SAHRDAYA AUTONOMOUS
COLLEGE OF ENGINEERING & TECHNOLOGY
A CENTRE OF EXCELLENCE IN SCIENCE & TECHNOLOGY | MANAGED BY IRINJALAKUDA DIOCESAN EDUCATION TRUST
Approved by AICTE & Affiliated to APJ Abdul Kalam Technological University | Accredited by:
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B. Tech

Curriculum and Syllabus (2024) - Semester III & IV

Civil Engineering

Branch Code: CE

(SHR/AC/Auto/ Acad. Council /B.Tech/3/Syll./CE/S3-S4)

Recommended by BoS on 17/06/2025

Approved by Academic Council on 05/07/2025

THIRD SEMESTER (July-December)												
Sl. No:	**Slot**	**Course Code**	**Course Type**	**Course Title (Course Name)**	**Credit Structure**				**Total Marks**		**Credits**	**Hrs/ Week**
					L	**T**	**P**	**R**	**CIA**	**ESE**		
1	A	24MAT331	BSC	Probability Distributions, Statistical Inference & Numerical Methods	3	0	0	0	40	60	3	3
2	B	24CET302	PCC	Structural Analysis I	3	1	0	0	40	60	4	4
3	C	24CET303	PCC	Fluid Mechanics	3	1	0	0	40	60	4	4
4	D	24CER304	PCC-PBL	Concrete Technology and Building Planning	3	0	0	1	50	50	4	4
5	E	24HUT005	HMC	Engineering Economics	2	0	0	0	50	50	2	2
6	F	24EST306	ESC	Applied Data Science & Artificial Intelligence	3	1	0	0	40	60	4	4
7	L	24CEL307	PCL	Survey Lab	0	0	3	0	50	50	2	3
8	Q	24CEL308	PCL	Computer Aided Building Drawing Lab	0	0	3	0	50	50	2	3
9	J*	24SEK10N	SEC	Skill Enhancement Course3							1	
10	R/ M	24CEG3XX	VAC	Remedial/Minor							4*	4*
Total											**26/ 30***	**27/ 31***

FOURTH SEMESTER (January-June)												
Sl. No:	**Slot**	**Course Code**	**Course Type**	**Course Title (Course Name)**	**Credit Structure**				**Total Marks**		**Credits**	**Hrs./ Week**
					L	**T**	**P**	**R**	**CIA**	**ESE**		
1	A	24MAT431	BSC	Partial Differential Equations and Operational Research Techniques	3	0	0	0	40	60	3	3
2	B	24CET402	PCC	Structural Analysis II	3	1	0	0	40	60	4	4
3	C	24CET403	PCC	Soil Mechanics	4	0	0	0	40	60	4	4
4	D	24CER404	PCC-PBL	Water Resource Engineering	3	0	0	1	50	50	4	4
5	F	24CEE41N	PE	PE-1	3	0	0	0	40	60	3	3
6	L	24CEL406	PCL	Materials Testing Lab I	0	0	3	0	50	50	2	3
7	Q	24CEL407	PCL	Fluid Mechanics Lab	0	0	3	0	50	50	2	3
8	I*	24PWT208	PW	UHV II, Life skills & Community work	1	0	0	0	100	-	1	1
9	J*	24SEK10N	SEC	Skill Enhancement Course 4							1	
10	R/M	24CEG4XX/ 24CEH4XX	VAC	Remedial/Minor/Honours							4*	4*
Total											**24/ 28***	**25/ 29***

No Grade Points will be awarded for the MOOC, I and J slot courses.
The self-learning (S) hours for each course is calculated based on the formula,
S= (L*1.5+T*0.5+P*0.5+R*1)

PROGRAM ELECTIVE I: 24CEE41N

SLOT	COURSE CODE	COURSES	L-T-P-R	HOURS	CREDIT
F	24CEE411	Advanced Mechanics of Solids	**3-0-0-0**	3	**3**
	24CEE412	Engineering Geology	**3-0-0-0**		**3**
	24CEE413	Open Channel Hydraulics	**3-0-0-0**		**3**
	24CEE414	Environmental Impact Assessment	**3-0-0-0**		**3**
	24CEE415	Environmental Science	**3-0-0-0**		**3**
	24CEE416	Advanced Concrete Technology	**3-0-0-0**		**3**
	24CEE417	Numerical Methods for Engineers	**3-0-0-0**		**3**
	24CEE418	Submission drawing preparation for buildings#	**3-0-3-0**	**6**	**5**

#- Higher credit elective

SEMESTER-III
SYLLABUS

24MAT331	PROBABILITY DISTRIBUTIONS, STATISTICAL INFERENCE & NUMERICAL METHODS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:

This course provides a foundation in probabilistic modeling, statistical inferences, and numerical methods, enabling students to address complex real-world problems with confidence and precision. Also these concepts help civil engineers to analyze data, model uncertainties, and design reliable and efficient systems, preparing them to address real-world challenges in various domains of civil engineering.

Prerequisite: Basics of statistics and probability laws, Fundamentals of differentiation and integration.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop the ability to model and analyze real-world situations involving uncertainty using discrete probability distributions. **[Apply]**
CO 2	Apply continuous probability distributions, such as the Normal and Exponential distributions, to solve practical problems in engineering and science. **[Apply]**
CO 3	Apply the principles of statistical inference to formulate and test hypotheses, enabling evidence-based decision-making in practical scenarios. **[Apply]**
CO 4	Utilize numerical methods to differentiate and integrate multi-variable functions, extending their application to advanced engineering models. **[Apply]**

CO - PO MAPPING

CO	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	3	2	2						
CO 2	3	2	2	2							
CO 3	3	2	2	2							
CO 4	3	2	3		2						

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze				
Evaluate				
Create				

Mark Distribution of CIA					
Course Structure [L-T-P-R]	**Attendance**	**Theory [L]**			**Total Marks**
		Assignment	**Test-1**	**Test-2**	
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hours

End Semester Examination [ESE]			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions (2 Questions from each module), each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of two sub divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: DISCRETE PROBABILITY DISTRIBUTIONS [9 hours]

(Text 1: Relevant topics from sections 3.1,3.2,3.3,3.4,3.6)

Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the Binomial distribution.

Self-Study (13 hours):

1. A chip manufacturer produces defects with probability p=0.01. In a batch of 500 chips:
   (a) Compute the exact Binomial probability of 5 defects.
   (b) Approximate it using the Poisson distribution.
   (c) Compare the results.
2. Compare exact Binomial probabilities with Poisson approximations for different (n, p) values.
3. Implement simulations (using Python/MATLAB) for Binomial and Poisson distributions.
4. A server receives an average of 3 requests per second.
   (a) Find the probability of receiving 5 requests in 2 seconds.
   (b) If the server crashes when it gets ≥10 requests in 3 seconds, what is the crash probability?

MODULE II: CONTINUOUS PROBABILITY DISTRIBUTIONS [9 hours]

(Text 1: Relevant topics from sections 4.1,4.2,4.3,4.4)

Continuous random variables and their probability distributions, Cumulative distribution function, Expectation, mean, and variance, exponential and normal distributions.

Self Study (14 hours):

1. Derive mean and variance of uniform distribution.
2. Prove the memoryless property of the Exponential Distribution.
3. A batch of chips has lifetimes X~N(8yrs,1.52). The warranty covers chips failing within 5 years.
   (a) What percentage will the manufacturer replace?
   (b) To reduce replacements to 1%, what should the mean lifetime μ be (fixing σ=1.5)?
4. A machine produces bolts with diameters X~N(5mm,0.022) . Bolts are rejected if X<4.95mm or X>5.05mm.
   (a) Find the rejection probability.
   (b) If 1000 bolts are made, how many are within tolerance?

MODULE III: STATISTICAL INFERENCE [9 hours]

(Text 1: Relevant topics from sections 7.1,7.2,7.3,8.1,8.2,8.3,8.4)

Confidence Intervals, Confidence Level, One-side confidence intervals for a Population Mean for large and small samples (normal distribution and t-distribution), Hypotheses and Test Procedures, Type I and Type II error, z Tests for Hypotheses about a Population Mean (for large sample), t Test for Hypotheses about a Population Mean (for small sample), Tests concerning a population proportion for large and small samples.

Self Study (13 hours):

1. A drug claims to reduce blood pressure by 10 mmHg. A sample of 25 patients shows $\bar{x}$ =8 mmHg, s=3 mmHg. Test efficiency at α=0.05(one-sided t-test).
2. A sample of 64 batteries has a mean lifespan of 120 hours and a standard deviation of 20 hours.
   (a) Construct a 95% CI for the true mean lifespan.
   (b) How does the width change if we increase the confidence level to 99%?
3. A manufacturer claims bolts have μ≥40 Nm strength. A sample of 50 bolts has $\bar{x}$=38.5 Nm, σ=5. Test at α=0.05 using a z-test.
4. For a test H0: μ=50 vs. H1: μ>50:
   (a) Describe a Type I error in context.
   (b) If α=0.05, what is the critical value for n=36, σ=10?

MODULE IV: NUMERICAL DIFFERENTIATION AND INTEGRATION [9 hours]

(Text 2: Relevant topics from sections 19.3, 19.5, 21.1)

Newton's forward and backward interpolation method, Lagrange's interpolation method, Solution of ordinary differential equations- Euler and Classical Runge- Kutta method of second and fourth order, Numerical integration- Trapezoidal rule and Simpsons rule.

Self Study (14 hours):

1. For $f(x)=\ln(x)$, use points at x=1,2,3,4 to approximate ln (1.5)
2. Given points (1,2), (2,5), (4,17), find the Lagrange polynomial and estimate f (3).
3. Compute $\int_1^3 \frac{1}{x}dx$ using Simpson's 1/3 rule with n=4.
4. Apply **RK4** to $\frac{dy}{dx} = -2xy, y(0) = 1$ to estimate y (0.4) with h=0.2.

Text books

1. Devore J. L., Probability and Statistics for Engineering and Sciences, Cengage learning, 9th edition.
2. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 10th Edition, 2016.

Reference books

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 42nd Edition, 2012.
2. Steven C Chapra, Raymond P.Canale, Numerical methods for Engineers, McGraw-Hill education ,8th Edition,2021.
3. Papoulis, A. & Pillai, S.U., Probability, Random Variables and Stochastic Processes, McGraw Hill. 4th Edition,2002.
4. Ross, S. M., Introduction to Probability and Statistics for Engineers and Scientists, Academic Press, 6th Edition,2020.

NPTEL/SWAYAM Courses for reference:

1.Probability and random process by Prof. Mrityunjoy Chakraborty IIT Kharagpur
https://archive.nptel.ac.in/courses/117/105/117105085/

2. Numerical Methods by Prof. Ameeya Kumar Nayak, Prof. Sanjeev Kumar, IIT Roorkee
NPTEL :: Mathematics - NOC:Numerical methods

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36]
	MODULE 1 [9 hours]	
1.1	Discrete random variables	1
1.2	Probability distributions of Discrete random variables	1
1.3	Expectation, Mean	1
1.4	Variance	1
1.5	Binomial Distribution	1
1.6	Poisson Distribution	2
1.7	Poisson approximation to the binomial distribution	2
	MODULE II [9 hours]	
2.1	Continuous random variables	1
2.2	Probability distributions of Continuous random variables	1

2.3	Cumulative distribution function	1
2.4	Expectation, mean	2
2.5	Variance	1
2.6	Exponential distributions	1
2.7	Normal distributions	2
MODULE III [9 hours]		
3.1	Confidence Intervals, Confidence Level	1
3.2	One-side confidence intervals for a Population Mean for large and small samples (normal distribution and t-distribution)	2
3.3	Hypotheses and Test Procedures	1
3.4	Type I and Type II error	1
3.5	z Tests for Hypotheses about a Population Mean (for large sample)	2
3.6	t Test for Hypotheses about a Population Mean (for small sample)	1
3.7	Tests concerning a population proportion for large and small samples.	1
MODULE IV [9 hours]		
4.1	Newton's forward & backward interpolation method	2
4.2	Lagrange's interpolation method	1
4.3	Solution of ordinary differential equations-Euler method	1
4.4	Solution of ordinary differential equations- Classical Runge-Kutta method of second order	1
4.5	Solution of ordinary differential equations-Kutta method of fourth order	2
4.6	Numerical integration-Trapezoidal rule	1
4.7	Numerical integration- Simpson's rule	1
CO Assessment Questions		
CO 1	1. A problem in Mechanics is given to three students A, B, C whose chances of solving they are ½ , 1/3 and ¼ respectively. What is the probability that the problem will be solved. **(Apply)** 2. If a random variable has a Poisson distribution such that P(1) = P(2) then find mean of the distribution and P(4) **(Apply)** **Team Work**: A company launches a new email marketing campaign. Based on past data, there's a 20% chance that any given customer will respond positively to the email. If the company sends the email to 15 customers. **(Apply)** (i) What is the probability that exactly 3 customers respond positively? (ii) What is the probability that at most 2 customers respond positively? (iii) How would the probability change if the success rate increased to 30%?	

CO 2	1. The lifetime (in hours) of a water pump used at a construction site follows an exponential distribution with a mean lifetime of 2000 hours. **(Apply)** (i) What is the probability that a pump fails before 1000 hours? (ii) What is the probability that a pump operates for more than 3000 hours without failure? 2. The compressive strength of concrete cylinders produced at a construction site follows a normal distribution with a mean strength of 30 MPa and a standard deviation of 4 MPa. **(Apply)** (i) What is the probability that a randomly selected cylinder will have a strength greater than 34 MPa? (ii) If the design requires that at least 95% of the concrete cylinders have a strength greater than a certain value, what is the minimum required strength? **Team Work:** The amount of rainfall (in cm) during a storm at a construction site is modelled as a continuous random variable X with the following probability density function (PDF): (i) Verify whether f(x) is a valid probability density function. (ii) What is the probability that the rainfall during a storm is less than 2 cm? (iii) What is the probability that the rainfall is between 1 cm and 3 cm? Compare the answer of (ii) when rainfall is less than 3cm. and compare the answer of (iii) when rainfall is between 1.5cm and 3.5cm. **(Apply)**
CO 3	1. A coin was tossed 400 times and the head turned up 216 times. Test the hypothesis that the coin is unbiased at 5% level of significance. **(Apply)** 2. A Mechanist is making engine parts with axle diameter of 0.7 inch. A random sample of 10 parts shows mean diameter 0.742 inch with a standard deviation of 0.04 inch. On the basis of of this sample, would you say that the work is inferior? **(Apply)** **Team Work**: A sample of 100 electric bulbs produced by manufacturer A showed a mean life time of 1190 hours and a standard deviation of 90 hours. A sample of 75 bulbs produced by manufacturer B showed a mean life time of 1230 hours with a standard deviation of 120 hours. Is there a difference between the mean life time of two brands? Compare the answers at two different significant levels and comment on the quality of manufactures A and B.

CO 4	1. Using Newton's method of interpolation find sin 520 from the data given below. when sin 450 = 0.7071, sin 500 = 0.7660, sin 550 = 0.8192, sin 600 = 0.8660? **(Apply)** 2. From the following data find log 656 **(Apply)** No. : 654 658 659 661 Log : 2.8156 2.8182 2.8189 2.8202 3. Use Trapezoidal rule to estimate the integral $\int_0^2 e^{x^2} dx$ taking 10 intervals. **Team Work:** Solve the ODE $\frac{dy}{dt} = -2y + e^{-t}, y(0) = 1, t \in [0, 5]$ using Runga Kutta method of 4th order (step size= h = 0.1) and compare the answer obtained using MATLAB's ODE solver. **(Apply)**

Prepared by
Anu Jose
Asst. Prof., ASH

24CET302	STRUCTURAL ANALYSIS I	L	T	P	R	C	Year of Introduction
		3	1	0	0	4	2024

Preamble:
The course enables the students to analyze various types of simple structures using appropriate methods and tools. It introduces the applications of principles of mechanics of solids to determine stress resultants in statically determinate and indeterminate structures. Specific cases of cables, suspension bridges and arches are also discussed at length. After this course students will be able to analyze structures subjected to moving loads as well.

Prerequisite: 24EST205 - Mechanics of Solids

Course Outcomes: After the completion of the course the student will be able to

CO1	Apply appropriate structural mechanics principles for estimation of force and deformation response of structural elements. **(Apply)**
CO2	Apply energy-based techniques for estimation of deformation response of structural elements and simple structural systems. **(Apply)**
CO3	Analyze statically determinate structures using displacement methods. **(Analyze)**
CO4	Analyze the effects of moving loads on structures using influence lines. **(Analyze)**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3									2
CO2	3	3			2						2
CO3	3	3			3						2
CO4	3	3			3						2

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√		√
Understand	√	√		√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate				
Create				

Mark Distribution of CIA					
Course Structure [L-T-P-R]	**Attendance**	**Theory [L-T]**			**Total Marks**
		Assignment	**Test-1**	**Test-2**	
3-1-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hours

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Mark**
PATTERN 1	2 Questions from each module. Total of 8 Questions, Each carrying 3 marks. (8x3 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 subdivisions. Each question carries 9 marks. (4x9 = 36 marks)	60

SYLLABUS

MODULE I: STATICALLY DETERMINATE TRUSSES, CABLES AND SUSPENSION BRIDGES (12 Hours)

Statically determinate trusses- Analysis using method of joints and method of sections.

Cables and Suspension bridges- Forces in loaded (concentrated and uniformly distributed) cables - length of cables – supports at same and different levels – maximum tension in the suspension cable and backstays, pressure on towers.

Simple suspension bridges with three hinged stiffening girders - bending moments and shear force diagrams.

Self-study (18hrs):

Q1. Using either STAAD.Pro or SAP2000, model a statically determinate truss with given dimensions and loading.

- Submit the model screenshots.
- Compare the software-generated member forces with your manual calculations using the method of joints or method of sections.
- Explain any discrepancies.

Q2. Choose a real-world example of a truss or suspension bridge failure (e.g., Quebec Bridge, Tacoma Narrows, or a local structure).
- Discuss the cause of failure and structural design lessons learned.
- Suggest how modern analysis methods could have helped prevent it.

Q3. A suspension bridge with a span of 120 m carries a uniformly distributed load of 30 kN/m. The supports are at the same level and the central dip is 12 m.
- Calculate the maximum tension in the cable.
- Determine the horizontal and vertical reactions at the supports.

MODULE II: DEFORMATION RESPONSE OF STATICALLY DETERMINATE BEAMS, ENERGY PRINCIPLES AND ENERGY THEOREMS (12 Hours)

Deformation Response of Statically Determinate Beams- Moment area method – Applications to determinate deformations of cantilever and simply supported beams subjected to concentrated and uniformly distributed loads.

Energy Principles and Energy Theorems- Castigliano's theorem I with problems, Principle of virtual work, Betti's theorem, Maxwell's law of reciprocal deflections.

Unit load method for determination of deflection of statically determinate beams, frames and trusses.

Self-study (18hrs):

Q1. Using the moment area method, calculate the slope at the supports and the deflection at midspan of a simply supported beam with different loading conditions.
- Show all steps and explain the significance of the theorems used.

Q2. Use unit load method for finding the deflection of trusses.
- Verify results with software.

Q3. State and prove Betti's Theorem and Maxwell's Law of Reciprocal Deflections.
- Illustrate both with a beam or truss example.

Q4. Model a simply supported beam in SAP2000 or ANSYS with a point load and UDL.
- Extract the deflection values and compare with results from the Castigliano's Theorem.
- Comment on deviations and modelling assumptions.

MODULE III: CONCEPT OF DISPLACEMENT APPROACH TO STRUCTURAL ANALYSIS (12 Hours)

Introduction to displacement methods of analysis- Kinematic indeterminacy.

Slope Deflection Method- Analysis of continuous beams and portal frames without sway. Frames with sway and settlement effects (illustration only).

Moment Distribution Method- Analysis of beams and frames – non sway analysis. Sway analysis (illustration only).

Self-study (18hrs):

Q1. A pedestrian bridge in your campus consists of a two-span continuous beam, fixed at one end and simply supported at the other, with a central point load on each span. Use the slope-deflection method to compute the end moments at each support.

Q2. Use the same bridge scenario from Q1.

- Model it in STAAD.Pro, SAP2000, or any equivalent software as a continuous beam.
- Compare support moments and deflected shape with your manual solution.

Q3. Consider three structures often used in residential buildings and determine the Kinematic indeterminacy.

1. A cantilever balcony beam
2. A rigid L-shaped portal frame for a car porch
3. A fixed-fixed frame over a small shopfront.

Q4. Assume you're designing a two-storey frame for a small commercial building, each bay X m wide and Y m tall. The roof carries a uniform live load of Z kN/m.

- Apply the moment distribution method to calculate moments at key joints (e.g., beam-column connections) for one storey.
- Use approximate fixed-end moment values.
- Create a simple Excel sheet or manual table to show carry-over and distribution.
- Explain the moment balancing logic in your own words.

MODULE IV: THREE HINGED ARCHES, MOVING LOADS AND INFLUENCE LINES (12 Hours)

Three Hinged Arches- Action of an arch - Eddy's theorem – Three hinged, parabolic and circular arches (with supports at same level) - determination of horizontal thrust, bending moment, normal thrust and radial shear.

Moving Loads and influence lines - Introduction to moving loads - concept of influence lines - influence lines for reaction, shear force and bending moment in simply supported beams – analysis for different types of moving loads (single concentrated load - uniformly distributed load shorter and longer than the span) conditions for maximum bending moment and shear force.

Self-study (18hrs):

Q1. You're evaluating an old arch masonry bridge for structural safety.

- Apply Eddy's theorem to find the location of the zero bending moment under a specific loading condition (central point load).
- Discuss how this information can help in arch retrofitting or reinforcement design.

Q2. A single-span simply supported bridge of 20 m is subjected to a truck load

modelled as a single 200 kN concentrated load. Calculate the maximum shear force and bending moment due to the moving load. Identify the critical position of the load using influence line logic. Explain practical implications for highway bridge design.

Q3. Manually construct influence lines for a 12 m simply supported beam:

a) Reaction at support A

b) Shear force at 6 m from A

c) Bending moment at midspan

Use software (SkyCiv, STAAD.Pro, or Excel) to generate the same diagrams.

• Compare and discuss differences in slope, curvature, or scaling.

Q4. You're tasked with a preliminary design for an urban footbridge.

• Write a short note on how influence lines and moving load analysis would guide: Placement of supports, Structural member sizing and Load combinations and critical load cases.

Text Books:

1. S.B. Junnarkar & H.J. Shah, Mechanics of Structures Vol I & II, Charotar Publishing House, 2015.
2. S S Bhavikatti, Structural Analysis I, Vikas Publishing House Pvt. LTD, Fourth Edition.
3. Structural Analysis Vol. I, Dr. R. Vaidyanathan, Dr. P. Perumal, Laxmi Publications Pvt LTD, Third Edition.

Reference books

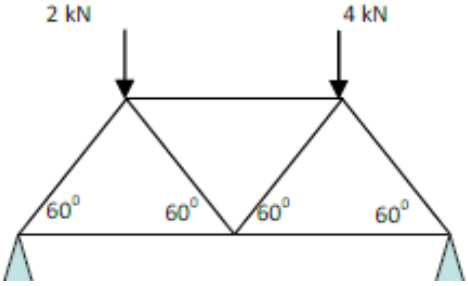
1. C.S. Reddy, Basic Structural Analysis, New Delhi: Tata McGrawHill, New Delhi.
2. Devdas Menon, Structural Analysis, Narosa Publishers, New Delhi.
3. Structural Analysis, L.S. Negi and R.S. Jangid, Tata McGraw Hill.

