computing
- Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 37	Course Name: Structural Analysis-II Topic: Analysis of asymmetrical portal frames by Stiffness method.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: c. Understand the principle of virtual work. d. Apply the principle to calculate deflections in structural systems.
Teaching Aids (if any)	c. Visual aids illustrating Maxwell's reciprocal theorem. d. Examples of reciprocal forces in structures.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap the principle of virtual work.Introduce Maxwell's reciprocal theorem and its application. Development (30 minutes) <ul style="list-style-type: none">Explain Maxwell's reciprocal theorem in detail.Derive relevant equations and apply them to solve structural deflection problems.Solve examples involving reciprocal forces. Exercise (5 minutes) –Analyze the deflection in a structure using Maxwell's reciprocal theorem. Problem: For a simple beam supported at both ends with a length of 6 meters, apply Maxwell's reciprocal theorem to calculate the deflection at the midpoint due to a 20 kN load applied 2 meters from one end.
Closure	4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 6. Homework Apply Maxwell's reciprocal theorem to analyze deflection in a truss.
Evaluation	3. Reflective Questions (What, why, Who?). Allow students to answer and discuss. 4. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents



Lesson Plan No. 38	Course Name: Structural Analysis-II Topic: Analysis of continuous beams by Flexibility method when supports are at same level.	Course No.: CE-401
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Objectives	At the end of the lesson the student shall be able to: c. Understand the first theorem of Castigliano. d. Apply Castigliano's theorem to calculate deflections in structures.
Teaching Aids (if any)	c. Visual aids illustrating Maxwell's reciprocal theorem. d. Examples of reciprocal forces in structures.
Teaching Development	Introduction (5 minutes) <ul style="list-style-type: none">Recap previous methods for deflection calculation.Introduce Castigliano's first theorem. Development (30 minutes) <ul style="list-style-type: none">Explain the first theorem of Castigliano in detail.Derive relevant equations.Solve examples involving the application of the theorem to calculate deflections in trusses and frames. Exercise (5 minutes) –Apply Castigliano's theorem to solve a deflection problem in a given truss (Take an example of truss from a textbook) Problem: Using Castigliano's theorem, calculate the horizontal deflection at the top of a triangular truss subjected to a horizontal load of 15 kN at the top joint. The length of each truss member is 3 meters, and the modulus of elasticity is 210 GPa.
Closure	4. Summarize the Lesson Learning Outcomes and get affirmation from students on these. 5. Suggested Reading https://archive.nptel.ac.in/courses/105/105/105105162/ 6. Homework Apply the first theorem of Castigliano to solve a deflection problem in a frame.
Evaluation	3. Slope deflection equations, Distribution factors, Fixing moment equations. 4. Nearpod Quiz on Cloud Computing Spend 5 minutes to evaluate student assimilation of the lesson contents