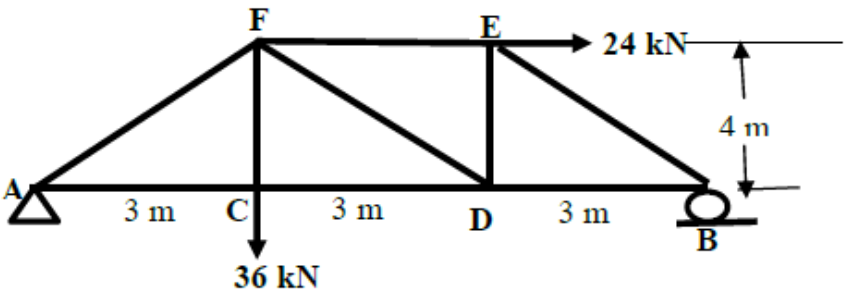
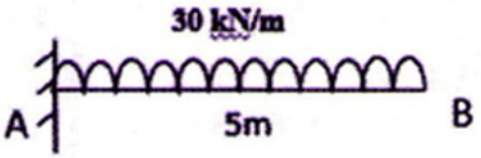
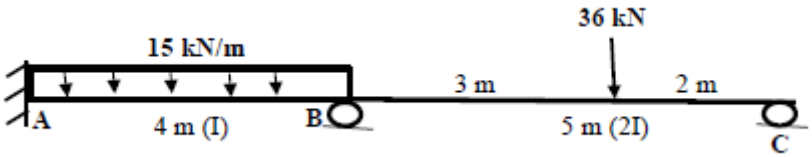
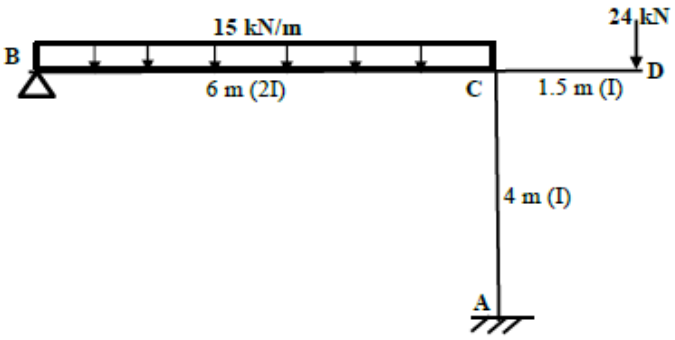
NPTEL/SWAYAM Courses for reference:

1. Structural analysis I, IIT Kharagpur, Prof. Amit Shaw, https://nptel.ac.in/courses/105105166
2. Structural Analysis II, IIT Kharagpur, Prof. L.S. Ramachandra, Prof. Sudhir Kumar Barai, https://nptel.ac.in/courses/105105109

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [48]
	MODULE I (12 Hours)	
1.1	Introduction: Types of support, loading and reaction	1
1.2	Statically determinate trusses: Analysis using method of joints	2

1.3	Statically determinate trusses: Analysis using method of sections.	2
1.4	Cables: Forces in loaded (concentrated and uniformly distributed) cables.	1
1.5	Length of cables.	1
1.6	Supports at same and different levels.	2
1.7	Maximum tension in the suspension cable and backstays, pressure on towers.	1
1.8	Simple suspension bridges with three hinged stiffening girders.	1
1.9	Bending moments and shear force diagrams.	1
MODULE (12 Hours)		
2.1	Deformation Response of Statically Determinate Beams.	1
2.2	Moment area method – Applications to determinate deformations of cantilever beams.	2
2.3	Simply supported beams subjected to concentrated and uniformly distributed loads.	2
2.4	Castigliano's theorem I – Problems.	2
2.5	Principle of virtual work, Betti's theorem, Maxwell's law of reciprocal deflections.	1
2.6	Unit load method for determination of deflection of statically determinate beams.	2
2.7	Unit load method for the analysis of frames and trusses.	2
MODULE III (12 Hours)		
3.1	Introduction to displacement methods of analysis. Kinematic indeterminacy.	2
3.2	Slope Deflection Method: Analysis of continuous beams.	2
3.3	Slope Deflection Method: Analysis of portal frames without sway.	2

3.4	Frames with sway and Settlement effects (illustration only).	1
3.5	Moment Distribution Method: Analysis of beams.	2
3.6	Moment Distribution Method: Analysis of frames – non sway analysis.	2
3.7	Sway analysis (illustration only).	1
MODULE IV (12 Hours)		
4.1	Three Hinged Arches: Action of an arch - Eddy's theorem.	1
4.2	Three hinged, parabolic arche (with supports at same level) - determination of horizontal thrust, bending moment, normal thrust and radial shear.	2
4.3	Three hinged, circular arch (with supports at same level) - determination of horizontal thrust, bending moment, normal thrust and radial shear.	2
4.4	Moving Loads and influence lines- concept of influence lines.	1
4.5	Influence lines for reaction, shear force and bending moment in simply supported beams.	2
4.6	Analysis for different types of moving loads (single concentrated load.	2
4.7	Uniformly distributed load shorter and longer than the span) conditions for maximum bending moment and shear force.	2
CO Assessment Questions		
CO1	1. Find the forces in the members of the truss using method of joints. **(Apply)**  2. A cable is hanging between two supports A and B at a horizontal distance of 60 m. The right support is 5 m below the left support. Two concentrated loads of 45 kN and 60 kN are hanging from points C and D at horizontal distances of 20 m and 40	

	m respectively from support A. Point D is 3 m below support B. Determine the support reactions, cable tensions with its angles and the length of the cable. **(Apply)**
CO2	1. Figure shows a loaded truss of span 9 m. Compute the vertical deflection at D using unit load method. E = 200 GPa and cross sectional area is 750 mm^2 for all the members. **(Apply)**  2. Find the slope and deflection at B of the cantilever beam using moment area method. E = 2 x 10^5 N/mm^2, I = 8500 cm^4 **(Analyze)** 
CO3	1. Figure shows a loaded beam of span 9 m. Analyse using 'Slope Deflection Method', determine the end moments and draw the SFD and BMD. **(Analyze)**  2. Figure shows a loaded frame. Analyse using 'Moment Distribution Method', determine the end moments and draw the BMD. **(Analyze)** 

CO4	**1.** A three-hinged arch of horizontal span AB = 24 m has a rise of 6 m. It is subjected to a uniformly distributed load of 15 kN/m over the left half and a concentrated load of 90 kN at D, 3 m horizontally to the right of the middle hinge C. Analyse and determine the reactions and horizontal thrust. Also determine the bending moment, normal thrust and radial shear at E, 5 m horizontally to the right of left support A. **(Analyze)** **2.** A train of moving loads 100 kN, 80 kN, 60 kN and 120 kN (distance between each load being 2 m) is moving from left to right (100 kN leading) on a simply supported beam of span AB = 24 m. Compute the maximum SF and BM at a point C, 6 m from right support B. Also, determine the absolute maximum shear force in the beam. **(Analyze)**

Prepared by,
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24CET303	FLUID MECHANICS	L	T	P	R	C	Year of Introduction
		3	1	0	0	4	2024

Preamble: The aim of this course is to introduce students to the core principles of fluid mechanics, as well as the hydraulics of pipes and open channels, while enhancing their problem-solving abilities. The knowledge gained will be valuable for applying these concepts in the design of hydraulic structures and addressing real-world fluid flow challenges.

Prerequisite: 24EST113 Engineering Mechanics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the fundamental properties of fluids and apply the basic principles of fluid statics and dynamics to solve practical problems in Hydraulic Engineering. **(Apply)**
CO 2	Apply the relevant principles of hydrostatics to check the stability of bodies and estimate the fluid pressure. **(Apply)**
CO 3	Evaluate the flow rate using various flow measuring instruments and apply the relevant principles of hydraulics to analyze pipe flow problems. **(Apply, Analyze)**
CO 4	Analyze the flow through open channels. **(Apply, Analyze)**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3										
CO 2	3	2			2						2
CO 3	3	3									
CO 4	3	3	2			2					

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze		√	√	√
Evaluate				
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Theory [L-T]			Total Marks
		Assignment	Test-1	Test-2	
3-1-0-0	5	10	12.5	12.5	**40**

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE(Marks)**	**ESE Duration**
100	40	60	2.5 hrs

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions (2 questions from each module), each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9marks. Marks: (9x 4 = 36 marks)	60

SYLLABUS

MODULE I: FLUID PROPERTIES AND MEASUREMENT OF FLUID PRESSURE (12 hours)

Fluid properties- Density, Temperature, Pressure, Specific Gravity, Specific Volume, surface tension, compressibility, Viscosity - Newton's law of viscosity - Types of fluids.

Fluid statics- Fluid pressure, Pascal's Law, Hydrostatic law, Variation of pressure in a fluid - Numerical Problems.

Measurement of fluid pressure using piezometers and manometers- Simple manometer (Piezometer and U-tube manometers) and Differential manometers (U-tube and inverted U-tube) - Numerical Problems. Modern Pressure Gauge Devices.

Dimensional analysis- dimensional homogeneity - dimensional groups - dimensional analysis using Buckingham's π theorem method

Self Study (18 hours):

- Create a comparison table for different types of fluids based on viscosity and compressibility.
- Estimate pressure using height difference and compare with theoretical.
- Create a one-page infographic or short report on digital pressure sensors and gauges (e.g., Bourdon gauge, piezoelectric sensors).
- Choose a physical phenomenon (e.g., terminal velocity) and perform full dimensional analysis with explanation of each step.

MODULE II: DETERMINATION OF TOTAL PRESSURE AND CENTRE OF PRESSURE (12 Hours)

Determination of total pressure and centre of pressure on surfaces-Vertical plane surface, Horizontal plane surface, inclined plane surface, curved surfaces - Numerical Problems.

Buoyancy and Floatation- Basic concepts, centre of buoyancy, meta-centre and meta-centric height of floating bodies, determination of meta-centric height using analytical and experimental methods, conditions for stability of floating and

submerged bodies - Numerical Problems.

Self Study (18 hours):

- Estimate theoretical vs. experimental pressure forces using mini lab setup.
- Solving numerical problems and creating a comparison chart of pressure magnitude and center of pressure for each case.
- Estimate approximate centre of buoyancy visually.
- Applications of buoyancy real-world.
- Fluid pressure simulation (online or MATLAB)

MODULE III: FLUID KINEMATICS & DYNAMICS (12 Hours)

Fluid Kinematics- Methods of describing fluid motion, Lagrangian and Eulerian methods. Continuity equation in 1D, 2D and 3D (derivation not required). Determination of velocity and acceleration at a point in fluid flow - Numerical Problems.

Description of streamline, pathline and streakline, velocity potential, stream function and flow net.

Fluid Dynamics- Derivation of Bernoulli's equation from Eulers's equation of motion with assumptions, Practical Applications of Bernoulli's equation- Venturimeter, orifice meter and Pitot tube - Numerical Problems.

Pipe flow: Computation of major losses in pipes (derivation of Darcy Weisbach equation) - Computation of minor losses in pipes (derivation not required), hydraulic gradient line and total energy line, pipes in series and parallel - equivalent pipes - Numerical Problems.

Self Study (18 hours):

- Draw streamline, pathline, and streakline for given flow conditions (e.g., around a cylinder).
- Create a flow net diagram for a basic flow situation using the stream function and potential function (manual or Excel-based).
- Draw and label HGL and TEL for given pipe systems. Create a comparison chart for major vs. minor losses.
- Plot flow nets and analyzing experimental data using Excel or MATLAB

MODULE IV: FLOW IN OPEN CHANNEL (12 hours)

Flow through Orifices: hydraulic coefficients and experimental determination of hydraulic coefficients. Discharge through large orifices: rectangular orifice (discharging freely, fully submerged and partially submerged), time of emptying of a rectangular tank through an orifice at its bottom - Numerical Problems.

Flow in Open channel- Comparison between pipe flow and open channel flow, classification of flow in open channels, velocity distribution in open channels, types of channels. Specific energy-Critical flow-Rapidly varied flow-Hydraulic jump.

Flow measurement in channels through Notches and weirs- classification of notches and weirs, discharge over a rectangular notch/weir, discharge over a triangular notch/weir, discharge over a trapezoidal notch/weir, velocity of approach and end contraction - Numerical Problems.

Self Study (18 hours):

- Observe an irrigation canal or roadside drain. Take photos or sketch the flow profile. Identify possible hydraulic jumps or subcritical/supercritical zones.
- Create a table listing discharge equations, assumptions, and correction factors for each notch type.

Text Books:

1. Modi P. N. and S. M. Seth, Hydraulics and Fluid Mechanics including Hydraulic machines, S.B.H Publishers, New Delhi, 22nd edition, 2019.
2. Subramanya K, Flow in Open channels, Tata McGraw-Hill 5th edition 2019.
3. Hanif Chaudhary M, Open - Channel Flo, Springer 2nd edition 2007
4. R K Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications 10th edition, 2020.
5. John F Douglas, Janusz . Gasiorek, John A. Swaffield, Lynne B. Jack, Fluid Mechanics, Pearson Publications 6th edition 2011.

Reference Books:

1. Victor Streeter , E. Benjamin Wylie , K.W. Bedford, Fluid Mechanics , Mc Graw Hill Publishers. 9th edition 2017.
2. Philip M. Gerhart John I. Hochstein, Andrew L. Gerhart, Munson, Young and Okiishi's Fundamentals of Fluid Mechanics , John Wiley & Sons Inc 9th edition 2020.
3. Bruce R. Munson, Donald F. Young, Theodore H. Okiishi, Fundamentals Of Fluid Mechanics, John Wiley & Sons Inc 5th edition 2005.
4. Joseph Katz, Introductory Fluid Mechanics, Cambridge University Press 2015.
5. Arora.K.R, Fluid Mechanics, Hydraulics and Hydraulic Machines , Standard Publishers 2005.
6. Narasimhan S. , A First Course in Fluid Mechanics , University Press (India) 2006.
7. Kumar.D.N. ,Fluid Mechanics and Fluid power Engineering, S.K.Kataria & sons 2013.
8. Narayana Pillai, N, Principles of Fluid Mechanics and Fluid Machines, University Press 2011.

NPTEL/SWAYAM Courses for reference:

1. Introduction To Fluid Mechanics- by Prof. Suman Chakraborty- IIT Kharagpur - https://onlinecourses.nptel.ac.in/noc22_me31/preview
2. Fluid Mechanics by Dr. N. Sahoo, Dr. Subhashisa Dutta- IIT Guwahati- https://nptel.ac.in/courses/105103095
3. Advanced Hydraulics, IIT Roorkee-Dr. C. S. P. Ojha-

https://nptel.ac.in/courses/105107059		
No.	**COURSE CONTENTS AND LECTURE SCHEDULE**	**No. of Hours (48)**
Module 1 (12 Hours)		
1.1	Fluid properties – Density, Temperature, Pressure, Specific Gravity	2
1.2	Fluid properties -Specific Volume, surface tension, compressibility, Viscosity, Newton's law of viscosity, types of fluids.	2
1.3	Fluid statics: Fluid pressure, Pascal's Law, Hydrostatic law, Measurement of fluid pressure using manometers , variation of pressure in a fluid (Numerical problems)	2
1.4	Measurement of fluid pressure using piezometers and manometers: Simple manometer (Piezometer and U-tube manometers) and Differential manometers (U-tube and inverted U-tube) - Numerical Problems..	2
1.5	Modern Pressure Gauge Devices	1
1.6	Dimensional analysis: dimensional homogeneity - dimensional groups - dimensional analysis using Buckingham's π theorem method	1
1.7	Tutorial	2
Module II (12 Hours)		
2.1	Determination of total pressure and centre of pressure on surfaces : Vertical plane surface, Horizontal plane surface, inclined plane surface, curved surfaces- Numerical problems	4
2.2	Buoyancy and Floatation: Basic concepts, centre of buoyancy, meta-centre and meta-centric height of floating bodies	2
2.3	Determination of meta -centric height using analytical and experimental method,	2
2.4	Conditions for stability of floating and submerged bodies – Numerical problems	2
2.5	Tutorial	2
Module III (12 Hours)		
3.1	Fluid Kinematics: Methods of describing fluid motion, Lagrangian and Eulerian methods. continuity equation in one, two and three dimensions.	2
3.2	Determination of velocity and acceleration at a point in fluid flow , Description of streamline, pathline and streakline, velocity potential, stream function and flow net	2

3.3	Fluid dynamics: Derivation of Bernoulli's equation from Eulers's equation of motion with assumptions, Practical Applications of Bernoulli's equation- Venturimeter, orifice meter and Pitot tube	2
3.4	Pipe flow- Computation of major losses in pipes (derivation of Darcy Weisbach equation) - Computation of minor losses in pipes (equations only)	2
3.5	Hydraulic gradient line and total energy line, pipes in series and parallel - equivalent pipes	2
3.6	Tutorial	2
Module IV (12 Hours)		
4.1	Flow through Orifices: hydraulic coefficients and experimental determination of hydraulic coefficients Discharge through large orifices- rectangular orifice (discharging freely, fully submerged and partially submerged), time of emptying of a rectangular tank through an orifice at its bottom	2
4.2	Flow in Open channel: Comparison between pipe flow and open channel flow, classification of flow in open channels, velocity distribution in open channels, types of channels.	2
4.3	Specific energy-Critical flow-Rapidly varied flow-Hydraulic jump.	2
4.4	Flow measurement in channels through Notches and weirs: classification of notches and weirs, discharge over a rectangular notch/weir,	2
4.5	discharge over a triangular notch/weir, discharge over a trapezoidal notch/weir, velocity of approach and end contraction.	2
4.6	Tutorial	2
CO Assessment Questions		
	3-Mark Questions 1. Differentiate between Newtonian and non-Newtonian fluids with examples. **(Apply and Understand)** 2. Explain the compressibility of a fluid and its relevance in hydraulic systems. **(Apply and Understand)** 3. State Pascal's Law and give one practical application. **(Apply and Understand)** 4. Calculate the pressure at a depth of 2.5 m below the free surface of water. (Assume density = 1000 kg/m^3). **(Apply and Understand)** 5. Explain the difference between a piezometer and a differential U-tube manometer. **(Apply and Understand)** 6. State the Buckingham π-theorem. What is the minimum number of π-terms that can be formed. **(Apply and Understand)**	

CO1	**9-Mark Questions** 1. A tank is filled with two immiscible fluids: oil of specific gravity 0.8 to a height of 2 m, and water to a height of 3 m above the oil. i. Determine the pressure intensity at the bottom of the tank. (b) If a pressure gauge is installed at the bottom, what will be the gauge pressure reading? (c) Convert the pressure obtained in (a) to kPa and also express it in terms of the height of the water column. **(Apply and Analyze).** 2. A hydraulic press has a plunger of diameter 50 mm and a ram of diameter 250 mm. If a force of 500 N is applied on the plunger: (a)Calculate the pressure transmitted to the fluid. (b)Determine the force exerted by the ram. (c) If the mechanical efficiency of the system is 85%, what is the effective lifting force of the ram? **(Apply and Analyze).** 3. A U-tube manometer is used to measure the pressure of water in a pipeline which is in excess of atmospheric. The left limb is connected to the pipeline and right limb is open to atmosphere. The free surface of mercury in the right limb is in level with the centre line of the pipe and the level difference of mercury in the limbs of the manometer is 20 cm. Compute the water pressure in the pipeline. If the pressure of water is increased by 50 %, compute the manometric reading. **(Apply and Analyze).** 4. An inverted differential manometer is connected to two pipes A and B which convey water. The centreline of pipe B is 50 cm below the centreline of pipe A. Pipe B is to the right side of pipe A. The oil level in the left limb is 40 cm above the centreline of pipe A and that in the right limb is 60 cm above the centreline of pipe B. The fluid in the manometer is oil of specific gravity 0.85. Find the pressure difference between A and B. **(Apply and Analyze).**
CO2	**3-Mark Questions** 1. Define total pressure and centre of pressure. How are they different? **(Apply and Understand)** 2. What is the significance of metacentric height in the stability of floating bodies? **(Apply and Understand)** 3. State the conditions for stability of floating and submerged bodies with neat sketches. **(Apply and Understand)** 4. Explain the concept of centre of buoyancy. Where is it located in a floating body? **(Apply and Understand)** 5. Write the expression for total pressure and centre of pressure on a vertical plane surface submerged in a liquid. **(Apply and Understand)** **9-Mark Questions** 1. A vertical rectangular gate 1.5 m wide and 3 m high is immersed in

	water with the top edge 1 m below the free surface. (a) Calculate the total hydrostatic pressure on the gate. (b) Determine the depth of the centre of pressure from the free surface. **(Apply and Analyze).** 2. A rectangular plate 2 m wide and 3 m long is immersed in water, making an angle of 30° with the horizontal. The top edge is 1 m below the free surface. (a) Calculate the total pressure on the plate. (b) Find the depth of the centre of pressure. **(Apply and Analyze).** 3. A wooden block (density = 650 kg/m^3) of size 1 m × 0.5 m × 0.3 m floats in water with its largest face horizontal. (a) Calculate the volume of water displaced. (b) Determine the position of the centre of buoyancy from the base of the block. (c) Find the buoyant force acting on the block **(Apply and Analyze).** 4. A floating cylindrical buoy of diameter 1.2 m and height 2.5 m weighs 9000 N. (a) Determine the depth of immersion. (b) Find the position of the centre of buoyancy. (c) Calculate the metacentric height and comment on the stability. **(Apply and Analyze).** 5. A quarter cylindrical gate of radius 2 m and length 4 m lies in a horizontal plane submerged in water. (a) Determine the total hydrostatic force acting on the curved surface. (b) Find the direction and point of application of the resultant force. **(Apply and Analyze).**
CO3	**3-Mark Questions** 1. Differentiate between Lagrangian and Eulerian methods of describing fluid motion. Give one example for each. **(Apply and Understand)** 2. Define streamline, pathline, and streakline. How are they different for unsteady flow? **(Apply and Understand)** 3. State Bernoulli's equation. List the assumptions made in its derivation. **(Apply and Understand)** 4. What is the function of a Pitot tube? Briefly explain how it measures fluid velocity. **(Apply and Understand)** 5. Define the following hydraulic coefficients for flow through an orifice:Coefficient of discharge (Cd),Coefficient of velocity (Cv), Coefficient of contraction (Cc) **(Apply and Understand)** **9-Mark Questions** 1. Water flows through a pipe that tapers from a diameter of 300 mm to 150 mm. The velocity at the larger section is 2 m/s. (a) Calculate the velocity at the smaller section.

	(b) Determine the volumetric flow rate. (c) If the flow is steady and incompressible, comment on the mass conservation **(Apply and Analyze).** 2. A horizontal venturimeter is fitted in a pipe carrying water. The inlet diameter is 200 mm and throat diameter is 100 mm. The differential mercury manometer shows a reading of 200 mm. (a) Calculate the flow rate through the pipe (Take Cd = 0.98). (b) Determine the velocity at inlet and throat. (c) Comment on pressure difference and flow efficiency. **(Apply and Analyze).** 3. A Pitot tube inserted into a pipe shows a stagnation pressure head of 6 m of water and the static pressure head is 3.5 m. (a) Calculate the velocity of water in the pipe. (b) Compute the dynamic pressure. (c) If the actual velocity is found to be 0.95 times the theoretical, find the coefficient of velocity. **(Apply and Analyze).** 4. A rectangular orifice 0.8 m wide and 0.5 m deep is fitted in a tank containing water. The water level is 2.5 m above the top of the orifice. (a) Determine the discharge through the orifice if it is discharging freely. (b) If the orifice is fully submerged, calculate the discharge. (c) Take coefficient of discharge Cd = 0.62. **(Apply and Analyze).** 5. A rectangular tank 5 m long, 3 m wide, and 2.4 m deep is to be emptied through a small orifice of diameter 0.15 m at the bottom. (a) Calculate the time required to empty the tank completely. (b) Determine the average discharge during emptying. (c) Take Cd = 0.6 and assume water as the fluid. **(Apply and Analyze).** 6. Water flows through a 150 mm diameter pipe, 60 m long, with a velocity of 2.5 m/s. The friction factor fff is 0.02. The pipe includes two 90° bends (K = 0.3 each) and a sudden contraction (K = 0.5). (a) Compute the major loss using the Darcy–Weisbach equation. (b) Calculate the total minor losses. (c) Find the total head loss and comment on the significance of minor losses. **(Apply and Analyze).**
CO4	**3-Mark Questions** 1. Differentiate between open channel flow and pipe flow with at least two key differences. **(Apply and Understand)** 2. Define Hydraulic Gradient Line (HGL) and Total Energy Line (TEL). Sketch and explain their significance. **(Apply and Understand)** 3. What is a hydraulic jump? Where does it occur, and why is it important in energy dissipation? **(Apply and Understand)** 4. Classify open channel flow based on geometry, flow depth, and time variation. **(Apply)**

	5. List the types of notches and weirs used for discharge measurement in open channels and state one practical application of each. **(Apply)** **9-Mark Questions** 1. A rectangular channel is 3 m wide and carries a discharge of 6 m^3/s. (a)Compute the specific energy when the depth of flow is 1.2 m. (b) Determine the critical depth and minimum specific energy. (c) Comment on whether the flow is subcritical or supercritical. **(Apply and Analyze).** 2. Water flows over a rectangular weir 2 m wide with a head of 0.3 m. A triangular (V-notch) weir is also installed with an angle of 90° and the same head. (a) Calculate the discharge over the rectangular weir (Take Cd = 0.6). (b) Calculate the discharge over the V-notch (Take Cd = 0.58). (c) Compare the discharges and discuss efficiency. **(Apply and Analyze).** 3. A rectangular channel 4 m wide has a pre-jump depth of 0.5 m and velocity of 6 m/s. (a) Determine the sequent depth (after the jump). (b) Compute the energy loss due to the hydraulic jump. (c) Discuss how this jump could be used as an energy dissipator downstream of spillways. **(Apply and Analyze).** 4. Water flows over a 1.8 m wide sharp-crested weir with a head of 0.5 m. The velocity of approach is 1.2 m/s. (a) Compute the corrected head considering velocity of approach. (b) Find the discharge including velocity of approach. (c) Use Cd = 0.62. **(Apply and Analyze).**

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24CER304	CONCRETE TECHNOLOGY AND BUILDING PLANNING	L	T	P	R	C	Year of Introduction
		3	0	0	1	4	2024

Preamble:
The objective of this course is to provide students with a comprehensive understanding of various principles and techniques of concrete technology. This will also enable them to perform the functional planning and designing of various types of building as per NBC and KMBR/KPBR.

Prerequisite: 24EST124: Introduction to Civil Engineering, 24ESL106: Civil Engineering Workshop & 24EST203 Engineering Graphics and Computer Aided Drawing

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze the quality of materials and the testing of properties and compare with standards. **[Apply]**
CO 2	Identify the functional role of all ingredients of concrete and their use for normal and special purpose concrete. **[Apply]**
CO 3	Apply the principle of sustainability for the utilization of waste, novel and innovative materials for concrete. **[Apply]**
CO 4	Design concrete mixes suitable for both conventional and specialized applications. **[Apply]**
CO 5	Understand the basic principles involved in the planning of buildings. **[Understand]**
CO6	Develop, design, and produce detailed construction drawings for buildings. **[Create]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3					1	1	1		1	3
CO2	3					1		1		1	3
CO3	3	3				1				1	3
CO4	3					2	2			1	3
CO5	3	2	2	1	2	3	2	2	1	1	1
CO6	3	1	3	2	3	2	1	1	1	1	1

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√

Analyze	√	√	√	√
Evaluate		√	√	√
Create		√	√	√

Assessment Pattern for Project Component

Bloom's Category	**Continuous Assessment Tools**		
	Evaluation 1	**Evaluation 2**	**Report**
Remember	√	√	√
Understand	√	√	√
Apply	√	√	√
Analyze	√	√	√
Evaluate	√	√	√
Create	√	√	√

Mark Distribution of CIA

		Theory [L]			**Project [R]**			**Total Marks**
Course Structure [L-T-P-R]	**Attendance**	**Assignment**	**Test-1**	**Test-2**	**Evaluation 1**	**Evaluation-2**	**Report**	
3-0-0-1	5	10	7.5	7.5	5	10	5	50

Total Marks distribution

Total Marks	**CIA (Marks)**	**ESE (Mark)**	**ESE Duration**
100	50	50	2 hrs

End Semester Examination [ESE]

PATTERN	**PART A**	**PART B**
PATTERN 2	2 Questions from each module. Total of 8 Questions, Answer any 6 questions. Each carrying 3 marks (6x3 =18 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 subdivisions. Each question carries 8 marks. (4x8 = 32 marks)

SYLLABUS

MODULE I: PROPERTIES OF INGREDIENTS (8 Hours)

Cement- Chemical composition, Bogue's compounds, hydration, types and uses of cement - ordinary Portland cement, Portland pozzolana cement, rapid hardening

Portland cement, hydrophobic cement, low heat Portland cement and sulphate resisting Portland cement - Grades as per relevant I.S. codes.
Coarse and Fine aggregates and their influence on concrete, Types of aggregates and their properties - Testing of aggregates as per relevant IS Codes.

Admixtures - Types, necessity and benefit - Mineral admixture - Fly ash, silica fume, blast furnace slag, and agro waste based pozzolana - Chemical admixtures - Accelerator, retarder, plasticizer and superplasticizer, GGBS, Metakaolin - their functions and dosage.

Self study (18 hours)

1. Collect different types of cement and learn their properties.
2. Collect different types of fine and coarse aggregates and learn their properties.
3. Collect different types of admixtures and learn their properties.

MODULE II: PROPERTIES OF CONCRETE (10 Hours)

Concrete for structural work, High Performance concrete, Polymer Concrete, Fiber Reinforced Concrete, lightweight concrete, high density concrete, biological concrete - workability, durability and strength requirements, effect of w/c ratio on properties of fresh and hardened concrete, acceptability criteria, Fire resistant properties of hardened concrete.
Destructive and non-destructive testing of fresh and hardened concrete.
Process of manufacturing of concrete, transportation, placing, compaction and curing of concrete.
Special Concreting methods- Extreme weather concreting, vacuum dewatering, underwater concrete, Plum Concrete and Self-Compacting Concrete - special form work.
Ready mix concrete- Requirements of ready-mix concrete, properties of RMC, transit mixer details, Automation, instrumentation and Layout of RMC plant.

Self study: (18 hours)

1. Visit sites of concreting and learn the process of preparation of concrete.

MODULE III : CONCRETE MIX DESIGN (9 Hours)

Mix Design for compressive strength - I.S. methods, road note method, British method and ACI Method.
Mix design for flexural strength.

Self study: (18 hours)

1. Design different types of concrete mixes with field test and using admixtures.

MODULE IV : Understand planning requirements (9 Hours)

Building Planning Requirements as per NBC and KMBR/KPBR - Application of guidelines for functional planning of building units.

Self study: (18 hours)

1. Prepare site plans and location plans.
2. Prepare building plans suitable for different plot conditions and requirements.
3. Justify the facilities provided comply with the standards.

Textbooks

1. M.L. Gambhir, Concrete Technology, McGraw Hill Book Company, Fifth Edition, 2017. (ISBN-1259062554, 978-1259062551).
2. M.S. Shetty, Concrete Technology, Theory and Practice, S. Chand Publication, Sixth Edition, 2018.(ISBN- 9788121900034,978-8121900034)
3. B.L. Gupta and A. Gupta, Concrete Technology, Jain Book Agency, 2013. (ISBN-8180140407,978-8180140402).
4. Building Planning Designing And Scheduling Paperback – by Gurcharan Singh , Jagdish Singh

Reference books

1. A.R. Santhakumar, Concrete Technology, Oxford University Press, New Delhi, 2018. (ISBN- 9780195671537, 978-0195671537).
2. A.M. Neville, Properties of Concrete, Pearson Publication, London, 2012. (ISBN- 978-0273755807, 9780273755807).
3. IS 10262-(2019) Recommended Guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi, 2019.
4. IS10262 (2019), Mix Design
5. IS269 (2015), Ordinary Portland Cement (33 Grade).
6. IS12269 (2013), Ordinary Portland Cement (53 Grade). 7
7. IS650 (1991), Specification of Standard Sand. 8. IS383 (1970), Specification for Coarse and Fine aggregate.

NPTEL/SWAYAM Courses for reference:

1. **Concrete Technology by Dr. B Bhattacharjee , IIT Delhi https://nptel.ac.in/courses/105102012**
2. **Concrete Engineering and Technology by Dr. Sudhir Misra, IIT Kanpur https://nptel.ac.in/courses/105104030**
3. **Admixtures And Special Concretes by Prof. Manu Santhanam, IIT Madras https://nptel.ac.in/courses/105106225**
4. **Advanced Concrete Technology by Prof. Manu Santhanam, IIT Madras https://nptel.ac.in/courses/105106176**
5. **Housing Policy & Planning by Prof. Uttam Kumar Roy, IIT Roorkee https://nptel.ac.in/courses/124107001**
6. **Engineering Drawing by Prof. P.S. Robi, IIT Guwahati https://nptel.ac.in/courses/112103019**

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours (36)
	MODULE I- Properties of Concrete Ingredients (8 Hours)	
1.1	Cement-Chemical composition of Cement, Bogue's compounds,	1

	hydration, types of cement and their use.	
1.2	Grades of cement, Types of cement, rapid hardening Portland Pozzolana cement, Blast furnace slag cement as per relevant I.S. codes.	1
1.3	Types of Cement: Hydrophobic cement, low heat Portland cement and sulphate resisting as per relevant I.S. codes.	1
1.4	Tests on Cement and their relevant standards as per IS codes.	1
1.5	Coarse and Fine aggregates and their influence on concrete, Types of aggregates and their properties.	1
1.6	Testing of aggregates as per relevant IS Codes.	1
1.7	Admixtures - types, necessity and benefit. Mineral admixture - Fly ash, silica fume, blast furnace slag, and agro waste based pozzolans.	1
1.8	Chemical admixtures - Accelerator, retarder, plasticizer and superplasticizer, GGBS, fly Ash, Metakaolin, Silica Fumes, their functions and dosage.	1
MODULE II-Properties of Concrete (10 Hours)		
2.1	Concrete for structural work, High Performance concrete, Polymer Concrete, Fiber Reinforced Concrete, light weight concrete, high density concrete, biological concrete.	2
2.2	Properties of Concrete-workability, durability and strength requirements.	1
2.3	Effect of w/c ratio on properties of fresh and hardened concrete.	1
2.4	Acceptability criteria, laboratory destructive and non-destructive testing of fresh and hardened concrete, Fire resistant properties of hardened concrete.	2
2.5	Process of manufacturing of concrete, Batching, Mixing, transportation, placing, compaction, Finishing and curing of concrete.	2
2.6	Extreme weather concreting, special concreting methods, vacuum dewatering– underwater concrete.	1
2.7	Special form work., Plum Concrete, Self-Compacting Concrete, Ready mix concrete: Requirements of ready-mix concrete, properties of RMC, transit mixer details, Automation, instrumentation and Layout of RMC plant.	1
MODULE III:DESIGN OF CONCRETE (9 Hours)		
3.1	Concrete mix design: Concept, objectives and design parameters of Mix Design.	1

3.2	Various methods of Mix proportioning.	2
3.3	Data required for Mix Design for compressive strength by I.S. methods and their standards.	2
3.4	Mix design using IS method IS 10262 -2019 with sample preparation and testing.	2
3.5	Mix design using IS method IS 10262 -2019 with sample preparation and testing for compression and flexure.	2
MODULE IV: BUILDING PLANNING (9 Hours)		
4.1	Understand planning requirements, Define basic terms like plinth area, floor area, carpet area, floor area ratio, etc and different types of structures.	2
4.2	Classification of buildings and requirements as per NBC and KMBR.	2
4.3	Application of guidelines for functional planning of building unit.	1
4.4	Developing lay out incorporating Building rules and Guidelines specified by NBC and local bodies of administration.	2
4.5	Preparation of Building plans of single floor and double floor for different types of buildings with all requirements as per Building rules and Guidelines specified by NBC and local bodies of administration.	2

Project:

Description:

1) Study on using any sustainable natural material as an ingredient in concrete and its compatibility.
2) Replacing any smart and sustainable material as an ingredient in concrete and its reliability.
3) Planning a specific use building in a site satisfying KPBR/KMBR and NBC.
4) Preparing the functional Planning for a specific use building within a site satisfying KPBR/KMBR and NBC.
5) Preparing all the required drawings for building permit for a given plan in a site satisfying KPBR/KMBR and NBC.

LESSON PLAN FOR PROJECT COMPONENT

No.	**Topic**	**No. of Hours (12)**
1	Preliminary Design of the Project	2
2	Zeroth presentation (4th week)	2
3	Project work - First Phase	2
4	Interim Presentation	2

5	Project work - Final Phase & Report writing (discussions in class during project hours)	2
6	Final Evaluation, Presentation and Exhibition (11th and 12th weeks)	3

CO Assessment Questions	
CO1	1. What are Bogue's compounds and their role in concrete? **(Remember)** 2. What are the ingredients of cement and their proportion? **(Remember)** 3. What is the function of aggregates in cement products? **(Remember)** 4. What are the different types of admixtures and their action in cement products? **(Remember)** 5. How does the gradation of aggregate affect the workability? **(Analyze)**
CO2	1. What are the different types of concrete and their specific purpose? **(Apply)** 2. What are the properties of Concrete- workability, durability and strength? **(Remember)** 3. Explain water cement ratio and its effects. **(Remember)** 4. Explain ready mix concrete, Requirements of RMC and properties of RMC. **(Apply)** 5. Prepare a flow chart showing the manufacture of concrete. **(Apply)** 6. Explain form work and special types available for smart form work. **(Remember)**
CO3	1. What do you understand from smart concrete? **(Remember)** 2. What is sustainable concrete? **(Remember)** 3. What are the care to be taken in replacing conventional concrete with waste and sustainable materials? **(Apply)** 4. What are the advantages of fiber reinforced concrete? **(Remember)** 5. How is light weight concrete advantageous? **(Remember)**
CO4	1. What is the concept of mix design? **(Remember)** 2. What are the different methods of mix design? **(Remember)** 3. What are the different parameters of mix design? **(Apply)** 4. Design a mix for the given parameters. **(Apply)** 5. Design a special mix for the given parameters with using fly ash as an additive. **(Remember)**
CO5	1. Explain different technical terms related to building planning. **(Remember)** 2. What are relevant references that take care of building rules in central and state? **(Remember)** 3. Prepare layout plan in a given site for given conditions. **(Apply)**

	4. What is parking and requirements as per rules for commercial complexes? **(Apply)** 5. What are the rules relating to provision of lifts in a building? **(Apply)**
CO6	1. What are the rules to prepare a site plan? **(Apply)** 2. Enumerate the different facilities to be provided in a bus terminal station. **(Apply)** 3. Prepare a plan for a primary health centre. **(Apply)** 4. Prepare a plan for a primary School. **(Apply)** 5. List and explain the importance of the documents to be submitted along with permit plan. **(Apply)**

Prepared by
Mr. Sunny C P
Assistant Professor, SCET

24HUT005	ENGINEERING ECONOMICS	L	T	P	R	C	Year of Introduction
		2	0	0	0	2	2024

Preamble: To provide students with fundamental concepts of economics related to engineering industry, understanding of how price and output determined in different markets, macroeconomic concepts and to deliver the basic concepts of value engineering.

Prerequisite: None

Course Outcomes: After the completion of the course, the student will be able to

CO 1	To learn the basic economic concepts and to understand the fundamentals of various economic issues. **[Understand]**
CO 2	To acquire knowledge regarding the functioning of firms in different market situations and to develop decision making capability by applying concepts relating to cost and revenue. **[Apply]**
CO 3	To demarcate the macro-economic principles of monetary and fiscal systems, national income and stock market. **[Understand]**
CO 4	To solve simple business problems using break -even analysis, capital budgeting techniques, and bring to bear the possibilities of value analysis and value engineering. **[Analyze]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1		2			2	2		2		3	3
CO 2		2			2	2		2		3	3
CO 3		2			2	2		2		3	3
CO 4		2			2	2		2		3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate				
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Theory [L-T]				Total Marks
		Assignment	Test-1	Test-2	Case study	
2-0-0-0	5	5	10	10	20	50

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE(Marks)**	**ESE Duration**
100	50	50	2 Hrs

End Semester Examination [ESE]: Pattern

PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 2	2 Questions from each module. Any full 6 Questions, each carrying 3 marks (6x3 =18 marks)	2 questions will be given from each module, of which 1 question should be answered. Each question can have a maximum of 3 subdivisions. Each question carries 8 marks. (4x8 = 32 marks)	50

SYLLABUS

MODULE I: DEMAND AND SUPPLY ANALYSIS (7 hours)

Basic Economic Concepts- Central problems of an economy-production possibility curve-Utility-Law of diminishing marginal utility-Law of Demand and supply-Elasticity-Measurement of elasticity and its applications-Market Equilibrium-Changes in demand and supply- its effects-Consumer surplus and producer surplus-Production functions in the short and Long run-Economies of scale-Internal and External economies-Cobb-Douglas Production function. Taxation-
Direct and indirect tax-Value Added tax -Goods and service tax-Deadweight loss.

Self-Study (8 Hours) :

1. Read and summarise what is economy and economics.
2. Read and make note on how does a consumers utility change when their income increases? Explain with the help of normal and inferior goods?
3. Explain the factors affecting the market demand of a commodity?
4. Study and make report on Impact of GST on small business in your city.

MODULE II: MARKET STRUCTURE (7 hours)

Costs Concepts- Social cost, Private cost-Explicit and Implicit cost-Sunk cost-Opportunity cost-Short run and long run cost curves-Revenue concepts- shut down point-Markets-Perfect competition- Monopoly-Monopolistic Competition-Oligopoly (price and output determination)- Non- price competition-Product pricing-Methods of product pricing. Case study on Monopolistic competition (Industry consumer electronics).

Self-Study (8 Hours) :

1. Explain cost estimation techniques for engineering projects?
2. Read and summarise fixed and variable cost?
3. With real life example explain opportunity cost?
4. Explain the importance and methods of product pricing?

MODULE III MACRO ECONOMIC CONCEPTS (7 hours)

National income -Concepts-Methods of estimating National income -Circular flow of income in two and four sector economy-Business financing -Bonds and shares-Financial Market-Stock market -Functions-Problems faced by the Indian stock market-Demat Account and Trading Account-Stock market indicators-SENSEX And NIFTY. Meaning and functions of Money-Central Banking-Inflation-Causes and effects -Measures to control inflation- Monetary and fiscal policies-Deflation-Case study on "Impact of rising food prices on middle income house holds in your city".

Self-Study (8 Hours) :

1. Read and Summarise how the national income of India is calculated?
2. Explain the causes of inflation?
3. Study and make report on :"A New Investor's Journey in Stock Market Trading"
4. Explain the impact of deflation in an economy?

MODULE IV:VALUE ANALYSIS AND VALUE ENGINEERING (7 hours)

Value Analysis and Value Engineering-Cost value, -Exchange value, -Use value-, Esteem value- Aims, Advantages and Application areas of value engineering-Value Engineering Procedure-Break-even-Analysis -Capital Budgeting-Time value of money-Net Present Value Method-Benefit Cost Ratio-Internal Rate of Return-Payback-Accounting Rate of Return-Decision tree analysis-Profit and balance sheet analysis-Game theory application in engineering. Case study on Value addition in food processing industry.

Self-Study (8 Hours) :

1. Explain the Time value of money in project evaluation.
2. Read and summarize the importance of cost benefit analysis?
3. Explain engineering decision- making under uncertainty.
4. Study and make report on "The rise of Gig economy and its impact on engineers".
5. Explain Nash equilibrium.

Textbooks

1. Piyali Gosh Geetika and Purba Roy Chowdhury , Managerial Economics, Tata McGrawHill, 3rd edition, 2017.
2. H.G.Thuesen, W.J Fabrycky, Engineering Economy, PHI-1966.
3. R.Paneerselvam, Engineering Economics ,PHI-2012

Reference books

1. Leland Blank.P.E,Anthony Tarquin P.E-,Engineering Economy– Mc Graw Hill – 7th Edition.
2. Khan.M.Y-,IndianFinancialSystem– Tata Mc Graw Hill –2011
3. Donald .G.Newman, Jerome.p.Lavelle-Engineering Economics And Analysis-Engineering press Texas-2002
4. Chan.S.Park-Contemporary Engineering Economics-Prentice Hall of India Ltd-2001

NPTEL/SWAYAM Courses for reference:

1. NPTEL: Principles of Economics, Prof.Sabuj Kumar Mandal [IIT Madras] https://onlinecourses.nptel.ac.in/noc23_ec06/preview

2. NPTEL:Engineering Economic Analysis ,Dr.Pradeep Kumar Jha[IIT Roorkee] https://onlinecourses.nptel.ac.in/noc23_ec03/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours (28)
	MODULE I (7 hours)	
1.1	Basic Economic Concepts-Central Problems of an economy-Production possibility curve-Utility -Law of Diminishing Marginal Utility-Law of equi -marginal utility.	2
1.2	Law of Demand and Supply-Elasticity of Demand-Measurement of Elasticity and its applications.	1
1.3	Market Equilibrium - Changes in demand and supply-its effects-Consumer Surplus and Producer Surplus.	2
1.4	Production function in the Short and long run.	1
1.5	Economies of Scale-Internal and external economies-Cobb -Douglas production function, Taxation, Deadweight loss.	1
	MODULE II (7hours)	
2.1	Cost Concepts- Social cost -Private cost -Explicit and implicit cost-Sunk cost- Opportunity cost.	1
2.2	Short run and Long run cost Curves-Revenue Concepts. -Shut down point.	1
2.3	Markets-Perfect competition – Monopoly.	2
2.4	Monopolistic competition – Oligopoly.	2
2.5	Non-price Competition - Product pricing- Methods of Product Pricing.	1
	MODULE: III (7 hours)	
3.1	National Income-Concepts-Methods of estimating national income.	2
3.2	Circular flow of income in two and four sector economy.	1
3.3	Business Financing-Bonds and Shares.	1
3.4	Financial market-Money market and Capital market.	1
3.5	Stock Market-Functions-Problems faced by the Indian Stock Market	1
3.6	Meaning and functions of money, Inflation and Deflation.	1
	MODULE IV (7 hours)	
4.1	Value analysis and value engineering-Cost value-Exchange value- Use value-Esteem value-Aims, Advantages and its Application- Areas of	1

	Value Engineering.	
4.2	Value Engineering Procedure.	1
4.3	Break- even- analysis.	1
4.4	Capital Budgeting-Time value of money-Net Present Value Method-Benefit Cost Ratio-Internal Rate of Return-Payback-Accounting Rate of Return.	2
4.5	Decision tree analysis-Profit and balance sheet analysis-Game theory application in engineering.	2
CO Assessment Questions		
CO1	1.Examine why the problem of choice arise? **(Apply)** 2.Explain central economic problems? **(Analyze)** 3.Outline how do we solve the basic economic problems? **(Apply)** 4.Interpret the relation between price and demand? **(Apply)**	
CO2	1.Explain shut down point? **(Analyze)** 2.Explain why monopolist called a price taker? **(Analyze)** 3Examine the equilibrium of a firm under monopolistic competition? **(Apply)** 4.Outline the methods of product pricing? **(Apply)**	
CO3	1.Explain the methods of estimating national income? **(Analyze)** 2.Distinguih between bonds and shares? **(Analyze)** 3.Examine the functions of money? **(Apply)** 4.Outline problems faced by Indian stock market? **(Apply)**	
CO4	1. Explain break even analysis? **(Analyze)** 2. Examine capital budgeting methods? **(Apply)** 3.Distinguish between exchange value and use-value? **(Analyze)** 4.Digramatically explain decision tree analysis? **(Analyze)**	

Prepared by
Ms Vini Valsan,
Asst. Prof, ASH

24EST306	APPLIED DATA SCIENCE & ARTIFICIAL INTELLIGENCE	L	T	P	R	C	Year of Introduction
		3	1	0	0	4	2024

Preamble:
This course covers the fundamentals of data analysis, including essential concepts in statistics and linear algebra, which form the basis for working with real-world data. Students will learn how to clean, transform, and visualize data, as well as handle missing values and detect outliers. The course provides hands-on experience with Python programming and data science libraries such as Pandas, NumPy, and Matplotlib. Additionally, it introduces the basics of machine learning and explores how these techniques are applied in engineering and industrial contexts.

Prerequisite: Problem Solving and Algorithmic Thinking with Python(24ESR105)

Course Outcomes: After the completion of the course the student will be able to

CO1	Apply advanced mathematical concepts such as matrix operations, singular values, and principal component analysis to analyze and solve engineering problems. **[Apply]**
CO2	Interpret data using statistical methods including descriptive statistics, correlation, and regression analysis to derive meaningful insights and make informed decisions. **[Apply]**
CO3	Carry out exploratory data analysis (EDA), including data collection, cleaning, visualization, and statistical summarization **[Apply].**
CO4	Demonstrate foundational knowledge of machine learning paradigms and apply selected algorithms for classification and regression problems using Python. **(Apply)**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	3	3	2						
CO 2	3	3	3	3	3						2
CO 3	2	3	3	3	3				2		
CO 4	3	3	2	3	3			2			2

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze		√	√	√

Evaluate				
Create				

Assessment Pattern for Lab component

Bloom's Category	Continuous Assessment Tools	
	Class work	Test1
Remember	√	√
Understand	√	√
Apply	√	√
Analyze	√	√
Evaluate		
Create		

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Assignment	Theory [L- T]		Total Marks
			Test-1	Test-2	
3-1-0-0	5	10	12.5	12.5	40

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hours

End Semester Examination [ESE]: Pattern

PATTERN	PART A	PART B	ESE Marks
PATTERN 1	8 Questions, each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: LINEAR ALGEBRA FOR DATA SCIENCE AND AI (11 Hours)

Role of Linear Algebra in Data Representation and Analysis, Introduction to vectors: properties, vector addition and subtraction, scalar multiplication. Vector norms and distance metrics. Interpretation and computation. Matrix Decomposition- Singular Value Decomposition (SVD): concept and applications. Dimensionality Reduction,

Principal Component Analysis.

Tutorial Questions:

- Vector addition, subtraction, and scalar multiplication
- Singular Value Decomposition

Self Study:(16 Hours)

- Principal Component Analysis (PCA) using Eigenvectors
- Orthogonality and Orthogonal Vectors
- Matrix Rank and Its Significance
- Vector and Matrix Broadcasting in NumPy.

MODULE II: APPLIED PROBABILITY AND STATISTICS FOR AI AND DATA SCIENCE (11Hours)

Basics of probability-random variables and statistical measures - rules in probability-Bayes theorem and its applications- statistical estimation Maximum Likelihood

Estimator (MLE) - statistical summaries Correlation analysis- linear correlation - regression analysis- linear regression (using least square method)
Types of Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics, Prescriptive Analytics, Big Data Analytics, Web Analytics, Social Media Analytics, Business Intelligence.

Tutorial Questions:

- Problems on Probability
- Measures of Dispersion
- Covariance and Correlation
- Linear

Self Study:(16 Hours)

- Difference Between Classical and Empirical Probability
- Understanding Conditional Probability with Real-Life Applications
- Bayes' Theorem and Its Applications in Decision Making
- Real world case study on Social Media Analytics
- Application of Business Intelligence.

MODULE III: EXPLORATORY DATA ANALYSIS (EDA) (14 Hours)

Introduction to data analysis and the EDA process. Types of data: structured, unstructured, categorical, numerical. Data collection techniques and sources (CSV files, APIs, databases). Data cleaning: fixing rows and columns, handling missing data, standardizing values, treating invalid entries, removing duplicates. Univariate analysis: distribution of individual variables. Bivariate analysis: relationships between two variables. Data visualization: histograms, boxplots, scatterplots, pair plots, heatmaps.

Tutorial Questions:

- Data Cleaning
- Bivariate Analysis

- Boxplots

Self Study:(18 hours)

- Feature engineering techniques
- Outlier detection and treatment methods
- Advanced data visualization with Plotly and Bokeh
- Time series data analysis basics, Introduction to big data tools for EDA (e.g., Apache Spark)
- Introduction to clustering for exploratory analysis
- Data quality assessment metrics and frameworks

MODULE IV: MACHINE LEARNING AND PYTHON FOR DATA SCIENCE (12 Hours)

Python data structures: lists, tuples, sets, dictionaries. Introduction to libraries: NumPy for numerical operations, Pandas for data manipulation, Matplotlib for visualization, SciPy for scientific computation. Introduction to machine learning: overview of supervised, unsupervised, and reinforcement learning. Key algorithms: regression, classification (logistic, Naïve Bayes), clustering (K-means). Model training and testing using scikit-learn. Evaluation metrics: accuracy, precision, recall, F1 score, confusion matrix. End-to-end implementation of a basic machine learning pipeline with real-world datasets.

Tutorial Questions:

- K-Nearest Neighbors (KNN) algorithm.
- Classification Examples
- Data Structure Applications

Self Study:(18 Hours)

- Ensemble learning basics (Random Forest, Gradient Boosting)
- Basics of neural networks and deep learning frameworks (TensorFlow, PyTorch)
- Introduction to unsupervised learning beyond K-means (DBSCAN, hierarchical clustering)
- Project Title: "Customer Segmentation and Purchase Prediction using Machine Learning"

Textbooks

1. Jake VanderPlas, Python Data Science Handbook. Essential Tools for Working with Data, O'Reilly Media, Year: 2016, First Edition
2. Peter Bruce, Andrew Bruce, Practical Statistics for Data Scientists: 50 Essential Concepts,O'Reilly Media, Year: 2017,Second Edition

Reference books

1. Mike X Cohen, Practical Linear Algebra for Data Science, O'Reilly Media, Inc., 2022,First Edition
2. Joel Grus, Data Science from Scratch , O'Reilly Media, Inc.,April 2015,Second Edition
3. Suresh Kumar Mukhiya, Usman Ahmed,Hands-On Exploratory Data Analysis

with Python, Packt Publishing, March 2020,First Edition		
NPTEL/SWAYAM Courses for reference: 1. Probability Theory for Data Science, Prof. Ishapathik Das, IIT Tirupati https://onlinecourses.nptel.ac.in/noc24_ma64/preview 2. Python for Data Science (Python-based), Prof. Ragunathan Rengasamy, IIT Madras, https://onlinecourses.nptel.ac.in/noc22_cs32/preview 3.Fundamentals of Artificial Intelligence, Prof. Shyamanta M. Hazarika, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc24_ge47/preview		
No.	**COURSE CONTENTS AND LECTURE SCHEDULE**	**No. of Hours [48]**
MODULE I [11 hours]		
1.1	Role of Linear Algebra in Data Representation and Analysis,	1
1.2	Introduction to vectors: properties, vector addition and subtraction, scalar multiplication.	2
1.3	Vector norms and distance metrics.	2
1.4	Interpretation and computation.	1
1.5	Matrix Decomposition- Singular Value Decomposition (SVD): concept and applications.	1
1.6	Singular Value Decomposition (SVD): concept and applications.	1
1.7	Dimensionality Reduction,	2
1.8	Principal Component Analysis.	1
MODULE II [11 hours]		
2.1	Basics of probability-random variables and statistical measures -	1
2.2	rules in probability	1
2.3	Bayes theorem and its applications- statistical estimation	1
2.4	Maximum Likelihood Estimator (MLE) - statistical summaries	1
2.5	Correlation analysis- linear correlation - regression analysis- .	1
2.6	linear regression (using least square method)	2
2.7	Types of Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics,	2
2.8	Prescriptive Analytics, Big Data Analytics, Web Analytics,	1
2.9	Social Media Analytics, Business Intelligence	1
MODULE III [14 hours]		
3.1	Introduction to data analysis and the EDA process.	1

3.2	Types of data: structured, unstructured, categorical, numerical.	1
3.3	Data collection techniques and sources (CSV files, APIs, databases).	2
3.4	Data cleaning: fixing rows and columns, handling missing data,	2
3.5	Data cleaning: standardizing values, treating invalid entries, removing duplicates.	2
3.6	Univariate analysis: distribution of individual variables.	1
3.7	Bivariate analysis: relationships between two variables.	2
3.8	Data visualization: histograms, box plots, scatterplots	2
3.9	Data visualization: pair plots, heatmaps.	1
MODULE IV [12 hours]		
4.1	Introduction to libraries: NumPy for numerical operations	1
4.2	Pandas for data manipulation, Matplotlib for visualization	2
4.3	SciPy for scientific computation.	1
4.4	Introduction to machine learning: overview of supervised, unsupervised, and reinforcement learning.	2
4.5	Key algorithms: regression, classification (logistic, Naïve Bayes), clustering (K-means).	2
4.6	Model training and testing using scikit-learn.	1
4.7	Evaluation metrics: accuracy, precision, recall, F1 score, confusion matrix.	1
4.8	End-to-end implementation of a basic machine learning pipeline with real-world datasets.	2
CO Assessment Questions		
CO 1	1. Define conditional probability and solve a problem involving Bayes' Theorem using real-world data.(6 marks) **[Remember and Apply]** 2. A dataset contains exam scores of 100 students. Calculate the mean, median, mode, variance, and standard deviation. Interpret your results.(6 marks) **[Apply]** 1. Compare and contrast population and sample distributions. Provide examples where sampling distribution plays a critical role.(5 marks)**[Apply]**	
CO 2	1. Given two vectors, compute their dot product, norm, and the distance between them.(5 marks)**[Apply]** 2. For a given 3×3 matrix, calculate its determinant, inverse, and eigenvalues using NumPy(6 marks). **[Apply]** 1. Explain the role of Singular Value Decomposition (SVD) in dimensionality reduction and demonstrate with a sample dataset.(6 marks) **[Remember and Apply]**	

CO 3	1. Collect a small dataset from a public source (e.g., Kaggle or UCI), identify missing values, and demonstrate how to handle them using Pandas.(5 marks) **[Apply and Analyze]** 2. Perform univariate and bivariate analysis on a dataset. Include visualizations (boxplots, histograms, scatterplots) and interpret the patterns.(6 marks) **[Apply and Analyze]** 1. Discuss the role of outlier detection in data cleaning. Use a boxplot to identify outliers in a numeric feature and explain your treatment method.(5 marks) **[Apply and Analyze]**
CO 4	1. Write Python code to read a CSV file, display summary statistics, and plot a histogram using Pandas and Matplotlib.(6 marks) **[Apply and Analyze]** 2. Using NumPy, create two matrices and perform operations: addition, multiplication, transpose, and trace. (6 marks) **[Apply]** 3. Use Seaborn to create a heatmap showing correlation between features in a dataset. Interpret the visual result.(6 marks). **[Analyze]**

Prepared By

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Dr. Krishnadas J
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Dr. Asha S
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24CEL307	SURVEY LAB	L	T	P	R	C	Year of Introduction
		0	0	3	0	2	2024

Preamble: The objective of this course is to provide students with hands-on experience by introducing them to various field surveying techniques. It aims to familiarize students with both conventional and modern surveying instruments.

Prerequisite: 24EST124 Introduction to Civil Engineering, 24ESL106 Civil Engineering Workshop , 24CER204 Surveying and Geomatics.

Course Outcomes: After the completion of course the student will be able to

CO1	Apply appropriate levelling principles to perform field surveying. **[Apply]**
CO2	Solve triangulation problems using theodolite and tacheometer. **[Apply]**
CO3	Set out a traverse and curve in the field using linear and angular measurements and apply suitable principle to balance the traverse. **[Apply]**
CO4	Employ advanced surveying equipments such as total station, auto level and so on for field surveying. **[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2			3			2			
CO2	3	2			3			2			
CO3	3		2		3	2	2	2			
CO4	3				3			2			2

Assessment Pattern

Bloom's Category	Continuous Assessment Tools		End Semester Examination
	Classwork	Lab Exam	
Remember	√	√	√
Understand	√	√	√
Apply	√	√	√
Analyze			
Evaluate			
Create			

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Classwork	Lab Exam	Total Marks
0-0-3-0	5	25	20	50

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	50	50	2.5 hrs

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks
(a) Procedure/Preliminary Work (10 Marks)
(b) Conduct of Experiment/Execution of Work (15 Marks)
(c) Result with Valid Inference (10 Marks)
(d) Viva Voce (10 Marks)
(e) Record (5 Marks)

SYLLABUS- DETAILS OF EXPERIMENTS

LEVELLING- Fly levelling, Profile levelling, Cross sectioning, Contouring.

THEODOLITE- Measurement of horizontal angle, Vertical angle, Determination of horizontal distances and elevations.

TACHEOMETRY- Tangential tacheometry.

TRAVERSING- Traversing and balancing the traverse using analytical and graphical methods.

TOTAL STATION- Determination of Heights and distances, Area computation, Contouring.

CURVE SURVEYING- Setting out of simple and compound curve.

STUDY- Automatic level, Digital level, Handheld GPS.

Self Study (24 hours):

- Principle of levelling.
- Temporary adjustments of Dumpy level / Auto level.
- Methods of contouring- Grid method.
- Interpolation to draw contour maps manually.
- Temporary and permanent adjustments of theodolite.
- Application of Sine rule and cosine rule.
- Working principle of total station.

Text books

1. J. Anderson and E. Mikhail, Surveying, Theory and Practice, 7th edition, New York: McGraw Hill Education, 2017.
2. Dr. B.C. Punmia, Ashok Kumar Jain & Arun Kumar Jain, Surveying , Laxmi publications (P) Ltd , 2005.
3. C. Venkatramaiah, Textbook of Surveying, Universities Press (India) Private Limited 2011
4. Prof. T.P.Kenetkar & Prof.S.V.Kulkarni, Surveying and Levelling , Pune VidyarthiGriha Prakashan,2004
5. W. Schofield and M. Breach, Engineering Surveying, 6th edition, Elsevier, CBSPD, 2007.

E-resource

1. Virtual lab on Surveying, NITK Surathkal- https://sl-iitr.vlabs.ac.in/

LIST OF EXPERIMENTS

(A minimum of 12 experiments are mandatory) **36 hours**

No.	Experiments
1.	Levelling- Fly levelling .
2.	Profile Levelling and Cross sectioning.

3.	Contouring using level (Dumpy level/Auto level)
4.	Theodolite – Repetition method.
5.	Theodolite – Reiteration method.
6.	Distance between inaccessible points (horizontal angle).
7.	Level difference between points (vertical angle).
8.	Tangential tacheometry (vertical angle).
9.	Traversing - Balancing the traverse using Transit rule and graphical method (Axis correction).
10.	Total station survey - Heights and distances.
11.	Area computation.
12.	Distance between inaccessible points using total station.
13.	Remote elevation method.
14.	Contouring - Determination of coordinates using total station and preparation of contour map using QGIS.
15.	Setting out of curve- simple curve.
16.	Setting out of curve - Compound curve using angular methods.
17.	Study of instruments a. Automatic level b. Digital level c. Handheld GPS
CO Assessment Questions	
CO1	Determine the level difference between first and last points in the given set, using Rise and fall method or Height of Instrument method. **(Apply)**
CO2	Deduce the distance between two given inaccessible points, using angular and linear measurements. **(Apply)**
CO3	Set out a traverse connecting the given points and balance the traverse using Bowditch's rule. **(Apply)**
CO4	Compute the area of given plot using total station. **(Apply)**

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24CEL308	COMPUTER AIDED BUILDING DRAWING LAB	L	T	P	R	C	Year of Introduction
		0	0	3	0	2	2024

Preamble: The objective of this course is to introduce students to the fundamentals of Civil Engineering drawing with a focus on computer-aided drafting techniques. The course aims to familiarize students with the principles of building planning and detailing, while developing proficiency in the use of drafting tools and software.

Prerequisite:
24EST203 Engineering Graphics, 24EST104: Introduction to Civil Engineering

Course Outcomes: After the completion of course, the student will be able to

CO1	Develop 2D drawings of building components and elements such as doors, windows, staircases, and trusses using AutoCAD. [**Apply**]
CO2	Interpret structural details from specifications and create accurate plan, section, and elevation views of various types of buildings. [**Analyze**]
CO3	Demonstrate proficiency in preparing detailed site plans, service plans, and building services drawings complying with relevant building rules and codes. [**Apply**]
CO4	Create and render 3D models of buildings for effective visualization and presentation. [**Create**]

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2				3						
CO2	2		2		3						
CO3	2		3		3	2					
CO4					3					2	

Assessment Pattern

Bloom's Category	Continuous Assessment Tools		End Semester Examination
	Classwork	Lab Exam	
Remember	√	√	√
Understand	√	√	√
Apply	√	√	√
Analyze	√	√	√
Evaluate			
Create	√	√	√

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Classwork	Lab Exam	Total Marks
0-0-3-0	5	25	20	50

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	50	50	2 .5 hrs

End Semester Examination Pattern:
The following guidelines should be followed regarding award of marks (a) Preliminary Work (10 Marks) (b) Execution of Work (15 Marks) (c) Quality of Work (10 Marks) (d) Viva Voce (10 Marks) (e) Record (5 Marks)
SYLLABUS
List of Experiments
(A minimum of 12 experiments are mandatory)
1. Draw plan, sectional details and elevation of panelled doors. (manually and AutoCAD)
2. Draw plan, sectional details and elevation of glazed windows and ventilators in wood.
3. Draw plan, section and elevation of dog legged staircase.
4. Draw plan, section and elevation of single storied residential buildings with flat roof. (manually and AutoCAD)
5. Draw plan, section and elevation of a two storied residential building.
6. Draw plan, section and elevation of a community hall having corrugated GI sheet roof.
7. Prepare detailed drawing on building services (for single and two storied buildings only) and on-site wastewater disposal systems like septic tank and soak pit.
8. Prepare a site plan and service plan as per latest building rules (KPBR or KMBR).
9. Draw plan, section and elevation of multi-storied framed buildings.
10. Draw plan, section and elevation of a public building – School.
11. Draw plan, section and elevation of a public building –public health centre
12. Draw plan, section and elevation of a public building – office complex, shopping centre, post office, bank etc.
13. Draw plan, section and elevation of an industrial building with corrugated GI steel roof and PEB based walling elements.
14. Create a 3D model of a two storied residential building and render the model.
Self-Study (24 hours) : **Standards for Doors and Windows – 5 Hours** • Study IS codes and standard sizes • Study materials, joinery, detailing methods • Review product catalogues and prepare a comparative sheet **Staircase Design Principles – 4 Hours** • Learn components, terminology, staircase types • Study geometric design rules and space requirements • Solve basic layout and calculation exercises **Structural Systems: Roof Trusses and Framed Buildings – 5 Hours** • Types of trusses, detailing of truss members • Study framed building components, layout of multi-storey buildings

- Detailing of connections and support arrangements

Building Rules & Regulations (KPBR/KMBR) – 5 Hours

- Study FAR, plot coverage, height restrictions, setbacks
- Understand site planning, service planning, submission drawings
- Work out examples on zoning and plot compliance

Study of Different Building Types – 5 Hours

- Residential buildings – single and multi-storey
- Public buildings – PHC, post office, banks
- Industrial buildings – steel sheds, PEB structures
- Community halls and comparative study of different functional layouts

Text Books:

1. Dr. Balagopal T.S. Prabhu, Building Drawing and Detailing, Spades Publishers, Calicut.
2. AutoCAD Essentials, Autodesk official Press, John Wiley & Sons, USA.
3. Shah, M.G., Kale, C. M. and Patki, S.Y. Building Drawing with an Integrated Approach to Built Environment, Tata McGraw Hill Publishing Company Limited, New Delhi.

Reference Books:

1. National Building Code of India. (refer the latest updates)
2. Kerala Panchayat Building Rules. (refer the latest updates)
3. Kerala Municipality Building Rules. (refer the latest updates)

CO Assessment Questions	
CO1	Draw the plan, section, and elevation of a panelled door (as per IS specifications) including all dimensions and labelling.
CO2	Draw the plan, elevation, and sectional view of a two-storied residential building with a flat roof.
CO3	Prepare a site plan and service plan of a residential building complying with KPBR/KMBR standards, including front/rear setbacks, access, and utility placements.
CO4	Create a 3D model of a two-storied residential building using AutoCAD.

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SEMESTER-IV
SYLLABUS

24MAT431	PARTIAL DIFFERENTIAL EQUATIONS AND OPERATIONAL RESEARCH TECHNIQUES	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:
The study of partial differential equations aims to explore the formulation, classification, and solution methods emphasizing their critical role in modeling natural processes and advancing technology. Techniques such as linear programming, transportation and assignment models equip learners with the tools necessary to analyze and solve complex decision problems effectively.

Prerequisite: Fundamentals of partial differentiation

Course Outcomes: After the completion of the course the student will be able to

CO 1	Create and solve partial differential equations which are widely used in different engineering situations.**[Apply]**
CO 2	Analyze 1-D wave equation and heat equation using the method of separation of variables applying appropriate initial and boundary conditions. **[Apply]**
CO 3	Use linear programming to optimize problems in various domains. **[Apply]**
CO 4	Apply transportation and assignment techniques to real-life scenarios in supply chain management, scheduling and workforce allocation. **[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2	3	2	2						
CO 2	3	2	2	2							
CO 3	3	2	2	2	2						
CO 4	3	2	3	2							

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze				
Evaluate				
Create				

Mark Distribution of CIA					
Course Structure [L-T-P-R]	**Attendance**	**Theory [L]**			**Total Marks**
		Assignment	**Test-1**	**Test-2**	
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hours

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: PARTIAL DIFFERENTIAL EQUATIONS (9 hours)

(Text 1-Relevant portions of sections 17.1, 17.2, 17.3, 17.4, 17.5, 17.7, 18.1, 18.2)

Formation of partial differential equations –elimination of arbitrary constants-elimination of arbitrary functions, Solutions of a partial differential equations. Equations solvable by direct integration, Linear equations of first order- Lagrange's linear equation. Solution of equation by the method of separation of variables.

Self-Study (13 hours):

1. A family of planes in 3D space is given by x+ay+bz=c , where a,b,c are arbitrary constants. Form a partial differential equation by eliminating the arbitrary constants.
2. A long, thin metal rod is heated and the temperature at any point along the rod is denoted by u(x,t) where x is the position along the rod and t is time. The temperature distribution is modeled by the equation: $u(x,t)=f(x-\alpha t)$ where f is an arbitrary function representing the initial temperature distribution, and α is a positive constant representing the speed at which heat propagates. Form the partial differential equation that describes the temperature distribution in the rod by eliminating the arbitrary function f.

MODULE II: APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS (9hrs)

(Text 1: Relevant topics from sections 18.3,18.4, 18.5)

One dimensional wave equation- vibrations of a stretched string, derivation, solution of the wave equation using method of separation of variables, One dimensional heat equation, derivation, solution of the heat equation .

Self- Study (14 hours):

1. A pipeline of length L=2 m transports a sensitive fluid that must stay close to room temperature. To prevent freezing or overheating, both ends of the pipe are maintained at a constant temperature of 20∘C. Initially, due to external exposure, the temperature along the pipe is nonuniform and given by: u(x,0)=20+10x(2−x), where x∈[0,2] meters. The fluid's temperature evolves according to the 1D heat equation with C^2 = 0.005 m^2/s . Find the steady-state temperature distribution along the pipe.
2. An underground tunnel of length L=500 m is modeled as a long elastic medium. During an earthquake, a seismic shock wave is initiated at one end of the tunnel. The wave propagation is modeled using the 1D wave equation with C^2 = 1500 m/s
   - The tunnel is fixed at both ends (no horizontal motion):
     $u(0,t) = u(500,t) = 0$
   - At $t = 0$, the ground is at rest: $u(x,0) = 0$
   - A sharp impulse is applied at the left end at $t = 0$, modeled by an initial velocity profile:

$$\frac{\partial u}{\partial t}(x,0) = \begin{cases} 10\left(1 - \frac{x}{50}\right), & 0 \le x \le 50 \\ 0, & 50 < x \le 500 \end{cases}$$

   Estimate the time it takes for the wave to reach the far end and reflect back and describe the physical meaning of the wave behavior at early and later times.

MODULE III: LINEAR PROGRAMMING AND OPTIMIZATION (9hours)

(Text 2: Relevant topics from sections 3.1,3.2,3.4,4.1,4.2,4.3,4.4)

Introduction to Linear programming, Formulation, Graphical solution, Basic feasible solution, Optimal solution, Simplex Method, tabular form, Optimality test.

Self-Study (13hours):

1. A factory manufactures two types of products: A and B. Each product requires time on two machines as shown below:

Machine	Time per unit of A (hours)	Time per unit of B (hours)	Total available time (hours)
M1	2	1	100
M2	1	1	80

The profit from each unit of product A is Rs.100, and from each unit of B is Rs.80. Determine how many units of products A and B the factory should produce to maximize profit, while not exceeding the available machine hours.

2. A fitness center wants to design an affordable and nutritious diet plan using two food items: Protein Shake (P) and Nutrition Bar (N). Each item contains different amounts of key nutrients, and the goal is to minimize cost while meeting daily nutritional requirements.

Item	Protein(g)	Carbs (g)	Fat (g)	Cost ($)
Protein Shake (P)	30	20	10	3
Nutrition Bar (N)	20	40	5	2

The daily minimum nutritional requirements for a member are: At least 60g of protein, At least 100g of carbohydrates and not more than 25g of fat. Determine how many Protein Shakes and Nutrition Bars the center should provide daily to minimize total cost while satisfying all nutritional constraints.

MODULE IV: ASSIGNMENT AND TRANSPORTATION PROBLEMS (9hours)

(Text 2: Relevant topics from sections 8.1,8.2,8.3,8.4)

Transportation Problems-Simplex Method, North-West corner rule, Least Cost rule, Vogels approximation Method, Assignment problems

Self-Study (14 hours):

A retail chain has three warehouses (Supply Nodes) and four retail stores (Demand Nodes). The company wants to transport goods from warehouses to stores at the lowest cost, but first needs an initial feasible shipping plan. The supply (in units) at each warehouse and the demand at each retail store are as follows:

Warehouse	Store-1	Store-2	Store-3	Store-4	Supply
A	4	6	8	13	50
B	5	7	9	6	60
C	6	4	7	5	40
Demand	30	20	70	30	

The cost per unit of shipping from each warehouse to each store (in $) is shown in the table.

1. Apply the North-West Corner Rule step-by-step to fill in the shipping table.
2. Calculate the total cost of this initial solution
3. Discuss whether this is optimal and what next steps (e.g., stepping stone or MODI method) would be used to optimize it.

Text books

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2018.
2. Hillier/Lieberman," Introduction to operations Research", McGraw Hill,7th edition,2019

Reference books

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 42nd Edition, 2012.
2. Peter V. O'Neil, Advanced Engineering Mathematics, Cengage, 7th Edition, 2012
3. Hamdy A. Taha, "Operations Research: An Introduction" ,10th Edition, 2017

NPTEL/SWAYAM Courses for reference:

1. Partial Differential Equations By Prof. Sivaji Ganesh, IIT Bombay
https://onlinecourses.nptel.ac.in/noc24_ma73
2. Optimization, By Dr.Debjani Chakraborty, IIT Kharagpur
https://nptel.ac.in/courses/111105039

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36]
	MODULE 1 [9 hours]	
1.1	Formation of partial differential equations	1
1.2	elimination of arbitrary constants	1
1.3	elimination of arbitrary functions	1
1.4	Solutions of a partial differential equations	1
1.5	Equations solvable by direct integration	1
1.6	Linear equations of the first order- Lagrange's linear equation	2
1.7	Solution of equation by method of separation of variables.	2
	MODULE II [9 hours]	
2.1	One dimensional wave equation	1
2.2	Vibrations of a stretched string, derivation	1
2.3	Solution of wave equation using method of separation of variables	2
2.4	One dimensional heat equation	2
2.5	Heat equation derivation	1
2.6	Solution of heat equation.	2
	MODULE III [9 hours]	
3.1	Introduction to Linear programming	1
3.2	Formulation of LPP	2
3.3	Graphical solution to LPP	1
3.4	Basic feasible solution	1
3.5	Optimal solution	2
3.6	Simplex Method , tabular form	1
3.7	Optimality test	1
	MODULE IV [9 hours]	
4.1	Transportation problems	1
4.2	Simplex Method	2
4.3	North-West corner rule	1
4.4	Least Cost rule	1
4.5	Vogels approximation Method	2
4.6	Assignment problems	2

CO Assessment Questions	
CO 1	1. The temperature T at any point in a thin rectangular metal plate depends on the distance r from a fixed point (say, the center of the plate). Form the partial differential equation that governs T, assuming T=f(r), where r = $\sqrt{x^2+y^2}$. **(Apply)** 2. Form a p.d.e. of all spheres of fixed radius and having centres in XY plane. **(Apply)** 3. Solve pyz + qzx = -2xy **(Apply)** **Team work:** Using MATLAB code solve the p.d.e given by $U_t + KU_x = 0$ where x∈[0 , 1], t ≥ 0
CO 2	1. What are the possible solutions of one dimensional wave equation? **(Apply)** 2. Find the displacement of a finite string of length 20m that is fixed at both ends is released from rest with an initial displacement f(x).**(Apply)** 3. What are the assumptions under which one dimensional heat equation can be derived? **(Apply)**
CO 3	1. A factory produces two products: tables and chairs. Each table requires 3 hours of carpentry and 1 hour of painting. Each chair requires 2 hours of carpentry and 2 hours of painting. The factory has 90 hours of carpentry and 80 hours of painting available per week. Each table yields a profit of Rs.540, and each chair yields Rs.400. How many tables and chairs should the factory produce per week to maximize profit? **(Apply)** 2. A company produces two products, P1 and P2. Each unit of P1 requires 1 hour of labor and 2 kg of material. Each unit of P2 requires 2 hours of labor and 1 kg of material. The company has 6 hours of labor and 6 kg of material available. Find the basic feasible solutions for the feasible region defined by these constraints. **(Apply)** **Team Work**: A person wants to create a diet that meets daily nutritional requirements at the lowest cost. They can choose from two foods, F1 and F2. • Each unit of F1 provides 2 units of protein and 1 unit of calcium, and costs Rs.120 • Each unit of F2 provides 1 unit of protein and 2 units of calcium, and costs Rs.150 • The diet must provide at least 8 units of protein and at least 6 units of calcium. Using MATLAB code, find how many units of each food should the person eat daily to minimize cost, while meeting nutritional needs?

CO 4	1. How can we apply North west corner rule to obtain an initial basic feasible solution; Illustrate with a suitable example. **(Apply)** 2. How assignment problem can be made use in real life situations? Explain with a specific example. **(Apply)** 3. Discuss merits and demerits of Vogel's approximation method? **(Apply)**

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24EST402	STRUCTURAL ANALYSIS II	L	T	P	R	C	Year of Introduction
		4	0	0	0	4	2024

Preamble:
The course enables the students to analyze various types of multistoreyed structures using appropriate methods and tools. It utilises the procedures of force methods and displacement methods for analysing structures. Plastic theory and its applications are introduced to students. A significant topic in the application of principles of dynamics to analyze structures undergoing dynamic deformations is also familiar. The course trains the students to develop mathematical models and helps to sharpen their analytical skills, which also helps the students to lay the foundation for further advanced topics like the finite element method.

Prerequisite: 24CET302 Structural Analysis I

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Understand the principles of plastic theory and its applications in structural analysis. **(Understand)**
CO 2	Apply approximate analysis of multistoried frames under vertical and lateral loads to ascertain stress resultants. **(Apply)**
CO 3	Apply the force method to analyze structures. **(Analyze)**
CO 4	Apply the displacement methods to analyze structures. **(Analyze)**
CO 5	Analyze the dynamic behaviour of single-degree-of-freedom (SDOF) systems, including free and forced vibration responses, and apply these concepts to simple portal frame problems. **(Analyze)**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	1								
CO 2	3	3	1					2			
CO 3	3	3	1					2			
CO 4	3	3	1					2			
CO 5	3	3	1					2			

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓	✓	✓
Understand	✓	✓	✓	✓
Apply	✓	✓	✓	✓
Analyze	✓	✓	✓	✓
Evaluate				
Create				

Mark Distribution of CIA

Attendance	Theory [L]			Total Marks
	Assignment	Test-1	Test-2	
5	10	12.5	12.5	**40**

Total Marks distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hrs

End Semester Examination [ESE]: Pattern

PATTERN	PART A	PART B	ESE Marks
PATTERN 1	8 Questions, each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 subdivisions. Each question carries 9 marks. Marks: (4x9 = 36 marks)	60

SYLLABUS

MODULE I: PLASTIC THEORY (12 hours)

Plastic Theory: Introduction- plastic hinge concepts, plastic modulus, shape factor (circular, rectangular, square, diamond, triangle, and symmetric I section), redistribution of moments – collapse mechanisms, Plastic analysis of beams and portal frames by equilibrium and mechanism methods. (single-storey and single-bay frames only).

Approximate methods of analysis of multi-storeyed frames: Analysis for vertical loads-substitute frames-loading condition for maximum hogging and sagging moments in beams and maximum bending moment in columns.

Self-Study (18 hours) :

- Discuss the conditions under which a plastic hinge forms in beams and frames.
- Compare the shape factors of different sections and analyze their implications on structural behavior.
- Explain the concept of moment redistribution in statically indeterminate structures.

Determine loading conditions for maximum hogging and sagging moments in beams and maximum bending moments in columns.

MODULE II : FLEXIBILITY METHOD (12 hours)

Approximate methods (continued): Analysis for lateral loads – portal method, cantilever method.

Flexibility method: Definition of flexibility influence coefficients - Concepts of physical approach. Flexibility matrices for beam, frame, and truss - load transformation matrix- development of a total flexibility matrix of the structure analysis of simple structures.

Self-Study (18 hours):

- Develop the flexibility matrix for a continuous beam with fixed and hinged supports.
- Derive the flexibility coefficients for simple beams and trusses using the physical approach.

Derive the load transformation matrix for a structure subjected to multiple loading conditions.

MODULE III : STIFFNESS METHOD (12 hours)

Stiffness Method - Definition of stiffness influence coefficients - Concepts of physical approach. Development of stiffness matrices by the physical approach- stiffness matrices

for beam, frame, and truss elements- displacement transformation matrix- analysis of simple indeterminate structures- beam, frame, and truss -nodal loads and element loads.
Direct stiffness method - Introduction to direct stiffness method- stiffness matrix of beam elements, assembly of load vector and stiffness matrix, Numerical problems in beams only.
Self-Study (18 hours):

- Derive the displacement transformation matrix for a beam and truss element.
- Explain how equivalent nodal loads are derived for distributed and concentrated loads.
- Explain the step-by-step procedure of the direct stiffness method.

MODULE IV: STRUCTURAL DYNAMICS (12 hours)

Introduction – dynamic loading and types, free and forced vibration, degrees of freedom - Basic components of a dynamic system, Equation of motion, D'Alembert's principle, Damping- free response of damped and undamped systems- damping ratio, critical damping, logarithmic decrement, simple portal frame problems.
Self-Study (18 hours):

- Develop the equation of motion for an SDOF system using Newton's second law and D'Alembert's principle.
- Derive the solution for undamped free vibration (natural frequency, amplitude, phase angle).

Analyze free vibration response of damped systems (underdamped, critically damped, overdamped).

Textbooks

1. James M Gere & William Weaver, Matrix Analysis of Framed Structures - (CBS Publishers)
2. Junnarkar S.B., Mechanics of Structures Vol I & II, Charotar Publishing House
3. Devdas Menon, Structural Analysis, Narosa Publications
4. V.K Manicka Selvam, Elements of Matrix and Stability Analysis of Structures, Khanna Publishers
5. S S Bhavikatti, Structural Analysis -II, Vikas Publishing House
6. Wang C.K., Intermediate Structural Analysis, McGraw Hill

Mario Paz, Structural Dynamics

Reference books

1. Pandit and Gupta, Structural Analysis – A Matrix Approach
2. Reddy C.S., Basic Structural Analysis, Tata McGraw Hill
3. Norris and Wilbur, Elementary Structural Analysis, Tata McGraw Hill
4. Punmia B. C., Strength of Materials and Mechanics of Structures, Laxmi Publications
5. RC Hibbeler, Structural Analysis
6. Wang C K, Matrix Method of Structural Analysis
7. Anil. K. Chopra, Dynamics of structures, Pearson Education/ Prentice Hall India,
8. Clough R.W. and Penzein, J., Dynamics of structures - Tata McGraw Hill
9. Madhujith Mukhopadhyay and Abdul Hamid Sheikh, Matrix and Finite Element Analysis of Structures, Ane Books India.
10. Rajasekharan & Sankara Subramanian, Computational Structural Mechanics
11. William T Thomson, Theory of vibration with application
    Tse, Morse Hinkle, Mechanical Vibrations

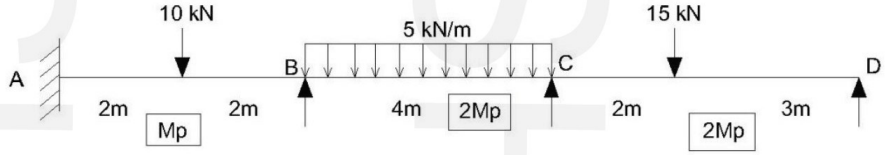
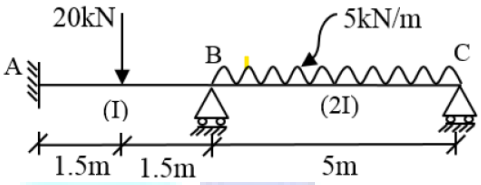
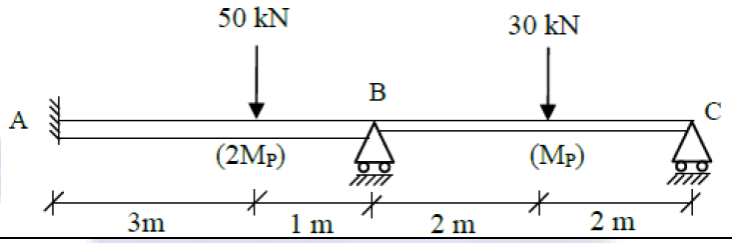
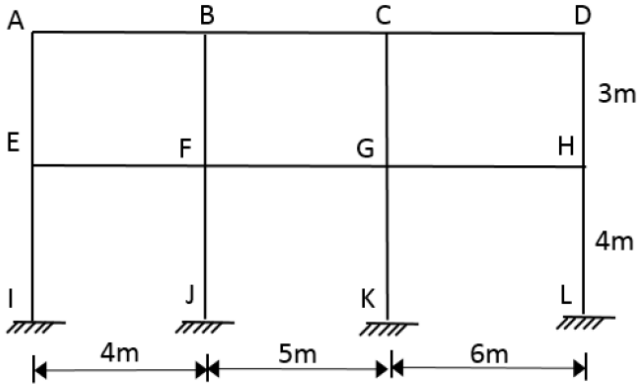
NPTEL/SWAYAM Courses for reference:

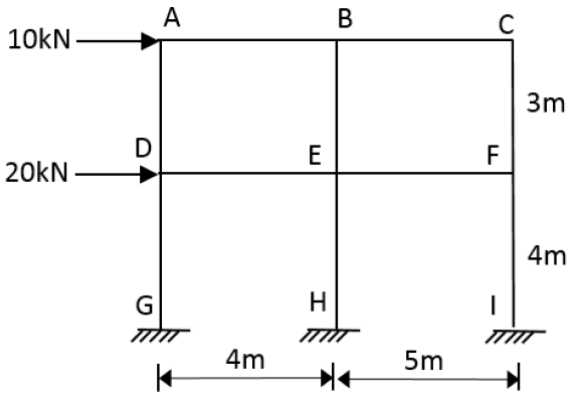
1. Structural Analysis II, IIT Kharagpur, Prof. L.S. Ramachandra, Prof. Sudhir Kumar Barai

   https://nptel.ac.in/courses/105105109
2. Structural Analysis II, IIT Bombay, Dr. P. Banerji
   nptel.ac.in/courses/105101086
3. Structural Dynamics, IIT Bombay, Dr. P. Banerji
   nptel.ac.in/courses/105101006

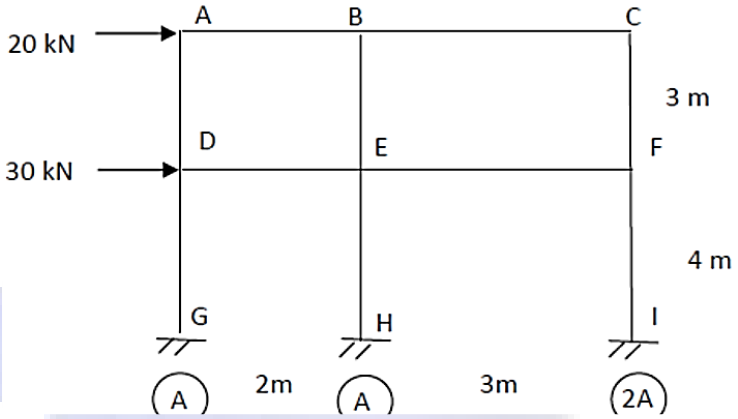
COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours (48)
	MODULE I (12 Hrs)	
1.1	**Plastic Theory:** Introduction- plastic hinge concepts, plastic modulus	1
1.2	Shape factor (circular, rectangular, square, diamond, triangle, and symmetric I section)	3
1.3	Redistribution of moments – collapse mechanisms, Plastic analysis of beams and portal frames by equilibrium and mechanism methods. (single-storey and single-bay frames only).	5
1.4	Analysis for vertical loads-substitute frames-loading condition for maximum hogging and sagging moments in beams and maximum bending moment in columns.	3
	MODULE II (12 Hrs)	
2.1	Analysis for lateral loads – portal method, cantilever method.	3
2.2	Definition of flexibility influence coefficients - Concepts of physical approach.	2
2.3	Flexibility matrices for beam, frame, and truss.	2
2.4	Load transformation matrix- development of a total flexibility matrix for the structure analysis of simple structures.	5
	MODULE III (12 Hrs)	
3.1	Definition of stiffness influence coefficients - Concepts of physical approach.	1
3.2	Development of stiffness matrices by the physical approach- stiffness matrices for beam, frame, and truss elements.	2
3.3	Displacement transformation matrix- analysis of simple indeterminate structures- beam, frame, and truss -nodal loads and element loads.	5
3.4	Introduction to direct stiffness method- stiffness matrix of beam elements, assembly of load vector and stiffness matrix, Numerical problems in beams only.	4
	MODULE IV (12 Hrs)	
4.1	Introduction – dynamic loading and types, free and forced vibration, degrees of freedom.	3
4.2	Basic components of a dynamic system, Equation of motion, D'Alembert's principle.	1
4.3	Damping- free response of damped and undamped systems- damping ratio, critical damping, logarithmic decrement.	3
4.4	Numerical problems in a simple portal frame.	5

	CO Assessment Questions
CO1	**1.** Derive an expression for the shape factor of a rectangular cross section. **(Understand)** **2.** Define the following terms: (a) Plastic moment, (b) Plastic hinge, (c) Plastic section modulus. **(Understand)** 3. Calculate the plastic moment of the given beam. **(Apply)**  4. Analyze the continuous beam shown in the figure below by the flexibility method. **(Analyze)**  5. Determine the plastic moment carrying capacity, Mp for the continuous beam shown in the figure below. Take load factor = 1.5. **(Apply)** 
CO2	1. What are the assumptions made in the portal method of analysis for horizontal loads? **(Understand)** **2.** Analyze the frame shown below for midspan positive moment on span FG, using the Substitute frame method. Total dead load is 15kN/m, and total live load is 30kN/m. Flexural rigidity EI is the same for all members. **(Analyze)**  3. Analyze and determine the beam and column moments for the frame shown in the figure below by the Portal method. Flexural rigidity EI is the same for all members. **(Analyze)**



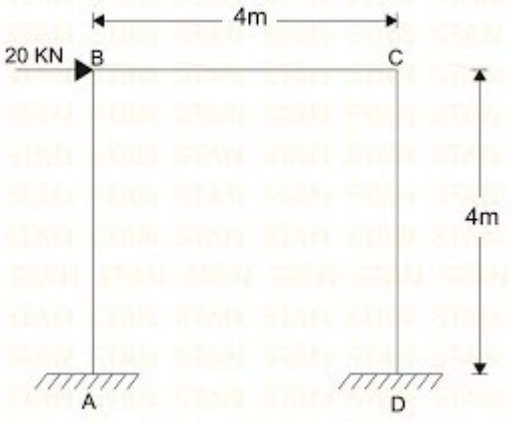
4. Analyze the rigid frame loaded as shown in the figure using the cantilever method. Compute the BM in beams and columns. Cross-section areas of columns are given as A, A, and 2A. **(Analyze)**



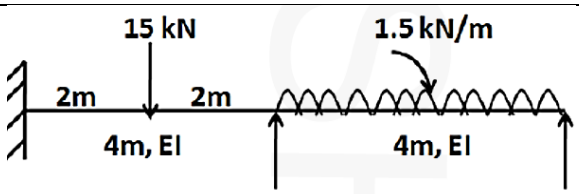
5. Write short note on the approximate method of analysis of multi storeyed building for vertical load. **(Understand)**

CO3

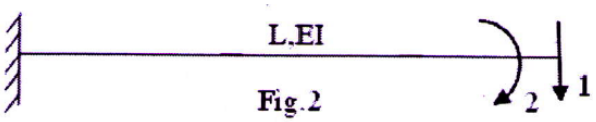
1. Analyze the frame using the flexibility matrix method. **(Analyze)**



2. Analyze the continuous beam shown in the figure below by the flexibility method. **(Analyze)**



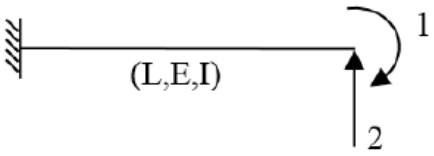
3. Derive the flexibility matrix using the physical approach for the coordinates marked in the figure. **(Apply)**



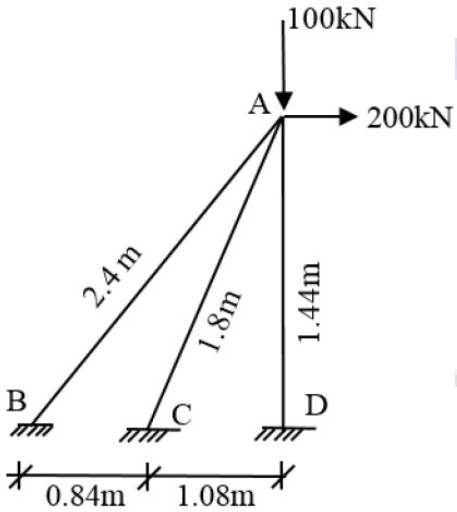
4. Define flexibility coefficient. **(Understand)**
5. Differentiate between the force method and the displacement method of analysis. **(Understand)**

CO4

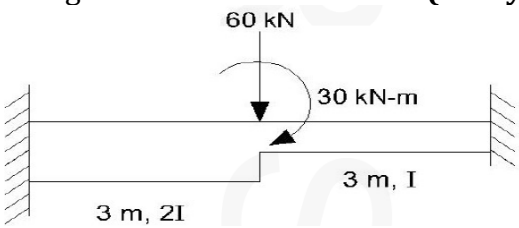
1. Derive the stiffness matrix for the coordinates shown in the figure below. **(Apply)**



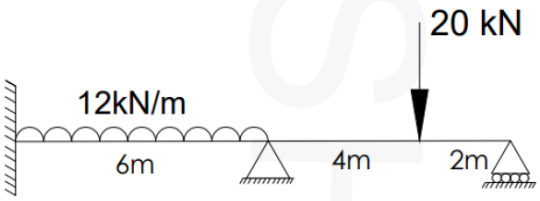
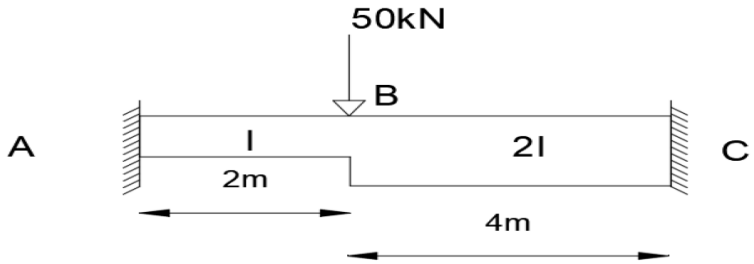
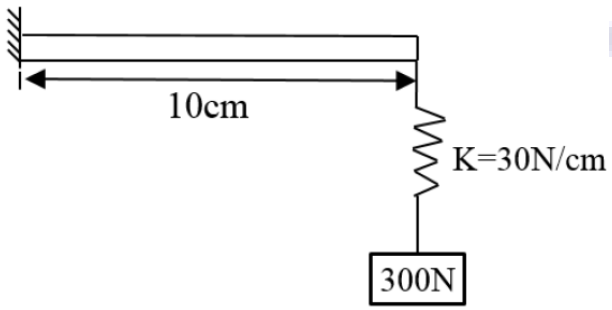
2. Find the vertical and horizontal deflection at joint A for the truss shown in figure below by stiffness method. Axial rigidity AE is same for all members. **(Apply)**



3. Analyze the beam using stiffness matrix method. **(Analyze)**



4. Analyze the continuous beam shown in figure using the direct stiffness

	method. **(Analyze)**  5. Analyze the beam shown in figure using the direct stiffness method.**(Analyze)** 
CO5	1. Define the following terms: (i) free and forced vibration, (ii) damped and undamped vibration. **(Understand)** 2. Derive an expression for the response of the SDOF system subjected to damped free vibration in 'x' direction with mass m, spring constant k, and damping constant c. **(Understand)** 3. Determine the natural frequency of the system shown in the figure below. A weight of 300N is connected to the cantilever through a spring of stiffness 30N/cm. The beam is 3.5cm wide and 0.5cm deep in cross section, and of span 10cm. Given the modulus of elasticity E = 2×10^5 N/mm^2. **(Apply)**  **4.** Calculate the natural frequency of transverse vibrations of a cantilever beam 40mm diameter circular cross-section, carrying a load of 500N at the free end. Span of the cantilever beam is 800mm. E= 200kN/mm^2. If a spring of stiffness 52.75kN/m is introduced between the mass and the beam. Calculate the change in natural frequency. **(Analyze)** **5.** Define (i)logarithmic decrement (ii) Damping ratio and (iii) Critical damping **(Understand)**

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24CET403	SOIL MECHANICS	L	T	P	R	C	Year of Introduction
		4	0	0	0	4	2024

Preamble

The objectives of this course are to understand the fundamental concepts of index and engineering properties of soil, and to explore various laboratory methods used to determine soil characteristics. Additionally, it aims to analyze stress distribution within soil and to investigate important soil behaviors such as shear strength, compaction, and consolidation characteristics.

Prerequisite: 24EST205- Mechanics of Solids, 24CET303-Fluid Mechanics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Evaluate the basic soil properties based on tests and functional relationships. **[Apply]**
CO 2	Classify soils based on index properties. **[Analyze]**
CO 3	Compute stresses developed in soil under different loading and hydraulic conditions. **[Apply]**
CO 4	Assess the engineering properties of soil using various tests and theorems. **[Analyze]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	3	2								
CO 2	3	3	3								
CO 3	3	3	3			2					
CO 4	3	3	3			2					

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓	✓	✓
Understand	✓	✓	✓	✓
Apply	✓	✓	✓	✓
Analyze	✓	✓	✓	✓
Evaluate				
Create				

Mark Distribution of CIA

Course Structure L-T-P-R	Attendance	Theory [L]			Total Marks
		Assignment	Test-1	Test-2	
4-0-0-0	5	10	12.5	12.5	40

Total Marks distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hrs

End Semester Examination [ESE]			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	2 questions from each module 8 Questions, each carries 3 marks. Marks:3x8=24 marks	2 questions will be given from each module, of which 1 should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9 marks. Marks: (4x 9 = 36 marks)	60

SYLLABUS

MODULE I: NATURE OF SOIL AND FUNCTIONAL RELATIONSHIPS (12 hours)

Introduction to geotechnical engineering– Soil types – Major soil deposits of India - Three phase system –Basic soil properties : Void ratio, porosity, degree of saturation, air content, water content, specific gravity, unit weight - Relationship between basic soil properties, Relative Density- Numerical problems.

Determination of Water content by oven drying, Specific gravity using pycnometer & specific gravity bottle - Determination of Field density by sand replacement method and Core Cutter method - Numerical problems.

Soil Structure and their effects on the basic soil properties –Basic structural units of clay minerals.

Self study (18 hours):

1. Summarize the different types of soil deposits found in India and evaluate their suitability for construction purposes.
2. Explain main types of soil structures and their effects on the basic soil properties.
3. Describe the basic structural units of clay minerals.

MODULE II : INDEX PROPERTIES, CONSISTENCY LIMITS & PERMEABILITY OF SOILS (12 hours)

Sieve analysis, Hydrometer analysis-stokes law, corrections to hydrometer readings, gradation of soil,

Atterberg Limits and indices – Plasticity charts – activity of soil-laboratory tests for Liquid Limit (Casagrande's apparatus and cone penetrometer), Plastic Limit and Shrinkage Limit - Numerical problems.

IS classification of soil .

Permeability, Darcy's law – Factors affecting permeability – Laboratory tests: Constant head and variable head permeability tests - Average permeability of stratified deposits - Numerical problems.

Self study (18 hours):

1. Explain the procedure for calibration of hydrometer.
2. Describe the process of combined sieve and hydrometer analysis of soil.
3. Compare IS system with other systems of soil classification.

MODULE III : STRESS DISTRIBUTION AND COMPACTION OF SOIL(12 Hours)

Principle of effective stress - Total, neutral and effective stress – Pressure diagrams in layered soil with water table, saturated by capillary action, subjected to surcharge load – Numerical problems- Quick sand condition – Critical hydraulic gradient

Stress distribution : Introduction - Boussinesq's equations for vertical pressure due to point loads and line loads – Assumptions and Limitations - Numerical problems - Vertical pressure due to uniformly distributed loads beneath strip, circular [no derivation required] - Numerical problems. Vertical pressure due to loading on rectangular area and Fadum's chart (Brief description only)Approximate methods for vertical stress: Equivalent Point Load method & 2:1 Distribution Method - Numerical problems - Pressure Isobars – Pressure bulbs. distribution of contact pressure beneath footings.

Compaction – OMC and MDD, Zero Air voids line, IS Light & Heavy- Factors affecting compaction-Numerical problems – Field compaction methods-compaction control – Proctor needle.

Self study (18 hours):

1. Describe the effect of water table and saturation on stresses in soil.
2. Analyse foundation failures due to poor stress evaluations.
3. Analyze how different compaction energy levels affect MDD and OMC. Then, justify which method is more suitable for:

   (a) Highway subgrade
   (b) Earth dam core

MODULE IV : CONSOLIDATION AND SHEAR STRENGTH OF SOIL (12 hours)

Consolidation - Definition – Concepts of Coefficient of compressibility and volume compressibility - e-log p curve - Compression index, Recompression index and Pre-consolidation Pressure - Normally consolidated, over consolidated and under consolidated soils - Terzaghi's theory of one-dimensional consolidation with its assumptions (no derivation required) - average degree of consolidation – Time factor - Coefficient of consolidation - Numerical problems - Laboratory consolidation test – Determination of Coefficient of Consolidation.

Shear strength of soils- Mohr-Coulomb failure criterion - Mohr circle method for determination of principal planes and stresses– relationship between shear parameters and principal stresses - Numerical problems - Brief discussion of Laboratory tests – Triaxial compression test - UU, CU and CD tests - Total and effective stress strength parameters - Unconfined compression test, Direct shear test and vane shear test.

Self study (18 hours):

1. Differentiate between consolidation and compaction .
2. Explain the test setup for Triaxial compression test including the auxiliary apparatus with neat sketches.
3. Describe the suitability of UU, CU, CD shear tests in real life scenarios.

Textbooks

1. Dr. K. R. Arora, Soil Mechanics and Foundation Engineering, Standard Publishers and distributers., Seventh Edition, 2020.
2. Rangan G. and A.S.R. Rao, Basic and applied soil mechanics, New Age International Private Limited., Fourth Edition, 2022
3. Dr. B C Punmia, Er. Ashok Kumar, Dr. Arun Kumar Jain, Soil Mechanics and Foundations, Laxmi Publications (P) ltd, Eighteenth Edition 2015
4. Venkatramaiah, Geotechnical Engineering, Universities Press.

Reference books

1. Purushothamaraj P., Soil Mechanics and Foundation Engineering, Dorling Indersley (India), Pvt. Ltd, 2013.
2. A V Narasimha Rao and C Venkatramaiah, Numerical Problems, Examples and Objective questions in Geotechnical Engineering,, Universities Press (India) Ltd.,2000.

Aid for Self-Learning (Recommended):

Soil structure, Clay mineralogy
https://archive.nptel.ac.in/content/storage2/courses/105103025/pdf/pdf2.pdf

NPTEL/SWAYAM Courses for reference:

1. Geotechnical Engineering 1 by Prof D N Singh, IIT Bombay- https://archive.nptel.ac.in/courses/105/101/105101201/
2. Soil Mechanics/ Geotechnical Engineering 1 by Prof D K Baidya, IIT Kharagpur - https://archive.nptel.ac.in/courses/105/105/105105168/

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours (48)
	MODULE I - 12 hours	
1.1	Introduction to geotechnical engineering, Three phase system.	1
1.2	Basic soil properties : Void ratio, porosity, degree of saturation, air content, water content, specific gravity, unit weight.	2
1.3	Relationship between basic soil properties, Relative Density- Numerical problems.	5
1.4	Determination of Water content by oven drying, Specific gravity using pycnometer & specific gravity bottle .	2
1.5	Determination of Field density by sand replacement method and Core Cutter method - Numerical problems.	2
	MODULE II- 12 hours	
2.1	Sieve analysis – Well graded, poorly graded and gap graded soils .	1
2.2	Hydrometer analysis-stokes law, corrections to hydrometer readings, gradation of soil.	1
2.3	Atterberg Limits and indices, Plasticity charts, activity of soil.	2
2.4	Laboratory tests for Liquid Limit (Casagrande's apparatus and cone penetrometer), Plastic Limit and Shrinkage Limit.	2
2.5	Numerical problems.	2
2.6	IS classification of soil- Numerical problems.	2
2.7	Permeability, Darcy's law -Factors affecting permeability– Laboratory tests: Constant head and variable head permeability tests - Average permeability of stratified deposits - Numerical problems.	2
	MODULE III - 12 hours	
3.1	Total, neutral and effective stress – Pressure diagrams in layered soil with water table, saturated by capillary action, subjected to surcharge load – Numerical problems.	4

3.2	Quick sand condition – Critical hydraulic gradient.	1
3.3	**Stress distribution** : Introduction - Boussinesq's equations for vertical pressure due to point loads and line loads – Assumptions and Limitations - Numerical problems.	1
3.4	Vertical pressure due to uniformly distributed loads beneath strip, circular [no derivation required] - Numerical problems. Vertical pressure due to loading on the rectangular area and Fadum's chart (Brief description only).	2
3.5	Approximate methods for vertical stress: Equivalent Point Load method & 2:1 Distribution Method - Numerical problems - Pressure Isobars – Pressure bulbs. distribution of contact pressure beneath footings.	2
3.6	**Compaction** –Factors affecting compaction, OMC and MDD, Zero Air voids line, IS Light & Heavy compaction.	2
3.7	Field compaction methods-compaction control –Proctor needle.	1
MODULE IV- 12 hours		
4.1	**Consolidation** - Definition – Concepts of Coefficient of compressibility and volume compressibility.	1
4.2	e-log p curve - Compression index, Recompression index and Pre-consolidation Pressure - Normally consolidated, over consolidated and under consolidated soils.	2
4.3	Terzaghi's theory of one-dimensional consolidation with its assumptions (no derivation required) - average degree of consolidation – Time factor - Coefficient of consolidation - Numerical problems.	3
4.4	Laboratory consolidation test – Determination of Coefficient of Consolidation.	1
4.5	**Shear strength of soils**- Mohr-Coulomb failure criterion, relationship between shear parameters and principal stresses - Numerical problems.	1
4.6	Brief discussion of Laboratory tests – Triaxial compression test - UU, CU and CD tests - Total and effective stress strength parameters. Unconfined compression test, Direct shear test and vane shear test.	3
4.7	Mohr circle method for determination of principal planes and stresses	1
CO Assessment Questions		
CO 1	**3-Mark Questions** 1. Derive the relationship between void ratio and porosity. **(Understand)** 2. Define Water Content, Degree of Saturation and Air Content. **(Understand)** 3. Draw phase diagrams for fully saturated and dry soil.**(Understand)** **9-Mark Questions** 1. A soil has a porosity of 40%, the specific gravity of solids of 2.65 and a water content of 12%. Determine the volume of water required to be added to 100m^3 of this soil for full saturation. **(Apply)**	

	The volume and weight of an undisturbed saturated soil sample are 1 x 10^{-3} m^3 and 17.2N, respectively. Given that the specific gravity of the soil solid is 2.62, determine the (i) moisture content, (ii) porosity, (iii) degree of saturation and (iv) saturated unit weight.**(Apply)** 2. The following observations were recorded in a field density determine by the sand-replacement method: Volume of can =10^{-3} m^3 Weight of empty can = 9.81N Weight of can + sand = 26.10 N Weight of sand required to fill the excavated hole = 8.12N Weight of excavated soil =9.17N In situ water content = 10% Determine the in situ bulk unit weight and in situ dry unit weight. **(Apply)**
CO 2	**3-Mark Questions** 1. What is the difference between Dry density and Relative Density? **(Apply)** 2. Define Liquidity Index, Consistency Index and Flow Index. **(Understand)** 3. List out the corrections applied in hydrometer readings. **(Understand)** **9-Mark Questions** 1. Sketch the IS plasticity chart for fine-grained soil. Explain the symbols used in the chart for soil classification. **(Apply)** 2. An undisturbed soil sample of clay brought from the field was noted to have a volume of 18.0 cc and weight of 30.8 g. On oven drying, the weight of the sample was reduced to 20.5g. The volume of dried sample as obtained by displacement of mercury was 12.5 cc. Calculate shrinkage limit and the specific gravity of solids. What is the shrinkage ratio? **(Apply)** 3. Sketch the particle size distribution curve for (a)Well graded soil, (b)Poorly graded soil and (c) gap graded soil. Show how the data for the effective size and uniformity coefficient are identified from the grading curve. **(Apply)**
CO 3	**3-Mark Questions** 1. Explain Total Stress, Effective Stress and Neutral Stress. **(Understand)** 2. With a neat sketch explain isobar and pressure bulb. **(Understand)** 3. Explain what is meant by the Quick sand Condition.**(Understand)** **9-Mark Questions** 1. A soil profile consists of top layer of sand 3 m thickness having bulk unit weight 16kN/m^3, an intermediate layer of clay 3.5m thickness having saturated unit weight 20kN/m^3 and bottom layer of sand 5 m thickness having saturated unit weight of 18kN/m^3. The water table is observed at 3m below ground level.Determine the total stress, neutral stress and

	effective stress at top, bottom and interface of layers and plot the variation of these stresses with depth. **(Apply)** 2. A water tank is supported by a ring foundation having an outer diameter of 7.5m and an inner diameter of 5m. The ring foundation transmits uniform load intensity of 200kN/m^2 . Compute the vertical stress induced at a depth of 5m below the centre of the ring foundation using the Boussinesq equation. **(Apply)** 3. An 8 m thick layer of stiff saturated clay (γ = 19 kN/m^3) is underlain by a layer of sand. The sand is under artesian pressure of 5 m. Calculate the maximum depth of cut that can be made without a heave. **(Apply)**
CO 4	**3-Mark Questions** 1. Explain normally consolidated, over consolidated and under consolidated soils.**(Understand)** 2. Explain Consolidated Undrained, Unconsolidated Undrained and Consolidated Drained Shear tests for soils. **(Understand)** 3. Outline the use of compaction curve developed from IS light compaction test in a soil sample taken from a borrow site selected for embankment construction. **(Apply)** **9-Mark Questions** 1. For a normally consolidated clay specimen drained on both sides, the following data are given. $\sigma 0$ = 30 kPa; e = e0 = 1.1 $\sigma 0 + \Delta\sigma$ = 60 kPa; e = 0.9 Thickness of clay specimen = 25.4 mm Time for 50% consolidation = 2 min Determine the hydraulic conductivity (mm/s) of the clay for the loading range. How long (in days) will it take for a 2 m clay layer in the field (drained on one side) to reach 60% consolidation? **(Apply)** 2. In a standard proctor test, 1.8 kg of moist soil was filling the mould (volume = 944 cc) after compaction. A soil sample weighing 23 g was taken from the mould and oven dried for 24 hours at a temperature of 110oC. Weight of the dry sample was found to be 20 g. Specific gravity of soil solids is G = 2.7. What is the theoretical maximum value of the dry unit weight of the soil at that water content?**(Apply)** 3. In a drained triaxial compression test on dense sand the cell pressure was 200kPa and the deviator stress to cause failure was 550kPa. Calculate the angle of shearing resistance. Also find the angle made by the failure plane with respect to the major principal plane. **(Analyze)**

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24CER404	WATER RESOURCES ENGINEERING	L	T	P	R	C	Year of Introduction
		3	0	0	1	4	2024

Preamble: The objective of this course is to develop an understanding of the hydrologic data like precipitation, run-off, groundwater, and its application in irrigation engineering. Students will have knowledge of management of water resources. Students will develop the skills to accurately collect, analyze, and interpret hydrological data and apply this knowledge for designing hydraulic structures in water resources engineering.

Prerequisite: 24CET303 Fluid Mechanics

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Interpret the different components of hydrologic cycle **[Understand]**
CO 2	Compute precipitation and runoff using hydrologic data**[Apply]**
CO 3	Describe soil water crop relationship and compute irrigation water requirements **[Apply & Evaluate]**
CO4	Propose methods for management of water resources **[Analyze & Evaluate]**
CO 5	Perform analysis of hydrologic data for management of water resources**[Create]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3										2
CO 2	3	3									2
CO 3	2	2	2			2					2
CO 4	2				3						2
CO 5	1	3	3	2	2	3		2	1	2	2

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓		✓
Understand	✓	✓	✓	✓

Apply	✓	✓	✓	✓
Analyze	✓	✓	✓	✓
Evaluate				
Create				

Assessment Pattern for Project Component

Bloom's Category	**Continuous Assessment Tools**		
	Evaluation 1	**Evaluation 2**	**Report**
Remember	✓	✓	✓
Understand	✓	✓	✓
Apply	✓	✓	✓
Analyze	✓	✓	✓
Evaluate		✓	✓
Create		✓	✓

Mark Distribution of CIA

Course Structure	**Attendance**	**Theory [L]**			**Project [R]**			**Total Marks**
		Assignment	**Test-1**	**Test-2**	**Evaluation 1**	**Evaluation-2**	**Report**	
3-0-0-1	5	10	7.5	7.5	5	10	5	50

Total Marks distribution

Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2 hrs

End Semester Examination [ESE]

PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 2	2 Questions from each module, 8 Questions, Answer any 6 Questions, Each question carries 3	2 Questions will be given from each module, out of which 1 question should be answered.	50

	marks. Marks: (6 x 3 = 18 marks)	Each question can have a maximum of 2 subdivisions. Each question carries 8 marks. Marks: (4 x 8 = 32 marks)	

SYLLABUS

MODULE I: SURFACE AND GROUNDWATER HYDROLOGY (9 hours)

Hydrologic cycle - Components of hydrologic cycle - catchment area - Water Budget equation.

Precipitation- types, forms- measurement using rain gauges.

Optimum number of rain gauges, estimation of missing precipitation, presentation of rainfall data- mass curve, hyetograph and point rainfall. Computation of mean precipitation over a catchment. Depth- Area- Duration (DAD)curves, Intensity Duration Frequency (IDF) curves (conceptual idea only).

Abstractions from precipitation- Losses- Evaporation-Evaporimeters, Evapotranspiration, Initial Loss, Infiltration- measurement by double ring infiltrometer, Horton's equation, infiltration indices.

Groundwater - Vertical distribution of groundwater - classification of aquifers, Water Table, Aquifer properties- Specific yield, Permeability

SELF-STUDY (18 hours)

1. Prepare a note on the world water balance.
2. Study weather systems for precipitation and characteristics of precipitation in India.
3. Study different types of wells

MODULE II: RUNOFF AND STREAMFLOW (9 hours)

Runoff - Components of runoff- Direct runoff, Base flow, Hydrograph- components of a Hydrograph, Base flow separation. Effective Rainfall, Unit Hydrograph – uses, assumptions and limitations of Unit Hydrograph- derivation of Unit Hydrographs

Computation of storm/flood hydrograph of different duration by method of Superposition and by development of S– Hydrograph.

Streamflow measurement- Measurement of stage, Measurement of velocity, selection of site for stream gauging station, Area Velocity method of stream gauging. Stage-discharge curve, Flow-Duration curve- uses and characteristics, Flow-mass curve (conceptual idea only).

SELF-STUDY (18 hours)

1. Study runoff characteristics of streams
2. Prepare a detailed note on measurement of stage and velocity in streams

3. Describe flood routing

MODULE III: IRRIGATION WATER REQUIREMENT (9 hours)

Irrigation- Necessity- Advantages- Disadvantages- ill-effects of irrigation. Types of irrigation- Direct and storage irrigation.

Crop water requirement: Crop period, Duty and delta, factors affecting duty and method of improving duty. Computation of crop water requirement by using the concept of duty and delta, Kharif -Rabi crop, kor-watering, cash crops, crops rotation. Irrigation efficiencies.

Consumptive Use (Evapotranspiration)- Consumptive Irrigation Requirement (CIR), Net Irrigation Requirement (NIR). Factors affecting Consumptive use.

Soil- Moisture- Irrigation relationship- Field Capacity, Readily available moisture, Soil- moisture deficiency, Equivalent moisture. Depth and frequency of irrigation

SELF-STUDY (18 hours)

1. Study techniques of water distribution in the farms/ways in which irrigation water can be applied to the farms.

MODULE IV: MANAGEMENT OF WATER RESOURCES (9 hours)

Hydraulic structures- components- Reservoirs - types, zones, yield of reservoir; determination of storage capacity and yield by mass curve method; Reservoir sedimentation and control - trap efficiency- computation of life of reservoir.

River training works- Riverbank protection works - causes for bank failure, Techniques for bank stabilization.

Peak flood- Flood-frequency studies, Rational and Empirical methods (no numerical problems), Standard Project Flood and Probable Maximum Flood

Flood management- Structural measures for flood mitigation, Non-structural measures for flood management

SELF-STUDY (18 hours)

1. Study layout of diversion headworks and its components.
2. Types of rivers on the basis of the topography of the river basin
3. Study on application of GIS in Water Resources management

Textbooks

1. Modi, P. N., Irrigation, Water Resources, and Water Power Engineering, Standard Book House, 2011.
2. Garg, S. K., Irrigation Engineering and Hydraulic Structures: Water Resources Engineering - Vol. II, Khanna Publishers, 2017.
3. Dandekar, M. M. and K. N. Sharma, Water Power Engineering, Vikas Publishing House, 2013.
4. Irrigation and Water Resources Engineering, G. L. Asawa, New Age International New Delhi, 2008

5. Ven T. Chow, David Maidment and Larry W Mays, Applied Hydrology, McGraw-Hill, Indian edition, 2017.
6. Subramanya, K., Engineering Hydrology, Tata McGraw- Hill Publishers, New Delhi, 2008.
7. Chang K., Introduction to Geographic Information Systems, Tata McGraw Hill Publishing Co. Ltd, 2008.

Reference books

1. Raghunath H.M., Hydrology: Principles, Analysis and Design., New Age International New Delhi, 2006
2. Wurbs R.A., and James W.P. , Water Resources Engineering, Prentice Hall of India, Eastern Economic Edition. ISBN: 81-203-2151-0, New Delhi, 2007.
3. Singh, V. P. "Hydrologic Systems", Prentice-Hall Englewood Cliffs, NJ 1989.
4. Mays, L. W., Water Resources Handbook, McGraw-Hill International Edition, 1996.
5. Kang-tsung Chang, Introduction to GIS, Tata McGraw Hill Publishing Co. Ltd, 8e, 2016.
6. Burrough P.A. and McDonnell R.A., "Principles of Geographical Information Systems",.Oxford University Press. New York. 1998.
7. Ian Heywood Sarah, Cornelius and Steve Carver "An Introduction to Geographical Information Systems". Pearson Education. New Delhi, 2002.

NPTEL/SWAYAM Courses for reference:

1. Water Resources Engineering:- Dr . Pranab K Mohapatra, Prof. Rajesh Srivastava, IIT Kanpur, https://archive.nptel.ac.in/courses/105/105/105105110/#
2. Engineering hydrology :- Prof. Sreeja Pekkat, IIT Guwahati https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ce19/
3. Groundwater hydrology and management:- Prof. Pennan Chinnasamy, IIT Mumbai, https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ce44/
4. Surface Water Hydrology :- Prof. Rajib Maity, IIT Kharagpur https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ce37/

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours (36)
	MODULE I (9 hrs)	
1.1	Hydrologic cycle- components of hydrologic cycle - catchment area- water budget equation	1

1.2	Precipitation- types, forms- measurement using rain gauges. Optimum number of rain gauges, estimation of missing precipitation, numerical problems	2
1.3	Presentation of rainfall data- mass curve, hyetograph and point rainfall. Computation of mean precipitation over a catchment	1
1.4	Depth- Area- Duration (DAD)curves, Intensity Duration Frequency (IDF) curves (conceptual idea only).	1
1.5	Abstractions from precipitation- Losses- Evaporation- Evaporimeters, Evapotranspiration- measurement, Initial Loss	1
1.6	Infiltration- measurement by double ring infiltrometer, Horton's equation, infiltration indices.	1
1.7	Groundwater- Vertical distribution of groundwater- classification of aquifers	1
1.8	Water Table, Aquifer properties- Specific yield, Permeability	1
MODULE II (9 hrs)		
2.1	Runoff- components of runoff- Direct runoff, Base flow	1
2.2	Hydrograph- components of a Hydrograph, Base flow separation.	1
2.3	Effective Rainfall, Unit Hydrograph – uses, assumptions and limitations of Unit Hydrograph- derivation of Unit Hydrographs	1
2.4	Unit hydrographs of different durations- method of superposition - numerical problems, method of development of S Hydrograph - numerical problems	3
2.5	Streamflow measurement- Measurement of stage, Measurement of velocity, Selection of site for stream gauging station.	1
2.6	Area Velocity method of stream gauging- numerical problems	1
2.7	Stage-discharge curve, Flow-Duration curve- uses and characteristics, Flow-mass curve (conceptual idea only).	1

	MODULE III (9 hrs)	
3.1	Irrigation- Necessity- Advantages- Disadvantages- ill-effects of irrigation. Types of irrigation- Direct and storage irrigation.	1
3.2	Crop water requirement: Crop period, Duty and delta, factors affecting duty and method of improving duty	2
3.3	Computation of crop water requirement by using the concept of duty and delta- numerical problems	2
3.4	Kharif -Rabi crop, kor-watering, cash crops, crops rotation. Irrigation efficiencies - numerical problems	1
3.5	Consumptive Use (Evapotranspiration)- Consumptive Irrigation Requirement (CIR), Net Irrigation Requirement (NIR). Factors affecting Consumptive use	1
3.6	Soil- Moisture- Irrigation relationship- Field Capacity, Readily available moisture, Soil- moisture deficiency, Equivalent moisture. Depth and frequency of irrigation	2
	MODULE IV (9 hrs)	
4.1	Hydraulic structures- components- Reservoirs - types, zones	1
4.2	Yield of reservoir; determination of storage capacity and yield by mass curve method- numerical problems	2
4.3	Reservoir sedimentation and control - trap efficiency- computation of life of reservoir- numerical problems	2
4.4	River training works- Riverbank protection works - causes for bank failure, Techniques for bank stabilization.	1
4.5	Peak flood- Flood-frequency studies, Rational and Empirical methods(no numerical problems), Standard Project Flood and Probable Maximum Flood	1
4.6	Flood management- Structural measures for flood mitigation, Non-structural measures for flood management	2
PROJECT		
The project aims to perform a comprehensive analysis of hydrologic data for a selected area and use the data for various civil engineering applications such as construction, planning, and management of water resources.		

LESSON PLAN FOR PROJECT COMPONENT		
No. Topic	**Topic**	**No. of Hours (12)**
1	Preliminary Design of the Project	2
2	Zeroth presentation (4th week)	2
3	Project work - First Phase	2
4	Interim Presentation	2
5	Project work - Final Phase & Report writing (discussions in class during project hours)	2
6	Final Evaluation, Presentation and Exhibition (11^{th} and 12^{th} weeks)	2
CO Assessment Questions		
CO 1	1. With a neat sketch, describe components of the hydrologic cycle.**[Understand]**	
	2. Describe vertical distribution of groundwater**[Understand]**	
	3. Differentiate between mass rainfall curve and hyetograph **[Understand]**	
CO 2	1. Describe a non-recording gauge for measurement of rain. **[Understand]**	
	2. The rates of rainfall for the successive 30 min period of a 3-hour storm are 17, 35,51,27,23 and 9 mm/hr. The corresponding surface runoff is estimated to be 36 mm. Establish the infiltration indices. **[Apply]**	
	3. The normal annual rainfall at stations A, B, C, and D in a basin are 80.97, 67.59, 76.28 and 92.01 cm respectively. In the year 1999, the station D was inoperative and the stations A, B and C recorded annual precipitations of 91.11,72.23 and 79.89 cm respectively. Estimate the rainfall at station D in the year 1999. **[Apply]**	
CO 3	1. Explain in detail the various types of irrigation efficiency **[Understand]**	
	2. If wheat requires about 7.5cm of water after every 28 days, and the base period for wheat is 140 days, find delta for wheat. **[Apply & Evaluate]**	

	3. The gross commanded area for a distributory is 10,000 hectares, 75% of which can be irrigated. The intensity of irrigation for Rabi season is 60% and that for Kharif season is 30%. If the average duty at the head of the distributory is 2500 hectares per cumec for Rabi season and 1000 hectares per cumec for Kharif season, determine the discharge required at the head of the distributory from average demand consideration. **[Apply & Evaluate]**
CO 4	1. Write down the procedure for determination of storage capacity of a reservoir **[Evaluate]**
	2. Examine causes for river bank failure and discuss techniques for bank stabilization **[Analyze]**
	3. Compare structural and non-structural measures for flood management **[Analyze]**
CO 5	1. Define a watershed boundary, analyze hydrologic data and prepare a report for surface water availability **[Create]**
	2.Identify flood-prone areas using rainfall data, river discharge, and topography. Prepare a report. **[Create]**
	3.Conduct groundwater exploration and prepare a report based on rainfall, slope, geology, soil type and land use. **[Create]**

Prepared by,
Mini M,
Assistant professor
Dept. of CE

24CEL406	MATERIAL TESTING LAB-I	L	T	P	R	C	Year of Introduction
		0	0	3	0	2	2024

Preamble: The objective of the course is to provide students with hands-on experience of testing different construction Engineering materials and their properties. It aims to familiarize students with commonly used construction materials, their properties, to make use of it in various fields of engineering and compare their standard engineering properties with IS code provisions for recommendation.

Prerequisite: 24EST124 Introduction to Civil Engineering.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the behaviour of engineering materials under various forms and stages of loading. **[Apply]**
CO 2	Evaluate the strength and stiffness properties of engineering materials under various loading conditions and recommend suitable material for structures. **[Apply]**
CO 3	Predict the quality of the material and its applicability. **[Apply]**
CO 4	Select appropriate and sustainable material suitable for the construction. **[Apply, Understand]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2			3			2			
CO2	3	2			3			2			
CO3	3		2		3	2	2	2			
CO4	3				3			2			2

Assessment Pattern

Bloom's Category	Continuous Assessment Tools		End Semester Examination
	Classwork	Test	
Remember	√	√	√
Understand	√	√	√
Apply	√	√	√
Analyze	√	√	√
Evaluate	√	√	√
Create	√	√	√

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Classwork	Lab Exam	Total Marks
0-0-3-0	5	25	20	50

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2 hrs 30 minutes

Mark Distribution of ESE

The following guidelines should be followed regarding award of marks
(a) Preliminary Work (10 Marks)
(b) Execution of Work (15 Marks)
(c) Result with valid inference (10 Marks)
(d) Viva Voce (10 Marks)
(e) Record (5 Marks)

SYLLABUS- DETAILS OF EXPERIMENTS

List of Experiments

(A minimum of 12 experiments are mandatory) 36 hours

No.	**Experiment**
1.	Test on stress-strain characteristics of mild steel and Tor Steel by conducting uniaxial tension test on rod specimens
2.	Shear test on mild steel rod (Compression Testing Shackle) Machine and Shear
3.	Flexural behaviour of steel by conducting a bending test on Rolled steel sections (I cross section)
4.	Torsional behaviour and estimation of modulus of rigidity of steel by conducting torsion test on rod specimens
5.	Estimation of modulus of rigidity of steel and brass / copper materials utilizing the principles of torsional vibrations – Torsion Pendulum.
6.	Estimation of toughness of steel specimens by conducting (a) Izod & (b) Charpy impact tests.
7.	Estimation of hardness properties of engineering materials such as brass, aluminium, copper, steel etc.by performing Brinell hardness test
8.	Estimation of Hardness properties of engineering materials such as brass, aluminium, copper, steel etc.by performing (a) Rockwell hardness test (b) Vicker's hardness test
9.	Estimation of modulus of rigidity of steel by performing tension and compression tests on spring specimens.

10.	Flexural behaviour of timber material by performing bending tests on beam specimens.
11.	Estimation of compressive strength of timber specimen.
12.	Experiment on verification of Maxwell's reciprocal theorem
13.	Demonstration of Fatigue Test
14.	Study/demonstration of Strain Gauges and load cells
15.	Bend & Rebend test on M S Rods
16.	Tensile behaviour of polymeric membranes, textiles, fibres etc.
17.	Digital Image Correlation Techniques for the study of material behaviour under various loading conditions

Text books

1) S.P. Timoshenko, History of Strength of Materials, , Dover publications 2003.
2) Egor P. Popov , Engineering Mechanics of Solids , Pearson 2015.
3) Lab manual prepared and distributed.

References

SL No	Title, Edition and Year
1	IS 1608 : Part 1 : 2022 Metallic materials - Tensile testing - Part 1 : Method of test at room temperature
2	IS 1598 (1977): Method for Izod Impact test of Metals, (Reaffirmed 2020)
3	IS 1757 Part:1(2020) : Metallic materials – Charpy Pendulum Impact test Method
4	IS 5242 (1979) Method of Test for determining Shear Strength of Metals, (Reaffirmed 2022)
5	IS 1500 Part:1 (2019): Metallic materials – Brinell Hardness test Part 1 Test method
6	IS 1500 Part:4 (2019): Metallic materials – Brinell Hardness test Part 4 table of hardness values
7	IS 1501 Part 1 (2020) : Metallic materials – Vickers Hardness test Part 1 Test method
8	IS 1501 Part 4 (2020) : Metallic materials – Vickers Hardness test Part 4 table of hardness values
9	IS 1586 Part 1 (2018) : Metallic materials – Rockwell Hardness test Part 1 Test method
10	IS 1586 Part 3 (2018) : Metallic materials – Rockwell Hardness test Part 3 Calibration of reference blocks (Scale A, B, C, D, E, F, G, H, K, N, T)
11	IS 1717 (2018): Metallic Materials – Wire – Simple Torsion Test

12	IS 883 (2016): Design of Structural Timber in Building- Code of Practice. (Reaffirmed 2021)
13	IS 13325 (1992) Determination of Tensile Properties of Extruded Polymer Geogrids Using the Wide Strip - Test Method (Reaffirmed Year : 2019)
14	IS17415(2023) Metallic Materials torsion test at room temperature.

E-resource

1. https://sm-nitk.vlabs.ac.in/- Virtual lab on Strength of Materials, NITK Surathkal
2. https://eerc01-iiith.vlabs.ac.in/- Virtual lab on Basic Engineering Mechanics and Strength Of Materials, NITK Surathkal

CO Assessment Questions

1.	Perform the test to determine the shear strength of the given steel rod. and predict the quality
2	Perform the test to determine the Rockwell Hardness of the test specimen and predict the quality
3	Perform the test to determine the Brinell Hardness of the test specimen and predict the quality
4	Perform the spring compression test to determine the stiffness and Modulus of Rigidity of the material and predict the quality
5	Perform the spring tension test to determine the Modulus of Rigidity of the material and predict the quality
6	Determine the toughness of the given material when the specimen is kept horizontally and the notch direction is positioned away from the striker.
7	Perform the Compression test on timber in both directions of the timber grains
8	Perform the Torsion pendulum test to determine the Modulus of Rigidity and Explain the basic principle of torsion pendulum and the kind of stress induced in the torsion pendulum wire.
9	Perform the test to determine the Vicker's Hardness of the given specimen and predict the quality
10	Perform the test to determine yield stress, ultimate tensile stress, nominal breaking stress of the given MS and HYSD steel bar.
11	Determine the toughness of the given material when the specimen is kept vertically and the notch direction is positioned towards the striker.

Prepared by
Sunny CP
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24CEL407	FLUID MECHANICS LAB	L	T	P	R	C	Year of Introduction
		0	0	3	0	2	2024

Preamble: The aim of this laboratory course is to provide students with hands-on experience in fundamental concepts of fluid mechanics, including the behaviour of fluids in motion and at rest, as well as flow through pipes and open channels. Through practical experiments, students will enhance their understanding of theoretical principles, develop analytical and observational skills, and learn to interpret and document experimental results effectively.

Prerequisite: 24CET303 Fluid mechanics

Course Outcomes: After the completion of the course the student will be able to

CO 1	To apply theoretical concepts in Fluid Mechanics to conduct laboratory experiments **[Apply]**
CO 2	Apply hydraulic principles to estimate flow rate using various flow measuring equipment**. [Apply]**
CO 3	Analyze the characteristics of various open channel flow. **[Analyze]**
CO 4	Analyze experimental data, interpret the results, and document the experimentation in the prescribed format. **[Analyze]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO10	PO11
CO1	3					2		2			
CO2	3	2				2	2	2			
CO3	3	2				2	2	2			
CO4	3	2						2	3		

Assessment Pattern

Bloom's Category	Continuous Assessment Tools		End Semester Examination
	Classwork	Test	
Remember	√	√	√
Understand	√	√	√
Apply	√	√	√
Analyze	√	√	√
Evaluate			
Create			

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Classwork	Lab Exam	Total Marks
0-0-2-0	5	25	20	50

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2 hrs 30 minutes

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks

(a) Procedure/Preliminary Work (10 Marks)

(b) Conduct of Experiment/Execution of Work (15 Marks)

(c) Result with Valid Inference (10 Marks)

(d) Viva Voce (10 Marks)

(e) Record (5 Marks)

SYLLABUS- DETAILS OF EXPERIMENTS

Calibration- Pressure gauges, Venturi meter, Orifice meter, water meter, rectangular notch, triangular notch

Stability Analysis of Floating Bodies

Pipe Flow Analysis- Bernoulli's theorem, friction co-efficient in pipes, loss co-efficient for pipe fittings

Open Channel Flow Analysis- Hydraulic coefficients of orifices and mouth pieces, Time of Emptying through orifice, Plotting Specific Energy

Study- pipe fittings, Parameters of Hydraulic Jump in Open channel Flow

Self-Study (24 hours):

- Study of Taps, Valves, Pipe Fittings, Gauges, Pitot Tubes, Water Meters, and Current Meters- Create a technical catalogue identifying: Function, Typical specifications, Application in civil engineering systems (e.g., water supply network, irrigation).
- Review real-world examples where metacentric height matters (e.g., floating bridges, pontoons). Task: Create a simulation model in Excel or software like GeoGebra to visualize stability under varying conditions
- Derive theoretical expressions for coefficients: C_d,C_v,C_c
- Derive and compare discharge equations of Rectangular and Triangular Notches
- Design a small-scale water distribution system using calibrated devices and estimate losses.
- Use EPANET or FLOW3D to simulate flow through valves, notches, and pipe networks.
- Observe real water flow installations on campus and correlate them to lab experiments.

List of Experiments

(Any 12 experiments out of 15 need to be performed)

1.Study of taps, valves, pipe fittings, gauges, Pitot tubes, water meters and current meters

2.Calibration of Pressure gauges
3.Determination of metacentric height and radius of gyration of floating bodies. 6
4.Verification of Bernoulli's theorem
5.Hydraulic coefficients of orifices and mouth pieces
6.Calibration of Venturi meter
7.Calibration of Orifice meter
8.Calibration of water meter.
9.Calibration of rectangular notch
10.Calibration of triangular notch
11.Determination of coefficient of discharge (Time of Emptying through orifice)
12.Plotting Specific Energy Curves in Open Channel flow
13.Study of Parameters of Hydraulic Jump in Open channel Flow
14.Determination of friction co-efficient in pipes
15.Determination of loss co-efficient for pipe fittings

Text books

1. Hydraulics and Fluid Mechanics including Hydraulic machines, Modi P. N. and S. M. Seth, S.B.H Publishers, New Delhi, 22nd edition 2019
2. Flow in Open channels, Subramanya K, Tata McGraw-Hill 5th edition 2019
3. Open - Channel Flo, Hanif Chaudhary M Springer 2nd edition 2007
4. Fluid Mechanics and Hydraulic Machines R K Bansal Laxmi Publications 10th edition 2020
5. Fluid Mechanics John F Douglas, Janusz. Gasiorek, John A. Swaffield, Lynne B. Jack Pearson Publications 6 th edition 2011

E-resource

1. Virtual lab on Fluid Mechanics, NITK Surathkal, https://sl-iitr.vlabs.ac.in/

COURSE CONTENTS AND SCHEDULE

No.		No. of Hours (36)
1	Study of taps, valves, pipe fittings, gauges, Pitot tubes, water meters and current meters	3
2.	Calibration of Pressure gauges	3

3.	Determination of metacentric height and radius of gyration of floating bodies.	3
4	Verification of Bernoulli's theorem	3
5	Hydraulic coefficients of orifices and mouth pieces	3
6	Calibration of Venturi meter	3
7	Calibration of Orifice meter	3
8	Calibration of water meter.	3
9	Calibration of rectangular notch	3
10	Calibration of triangular notch	3
11	Determination of coefficient of discharge (Time of Emptying through orifice)	3
12	Plotting Specific Energy Curves in Open Channel flow	3
13	Study of Parameters of Hydraulic Jump in Open channel Flow	3
14	Determination of friction co-efficient in pipes	3
15	Determination of loss co-efficient for pipe fittings	3
CO Assessment Questions		
1	Determine the Time of emptying the tank through the given orifice.	
2	Determine the hydraulic coefficients of the given orifice	
3	Determine the Coefficient of discharge of the given Rectangular Notch and plot the Calibration Curve for it.	
4	Determine the Coefficient of discharge of the given Venturimeter. Plot the Calibration Curve for it.	
5	Determine the Coefficient of discharge of the given Orifice meter and plot the Calibration Curve for it.	
6	Determine the Metacentric Height and Radius of Gyration of the given Floating body. Also, plot the graph to show the relationship between the Metacentric height and the Angle of Tilt of the given Floating body	
7	In the given Bernoulli's Theorem Apparatus, verify Bernoulli's Theorem for Constant Head in the Main Tank above orifice	

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24PWT208	UHV II,LIFE SKILLS AND COMMUNITY WORK	L	T	P	R	C	Year of Introduction
		1	0	0	0	1	2024

Preamble: This course aims to foster holistic development by integrating Universal Human Values (UHV II), essential life skills, and community engagement. Through self-reflection, discussion, and experiential learning, students will develop ethical awareness, emotional intelligence, and a sense of social responsibility. The course encourages active citizenship by engaging students in real-life community work, enabling them to apply values and skills for societal transformation.

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO1	Demonstrate an understanding of harmony in the self, family, society, nature, and existence by applying the principles of universal human values to reflect on ethical living, responsible relationships, ecological balance, and professional conduct. **[Evaluate]**
CO2	Apply principles of emotional intelligence, effective communication, and critical thinking to personal and professional contexts, and demonstrate the ability to manage time, solve problems, and interact empathetically and assertively. **[Apply]**
CO3	Demonstrate leadership, teamwork, and social responsibility by planning and implementing community-based initiatives that integrate human values, sustainable development principles, and participatory approaches, and critically reflect on their societal impact. **[Evaluate]**

CO – PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2				3	3	3		2	
CO2	2	3	2	2				3	3	3	2
CO3		3	3	2	2	3	3	3	3	3	3

Assessment Pattern

Blooms Category	Continuous Assessment Tools			
	Test1	Test2	Assignment	Field Work
Remember	√	√		

Understand	√	√	√	
Apply	√	√	√	√
Analyse	√	√	√	√
Evaluate			√	√
Create				√

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Theory [L]				Total Marks
		Assignment/ Activity	Test-1	Test-2	Field Work	
1-0-0-0	5	20	12.5	12.5	50	100

The assignments shall be evaluated as part of the activities under Modules 1, 2, and 3. Field work shall constitute the self-study component of Module 4.

SYLLABUS

MODULE 1: UNDERSTANDING THE SELF, RELATIONSHIPS, AND SOCIETY (3 Hours)

Session 1: Course Introduction and Self-Exploration (1 hour)
Course Purpose & Motivation, Recap of UHV-I, What is Self-Exploration?, Natural Acceptance & Experiential Validation, Human Aspirations: Continuous Happiness & Prosperity
Activities:

- *Reflection Exercise:* "Who am I?" – Write 5 statements about self and categorize as physical/sentient
- *Group Discussion:* Share experiences validating a value (e.g., truthfulness) through personal observation

Session 2: Understanding the Human Being and Prosperity (1 hour)
Co-existence of 'I' and Body, Needs of 'Self' vs 'Body', Body as Instrument of 'I', Sanyam (self-regulation) & Health, True Prosperity vs Accumulation
Activities:

- *Case Study:* "A Day in My Life" – Identify physical vs happiness-based needs
- *Role Play:* "Balanced Lifestyle vs Overconsumption"

Session 3: Harmony in Relationships and Society (1 hour)
Justice in Human Relationships, Trust vs Competence, Respect vs Differentiation, Visualizing Undivided Society, Universal Order, Gratitude in Relationships

Activities:

- *Circle Discussion:* Role of gratitude in student-teacher relationships
- *Scenario Analysis:* Interpersonal conflict – analyze based on values of trust and respect
- *Exercise:* Map your relationship network and reflect on mutual happiness

MODULE 2: HARMONY WITH NATURE AND PROFESSIONAL ETHICS (3 Hours)

Session 1: Harmony in Nature and Existence (1 hour)
Harmony in Nature: Four Orders, Mutual Fulfilment, Recyclability, Self-regulation, Existence as Co-existence, Holistic Perception of Harmony
Activities:

- *Film Screening & Discussion:* "Home" – Reflection on human impact on environment
- *Group Task:* Trace a natural cycle (e.g., water or carbon) and discuss its harmony

Session 2: Human Values and Professional Ethics (1 hour)
Ethical Human Conduct: Definitiveness & Natural Acceptance, Professional Competence & Responsibility, Humanistic Education, Constitution, and Universal Order
Activities:

- *Debate:* "Technology – Boon or Bane for Nature?"
- *Reflective Writing:* "What does it mean to be an ethical engineer?"

Session 3: Path to Universal Human Order (1 hour)
Transition Strategy: Individual & Societal Level, People- & Eco-friendly Systems, Case Studies of Holistic Models
Activities:

- *Case Study Discussion:* Amul Cooperative Model / Barefoot College
- *Action Plan Activity:* Create a personal code of ethics and action plan as a future professional

MODULE 3: LIFE SKILLS FOR PERSONAL AND PROFESSIONAL GROWTH (3 Hours)

Emotional intelligence: Self-regulation, empathy, Communication: Listening, assertiveness, empathy-based interaction; Problem-solving, decision-making, and critical thinking, Time management, goal setting, and personal productivity
Activity 1: Empathy Circle – "Walking in Their Shoes"
Objective: To practice empathetic listening and perspective-taking.
Instructions:

- Students form groups of 4–5.
- Each member shares a brief real-life or imagined story involving emotional difficulty or a moral dilemma (max. 3 mins).
- Other members respond with only empathetic reflections (no advice or judgment).
- Debrief as a class: How does it feel to be truly heard? What makes listening difficult?

Activity 2: Communication Styles Role-Play
Objective: To differentiate between passive, aggressive, and assertive communication.
Instructions:

- In pairs or small groups, students enact 3 short scenarios (e.g., refusing extra work, asking for help, handling group conflict) using each style.
- Each group presents one version to the class, followed by reflection:
  - What was the impact of each style?
  - When is assertiveness most effective?

Activity 3: Critical Thinking Puzzle – "What's the Real Problem?"
Objective: To strengthen problem-identification and decision-making skills.
Instructions:

- Present a real-world case (e.g., project failure, peer conflict, missed deadline).
- In groups, students:
  - Identify the root cause(s),
  - Propose at least two solutions,
  - Discuss possible consequences.
- Each group shares findings with the class.

Activity 4: Time Audit and Productivity Planning
Objective: To improve time management through self-awareness and planning.
Instructions:

- Students reflect on and write down how they spent the previous day (hour by hour).
- Identify time wasters and productivity blocks.
- Using the SMART method, each student sets 1 academic and 1 personal goal with an action plan.

Activity 5: Emotional Regulation Check-In
Objective: To raise awareness of emotional triggers and calming strategies.
Instructions:

- Students list 3 situations that trigger frustration or anxiety.
- For each, they note:
  - Physical/emotional reactions,
  - Current coping strategies,
  - One new strategy (e.g., deep breathing, journaling, re-framing thoughts).
- Optionally, share coping ideas in small groups.

(Any three activities to be completed)

MODULE 4: COMMUNITY ENGAGEMENT AND SOCIAL RESPONSIBILITY (5 Hours)

Values, Leadership, and Social Responsibility: Leadership, initiative, and teamwork as personal and social values, Community service as a form of experiential value education, Civic sense and responsibilities of educated citizens Gandhian Vision and Community Empowerment:Introduction to Gandhian concept of Village Republics, Rural self-sufficiency and non-violence in development, Institutional role in community upliftment.

Tools for Sustainable Community Engagement: Importance of eco-friendly, decentralized development, Science and technology for rural empowerment, Participatory planning, implementation, and monitoring, Knowledge, fund, and stakeholder convergence in development

Application through Service Learning: Integrating learning from values and life skills into community work, Designing small student-led interventions, Reflecting on leadership, empathy, and impact

Self -Study/Field Work: 16 hours

Students will identify a local community need and engage in a minimum 16-hour field project (individually or in small teams) aligned with the values studied.

Examples:

- Environmental awareness campaign
- Literacy or peer mentoring program
- Senior care/home visits with structured reflection
- Water/energy conservation drive
- Organic Farming
- Artisans, Industries and Livelihood
- Basic Amenities

Text Book

1. R R Gaur, R Asthana, G P Bagaria, 2019 (2nd Revised Edition), A Foundation Course in Human Values and Professional Ethics. ISBN 978-93-87034-47-1, Excel Books, New Delhi.
2. Premvir Kapoor, Professional Ethics and Human Values, Khanna Book Publishing, New Delhi, 2022.
3. Goleman, D. (1995). Emotional Intelligence. New Delhi: Bloomsbury Publishing India Private Limited
4. B. K. Mitra, Personality Development and Soft Skills, 3rd ed. New Delhi, India: Oxford Univ. Press, 2019.
5. K.G. Balakrishnan, *Unnat Bharat Abhiyan: Transforming India through Village Empowerment*, 1st ed., Ministry of Education, Govt. of India, 2022.

Reference books

1. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and Harper Collins, USA
2. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain.
3. S. R. Covey, *The 7 Habits of Highly Effective People*. New York, NY, USA: Free Press, 2004.
4. A. Kumar, *Youth and Social Transformation*. Jaipur, India: Rawat Publications, 2012.

NPTEL Course

1. Exploring human values: Visions of happiness of perfect Societies, Prof. A.K. Sharma, IIT Kanpur https://nptel.ac.in/courses/109104068
2. Developing Soft Skills and Personality, Prof. T. Ravichandran, IIT Kanpur https://onlinecourses.nptel.ac.in/noc22_hs77/preview
3. Corporate social responsibility, By Prof. Aradhna Malik, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc21_mg54/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours (14 hours)
MODULE 1 (3 Hours)		
1.1	Course Introduction and Self-Exploration	1
1.2	Understanding the Human Being and Prosperity	1
1.3	Harmony in Relationships and Society	1
MODULE 2 (3 Hours)		
2.1	Harmony in Nature and Existence	1
2.2	Human Values and Professional Ethics	1
2.3	Path to Universal Human Order	1
MODULE 3 (3 Hours)		
3.1	Emotional intelligence	1
3.2	Communication:	1
3.3	Problem-solving, decision-making, and critical thinking, Time management, goal setting, and personal productivity	1
MODULE 4 (5 Hours)		
4.1	Values, Leadership, and Social Responsibility	1
4.2	Gandhian Vision and Community Empowerment:	1
4.3	Tools for Sustainable Community Engagement	1
4.4	Application through Service Learning	2
LESSON PLAN FOR FIELD WORK		

No.	Topic	No. of Hours (16)
1	Orientation & Need Identification	1
2	Proposal Submission:	1
3	Field Implementation	9
4	Reflection Session:	3
5	Final Submission	2
No.	**Field Work Assessment**	**50 marks**
1	Problem identification	5
2	Planning and organization	5
3	Execution and teamwork	15
4	Reflection and learning outcomes	10
5	Report and presentation	15
CO Assessment Questions		
CO1	1. What is the meaning of natural acceptance? *[Understand]* 2. List the four levels of harmony discussed in the course. *[Remember]* 3. Explain the difference between prosperity and accumulation. *[Understand]* 4. How do trust and respect influence human relationships? *[Analyze]* 5. Apply the principle of Sanyam to your daily routine. What changes would you make? *[Apply]* 6. How can you promote harmony in your classroom or hostel? *[Apply]* 7. Analyze the current societal model in terms of human aspirations and values. *[Analyze]* 8. How does imbalance in nature reflect the lack of harmony at the human level? *[Analyze]*	
CO2	1. What are the key components of emotional intelligence, and why are they important in both personal and professional life? *[Understand]* 2. Explain the difference between assertive and aggressive communication. How can this distinction improve interpersonal relationships?*[Analyze]*	

	3. Describe a situation where you faced a communication challenge. How would you apply assertiveness and empathy to handle it differently now? *[Apply]* 4. Given a tight academic schedule and personal responsibilities, how would you apply time management techniques to maintain productivity and well-being? *[Apply]*
CO3	1. What are the core values promoted through Gandhian principles of rural development? *[Understand]* 2. List the essential elements of participatory planning in a community project. *[Remember]* 3. Explain how eco-friendly, decentralized development contributes to rural sustainability. *[Understand]* 4. Describe the relationship between civic responsibility and community engagement for students. *[Analyze]* 5. How would you apply leadership and teamwork skills in organizing a community-based awareness campaign on environmental sustainability? *[Apply]* 6. Devise a plan to involve your peers in a service-learning activity that addresses a local issue. *[Apply]* 7. Analyze the roles of different stakeholders (educational institutions, local governance, NGOs) in the successful execution of community projects. *[Analyze]* 8. Compare two community interventions and identify the factors that led to the success or limitations of each. *[Analyze]*

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PROGRAM ELECTIVE - I

24CEE411	ADVANCED MECHANICS OF SOLIDS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble

The objective of this course is to familiarize students with advanced concepts in the mechanics of materials and improve their problem-solving abilities. It focuses on analysing stress and strain in two-dimensional and three-dimensional solid bodies and introduces the fundamental principles of elasticity, failure theories, and failure criteria. By the end of the course, they will be equipped to evaluate the mechanical behaviour of elastic materials by calculating the stresses and strains resulting from applied loads.

Prerequisite: 24EST205- Mechanics of Solids

Course Outcomes: After the completion of the course the student will be able to

CO1	Determine the three-dimensional state of stress in a body and methods to reduce computational effort. **[Apply]**
CO2	Explain the state of strain in a body and establish relation between elastic strain energy stored. **[Apply]**
CO3	Identify the stress distribution in curved beams of various cross-sections and thick-walled cylinders subjected to internal and external pressure. **[Apply]**
CO4	Explain the mechanics of composite materials. **[Understand]**
CO5	Explain basic modes of fracture and fracture toughness. **[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	3	2		2							
CO 2	3	2		2							
CO 3	3	2		2							
CO 4	3	2									
CO 5	3	2									

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓	✓	✓
Understand	✓	✓	✓	✓
Apply	✓	✓	✓	✓
Analyze				
Evaluate				
Create				

Mark Distribution of CIA					
Course Structure L-T-P-R	**Attendance**	**Theory [L]**			**Total Marks**
		Assignment	**Test-1**	**Test-2**	
3-0-0-0	5	10	12.5	12.5	40

Total Marks distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hrs

End Semester Examination [ESE]: Pattern 1			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	2 questions from each module 8 Questions, each carries 3 marks. Marks:3x8=24 marks	2 questions will be given from each module, of which 1 should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9 marks. Marks: (4x 9 = 36 marks)	60

SYLLABUS

MODULE I: STRESS ANALYSIS AND ELASTIC BEHAVIOUR OF MATERIALS (9 Hrs)

Elementary concept of elasticity, stresses in three dimensions, Principal Stresses, Stress Invariants, Mohr's Circle for 3-D state of stress, Octahedral Stresses, State of pure shear, plane stress. Differential equations of equilibrium, plane stress problems and plane strain problems comparison.

Self-Study (14 hrs)

- Stress Visualization Using 3D Models
- Manually construct Mohr's Circles ($\sigma_1-\sigma_2$, $\sigma_2-\sigma_3$, $\sigma_3-\sigma_1$) and identify invariants (I_1, I_2, I_3).
- Select a case study (e.g., deformation of a dam, turbine blade, or bone under stress). Identify: stress state (3D or 2D), assumptions (plane stress/strain), critical stresses. Suggest methods of analysis and possible failure zones

MODULE II: STRAIN ANALYSIS AND ENERGY METHODS IN ELASTICITY (9 Hrs)

Analysis of strain, State of strain at a point, Strain Invariant, Principal Strains, Plane state of strain, Strain measurements, Compatibility conditions.

Energy Methods: Work done by forces and elastic strain energy stored.

Reciprocal relations, Theorem of virtual work.

Self-Study (14 hrs)

- Rubber Sheet Strain Demo - Tangible understanding of how material points deform and how principal strains arise
- Strain Rosette Simulation / Spreadsheet Tool

- Strain Invariant Derivation and Interpretation
- Work Done and Strain Energy Visualization
- Virtual Work Thought Experiment

MODULE III: ADVANCED BENDING AND AXISYMMETRIC STRESS ANALYSIS (9 Hrs)

Bending of beams: Asymmetrical bending, Shear centre, Bending of curved beams, Stress distribution in beam with rectangular, circular and trapezoidal cross- section, Deflection of thick curved bars.

Axisymmetric problems: Thick walled cylinder subjected to internal and external pressures, Compound cylinders, Shrink fit.

Self-Study (13 hrs)

- Asymmetrical Bending – Paper Strip Experiment
- Shear Centre Identification with Sketching Tool
- Curved Beam Stress Mapping
- Thick Cylinder Stress Plotting
- Shrink Fit Interactive Example
- Axisymmetric FEM or Simulation Exploration

MODULE IV : INTRODUCTION TO COMPOSITE AND FRACTURE MECHANICS (9 Hrs)

Introduction to Mechanics of Composite Materials: Lamina and Laminates, Micromechanics of FRP Composites.

Introduction to Fracture Mechanics: Basic modes of fracture, Fracture toughness evaluation.

Self-Study (13 hrs)

- Micromechanics Modeling: Rule of Mixtures Calculator
- Virtual Lab Exploration of Fiber-Matrix Interaction
- Composite Failure Map Sketching
- Crack Propagation Sketch Activity
- Material Comparison Table

Textbooks

1. Arthur P. Boresi, Richard J. Schmidt, Advanced Mechanics of Materials, John Wiley & Sons, 6th Edition, 2022.
2. L. S. Srinath, Advanced Mechanics of Solids, McGraw Hill Education, 3rd Edition , 2017.
3. Robert M. Jones, Mechanics of Composite Material, CRC Press, 2nd Edition , 1998.
4. T. L. Anderson, Fracture Mechanics: Fundamentals and Application, CRC Press , 4th Edition, 2017.
5. Mohammed Ameen, Computational elasticity, Narosa publishing house, 2008.

Reference books

1. A.R. Ragab, and S.E.Bayoumi, Engineering Solid Mechanics: Fundamentals and Applications, CRC Press, 1999.
2. M.H.Sadd, Elasticity: Theory, Applications and Numerics, Academic Press, 2006.
3. Egor P Popov, Engineering Mechanics of Solids, Pearson Education India, 2016.

NPTEL/SWAYAM Courses for reference:

1. Dr. U. Saravanan -Advanced Mechanics of Solids -IIT Madras - https://archive.nptel.ac.in/courses/105/106/105106049/

COURSE CONTENTS AND LECTURE SCHEDULE		
No.		No. of Hours (36)
MODULE I - 9 hours		
1.1	Elementary concept of elasticity, stresses in three dimensions, Principal Stresses.	1
1.2	Stress Invariants, Mohr's Circle for 3-D state of stress.	3
1.3	Octahedral Stresses, State of pure shear, plane stress.	3
1.4	Differential equations of equilibrium.	1
1.5	Plane stress problems and plane strain problems comparison.	1
MODULE II- 9 hours		
1.1	Analysis of strain, State of strain at a point.	1
1.2	Strain Invariant, Principal Strains.	1
1.3	Strain measurements, Compatibility conditions.	2
1.4	Energy Methods: Work done by forces and elastic strain energy stored.	3
1.5	Reciprocal relations, Theorem of virtual work.	2
MODULE III - 9 hours		
1.1	Asymmetrical bending, Shear centre.	1
1.2	Bending of curved beams	2
1.3	Stress distribution in beam with rectangular, circular and trapezoidal cross- section.	1
1.4	Deflection of thick curved bars.	2
1.5	Thick walled cylinder subjected to internal and external pressures.	1
1.6	Compound cylinders, Shrink fit	2
MODULE IV- 9 hours		
1.1	Introduction to Mechanics of Composite Materials: Lamina and Laminates	2
1.2	Micromechanics of FRP Composites.	3
1.3	Introduction to Fracture Mechanics: Basic modes of fracture	2
1.4	Fracture toughness evaluation.	2

CO Assessment Questions	
CO 1	**3 Marks questions:** 1. Define stress invariants. Explain their significance in stress analysis. **[Understand]** 2. State the assumptions used to simplify a 3D stress problem into a plane stress condition. **[Understand]** 3. Explain the concept of octahedral shear stress and its application in yield theories. **[Understand]** **9 Marks questions:** 1. A stress element is subjected to σ_x = 80MPa, σ_y=40MPa, σ_z=20 MPa, τ_{xy} =30MPa, τ_{yz}=0, τ_{zx}=10 MPa. **[Apply]** a. Determine the principal stresses. b. Draw the Mohr's circles for this 3D stress state. c. Compute the maximum shear stress. 2. For a given 3D stress state at a point, calculate the octahedral normal and shear stresses using: σ_1=90 MPa, σ_2=45 MPa, σ_3=10 MPa**[Apply]** 3. A steel element is under the following stresses: σ_x=50MPa, σ_y=30MPa, τ_{xy} =25MPa. Draw the Mohr's circle for the 2D state and identify the maximum shear stress and principal directions. **[Apply]**
CO 2	**3 Marks questions:** 1. Define plane stress and plane strain. How do they differ in practical applications? **[Understand]** 2. Define principal strains and mention their significance. **[Understand]** 3. State compatibility conditions and their importance in strain analysis. **[Understand]** **9 Marks questions:** 1. A material is subjected to plane stress with σ_x=100 MPa, σ_y=50 MPa, τ_{xy}=30 MPa. **[Apply]** a. Determine the strains using generalized Hooke's law. b. Calculate the strain energy stored per unit volume. c. Comment on the effect of Poisson's ratio on strain energy. 2. A beam under bending stores 10 J of strain energy. If the applied load is doubled, determine the new strain energy stored. Comment on the relationship. **[Apply]** 3. A strain rosette mounted on a surface reads: $\varepsilon_A=400\times10^{-6}$, $\varepsilon_B=250\times10^{-6}$, $\varepsilon_C=100\times10^{-6}$.Determine the strain components $\varepsilon_x,\varepsilon_y,\gamma_{xy}$**[Apply]**

CO 3	**3 Marks questions:** 1. State the practical application of shrink fit in engineering components? **[Understand]** 2. Briefly explain how strain energy is computed in a thick-walled cylinder under pressure. **[Understand]** 3. Explain the role of the shear centre in curved beam bending. **[Apply]** **9 Marks questions:** 1. A thick-walled cylinder (inner radius = 50 mm, outer radius = 100 mm) is subjected to internal pressure of 40 MPa. Compute the radial and hoop stresses at r = 60 mm and r = 90 mm. **[Apply]** 2. A curved beam of circular cross-section (radius = 150 mm, cross-section radius = 15 mm) is subjected to a bending moment of 500 Nm. Calculate the maximum tensile and compressive stresses. **[Apply]** 3. A thick curved bar fixed at both ends is subjected to a point load at the crown. Using energy methods, estimate deflection at the loaded point. **[Apply]**
CO 4	**3 Marks questions:** 1. Explain why compatibility conditions are essential in layered composite materials. **[Understand]** 2. Differentiate between a lamina and a laminate. **[Understand]** 3. Mention two advantages of using composites in structural applications. **[Understand]** **9 Marks questions:** 1. Discuss the role of compatibility conditions in ensuring consistent deformation across fiber-matrix interfaces in composite materials. **[Apply]** 2. Explain the effect of fiber orientation on the overall mechanical response of a laminate. **[Apply]** 3. A unidirectional FRP composite has: E_f=70 GPa, E_m=3 GPa, V_f=0.6 Calculate longitudinal modulus E_L using rule of mixtures. **[Apply]**
CO 5	**3 Marks questions:** 1. Define strain energy release rate (G) and its relation to fracture toughness. **[Understand]** 2. Illustrate and describe the three basic modes of fracture. **[Apply]** 3. List two methods of evaluating fracture toughness experimentally. **[Understand]** **9 Marks questions:** 1. Derive the relation between fracture toughness K_{IC} and strain energy release rate G for a linear elastic material. **[Apply]**

	2. A brittle material fails at a stress of 100 MPa when a crack of length 5 mm is present. Compute the fracture toughness K_{IC} **[Apply]** 3. A plate of width W=100 mm has a central crack of length 2a=20 mm. If K_{IC}=40 MPa$\sqrt{m}$, , determine the maximum allowable stress using $K_I = \sigma\sqrt{(\pi a)}$ **[Apply]**

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24CEE412	ENGINEERING GEOLOGY	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:
This course aims to introduce students to the basics of Earth processes, materials, and groundwater and the geological characteristics of such processes and materials relevant to Civil Engineering applications.

Prerequisite: Nil

Course Outcomes: After completion of the course, the student will be able to

CO 1	Identify and describe the significance of geology in civil engineering surface processes. **[Understand]**
CO 2	Analyze the causes and effects of internal geological processes. **[Apply]**
CO 3	Identify and classify common rock-forming minerals and rocks **[Understand]**
CO 4	Identify groundwater occurrence, aquifer characteristics, and flow dynamics using principles of hydrogeology. **[Understand]**
CO 5	Apply geological knowledge to real-world civil engineering problems, such as landslide prevention, foundation stability, and coastal groundwater management. **[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2					1	2				
CO 2	3	3					3				
CO 3	3										
CO 4	3										
CO 5	3	3					3				

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓	✓	✓
Understand	✓	✓	✓	✓
Apply		✓	✓	✓
Analyze				
Evaluate				
Create				

Total Marks distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hrs

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 subdivisions. Each question carries 9 marks. Marks: (4x9 = 36 marks)	60

SYLLABUS

MODULE I: SURFACE PROCESSES (9 hours)

Relevance of Geology in Civil Engineering. Surface Processes of the Earth -Types of weathering, Products of weathering. Soil profile, Soil erosion, and soil conservation measures. Geological processes by rivers – Basic definitions, potholes, river valley, gorges, canyon, waterfall, stream terraces. Landslides-types, causes, and controlling measures.

Self-Study -14 Hrs

- Case Study Compilation: Engineering Failures Due to Geological Neglect
- Soil Profile Jar.
- Create a sketchbook with labeled diagrams of: Potholes, River valleys (V-shaped, U-shaped), Canyons, Waterfalls, Stream terraces.
- Landslide Mapping with Google Earth

MODULE II: INTERNAL PROCESSES (9 hours)

Internal Processes of the Earth- Earthquakes-basic terminologies, types of waves, seismograph, Seismic waves, concept of intensity and magnitude of earthquake. Tectonic plates, plate boundaries. Seismic zones of India.

Self-Study -13 Hrs

- Earthquake Terminology- Definition, illustration and real-world example on the other
- Earthquake Wave Simulation using any Software.
- Seismic Zones of India Mapping

MODULE III: MINERALOGY AND PETROLOGY (9 hours)

Mineralogy-Physical properties of minerals, physical properties, and chemical composition of minerals like quartz, orthoclase, plagioclase, biotite, muscovite, hornblende, augite, hypersthene, calcite, gypsum.

Petrology- Igneous rocks - Chemical and mineralogical classification, structures & textures. Sedimentary rock types based on mode of formation and structures. Metamorphic rocks- structures only. Megascopic study of granite, dolerite, basalt, sandstone, limestone, shale, gneiss, marble, and charnockite, Rock types of Kerala.

Self-Study -14 Hrs

- Mineral Property Table
- Scratch & Streak Challenge (Practical/Virtual)
- Collect different types of rocks and prepare Rock Type Classification Chart
- Virtual Megascopic Study
- Kerala Rock Mapping

MODULE IV: HYDROGEOLOGY (9 hours)

Origin & Occurrence of groundwater, vertical distribution of groundwater. Aquifers and types of aquifers. Porosity and Permeability/hydraulic conductivity, Darcy's Law. Electrical resistivity. Seawater intrusion in Coastal area, Ghyben-Herzberg relation.

Self-Study -13 Hrs

- Infographic Assignment – Seawater Intrusion
- Electrical Resistivity Method (Virtual Lab / Research)
- Local Groundwater Case Study
- Groundwater Study Portfolio

Textbooks

1. Duggal S.K., Pandey H.K, and Rawat N (2014). Engineering Geology, McGraw-Hill Education, New Delhi.
2. Gokhale KVGK (2015), Principles of Engineering Geology, BS Publications, Hyderabad.
3. Singh P (2014) Engineering and General Geology, SK Kataria and Sons, New Delhi.
4. Subinoy Gangopadhyay (2017), Engineering Geology, Oxford University.
5. N. Chenna Kesavulu, Textbook of Engineering Geology, Macmillan India Limited.
6. Parbin Singh, Engineering and General Geology, S. K. Kataria & Sons.
7. D. Venkat Reddy, Engineering Geology, Vikas Publishing House Pvt. Ltd.

Reference books

1. David K Todd & Larry W Mays (2011), Groundwater Hydrogeology, Wiley India Pvt Ltd.
2. Gokhale N.W. (2015), Manual of Geological Maps, CBS Publishers, New Delhi.
3. Gribble CD (2005) Rutleys, Elements of Mineralogy, Springer.
4. Marland P Billings (2016), Structural Geology, Pearson education.

NPTEL/SWAYAM Courses for reference:

1. Dr. Debasis Roy - Engineering Geology- IIT Kharagpur
   https://archive.nptel.ac.in/courses/105/105/105105106/

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours (36)
MODULE I (9 Hrs)		

1.1	Relevance of Geology in Civil Engineering. Surface Processes of the Earth -Types of weathering, Products of weathering.	3
1.2	Soil profile, Soil erosion, and soil conservation measures.	2
1.3	Geological processes by rivers – Basic definitions, potholes, river valley, gorges, canyon, waterfall, stream terraces.	2
1.4	Landslides-types, causes, and controlling measures.	2
MODULE II (9 Hrs)		
2.1	Earthquakes-basic terminologies, types of waves, seismograph, Seismic waves,	3
2.2	Concept of intensity and magnitude of the earthquake.	2
2.3	Tectonic plates, plate boundaries.	2
2.4	Seismic zones of India.	2
MODULE III (9 Hrs)		
3.1	Physical properties of minerals.	2
3.2	physical properties, and chemical composition of minerals like quartz, orthoclase, plagioclase, biotite, muscovite, hornblende, augite, hypersthene, calcite, gypsum.	3
3.3	Igneous rocks - Chemical and mineralogical classification, structures & textures. Sedimentary rock types based on mode of formation and structures. Metamorphic rocks- structures only. Megascopic study of granite, dolerite, basalt, sandstone, limestone, shale, gneiss, marble, and charnockite,	3
3.4	Rock types of Kerala.	1
MODULE IV (9 Hrs)		
4.1	Origin & Occurrence of groundwater, vertical distribution of groundwater.	2
4.2	Aquifers and types of aquifers.	2
4.3	Porosity and Permeability/hydraulic conductivity, Darcy's Law. Electrical resistivity.	3
4.4	Seawater intrusion in Coastal area, Ghyben-Herzberg relation.	2
CO Assessment Questions		
CO1	1. Define weathering of rocks. Explain the weathering by mechanical means. **[Understand]** 2. Sketch the typical soil profile with a short description of each zone. [**Apply]** 3. Explain the factors that influence soil erosion and methods for soil conservation **[Remember]** 4. Define the following terms: Gorges, Potholes, Canyon. **[Remember]** 5. Discuss the civil engineering significance of weathering. **[Apply]**	

CO2	1. Discuss the fundamental concepts of the Plate tectonics theory. **[Apply]** 2. Give an account of the intensity and magnitude scale for rating earthquakes. **[Apply]** 3. Discuss the internal structure of the Earth based on the propagation of seismic waves. **[Understand]** 4. Discuss the types of plate boundaries and their relation to seismicity. **[Understand]** 5. Explore the application of seismic zoning in India to assess earthquake risk for construction projects. **[Apply]**
CO3	1. Describe the mineralogy of dolerite. **[Remember]** 2. Classify the structural features present on sedimentary rocks. **[Remember]** 3. Explain the hardness of minerals. **[Remember]** 4. Compare the texture and mineralogy of shale and limestone. **[Understand]** 5. List the chemical composition, cleavage, hardness, and streak of orthoclase and quartz. **[Understand]**
CO4	1. Explain hydraulic conductivity. **[Remember]** 2. Differentiate between aquifer and aquifuge and the conditions that form them. **[Understand]** 3. Compare the porosity and permeability characteristics of various rocks. **[Understand]** 4. Explain Darcy's Law. **[Remember]** 5. Explain the Ghyben-Herzberg relation with a neat sketch. **[Apply]**
CO5	1. Groundwater can generate problems for civil engineering structures. Do you agree with this? Give reasons to support your answer. **[Apply]** 2. Discuss the different soil conservation measures employed. **[Apply]** 3. When you get hard rocks for construction purposes at the project sites in Kerala, what is the most probable type of rock that you may get? Justify your answer. **[Apply]** 4. Explain different preventive measures taken for landslides. **[Remember]** 5. Compared to the Himalayan region, earthquakes are less frequent in Kerala -Elucidate. **[Apply]**

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24CEE413	OPEN CHANNEL HYDRAULICS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble: The aim of this course is to introduce students to the fundamental principles of fluid mechanics and the hydraulics of open channel flows. It emphasizes the development of analytical and problem-solving skills necessary for understanding fluid behaviour and applying these concepts in the design of hydraulic structures and in solving real-world water flow challenges**.**

Prerequisite: 24CET303 Fluid mechanics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply the principles and methods of uniform and gradually varied flow computations in open channels. **[Apply]**
CO 2	Analyze specific energy and critical flow concepts for practical applications in open channel hydraulics**. [Analyse]**
CO 3	Evaluate rapidly varied flow phenomena, such as hydraulic jumps, and interpret their engineering applications. **. [Analyse]**
CO 4	Analyze unsteady and spatially varied flow conditions in open channels, considering real-world implications**[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	2										
CO 2	3	2					2				
CO 3	3	3					2				
CO 4	3	3	2			2		2			3

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓	✓	✓
Understand	✓	✓	✓	✓
Apply	✓	✓	✓	✓
Analyze		✓	✓	✓
Evaluate				
Create				

Mark Distribution of CIA

Course Structure L-T-P-R	Attendance	Theory [L]			Total Marks
		Assignment	Test-1	Test-2	
3-0-0-0	5	10	12.5	12.5	40

Total Marks distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	60	40	2.5 hrs

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	2 questions from each module. 8 Questions, each carries 3 marks. Marks:3x8=24 marks	2 questions will be given from each module, of which 1 should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9 marks. Marks: (4x 9 = 36 marks) Time: 2.5 hours	60

SYLLABUS

MODULE I: INTRODUCTION TO OPEN CHANNEL FLOW (9 hrs)

Open channel flow, Uniform flow - Conveyance and section factor, Computation of discharge through compound channels; Design of channels for uniform flow-Non erodible channel Minimum permissible velocity-best hydraulic section. Velocity distribution in open channels, Pressure distribution in curvilinear flows- flows through spillway crest and spillway bucket.

Self-Study: (14hrs)

- Using Excel or MATLAB, compute and compare hydraulic parameters (area, wetted perimeter, hydraulic radius, section factor, conveyance) for different channel shapes (rectangular, trapezoidal, and circular) under uniform flow.
- Model a compound channel cross-section (main channel + floodplains). Compute discharge using standard methods (divided flow approach or composite roughness).
- Study the pressure variation over a spillway crest and bucket using sketches and application of Bernoulli's principle along streamlines

MODULE II : CONCEPT OF SPECIFIC ENERGY AND FORCE (9 hrs)

Momentum in open channel flow, Specific force. Specific energy- specific energy diagram and discharge diagram, Critical flow and its computation. - Application of Specific energy for channel transitions

Self-Study: (14hrs)

- For a rectangular channel with a fixed discharge, construct a **specific energy diagram** showing variation of total energy with flow depth. Use Excel, MATLAB, or Desmos to plot the diagram.
- Analyze a case where a channel width contracts or expands: Use specific energy principles to determine whether the flow will accelerate or decelerate. Compute energy losses or flow depths before and after transition.

- Using the **momentum equation**, plot the **specific force diagram** and determine conjugate depths (before and after jump).

MODULE III : (9 hrs) Gradually varied flow and rapidly varied flow

Gradually varied flow- Dynamic equation of gradually varied flow different forms; Computation of length of water surface profiles - direct step method.
Rapidly varied flow-Hydraulic jump - sloping and exponential channels, types based on tail water conditions. Uses of hydraulic jumps for energy dissipation below spillways-jump height curve; tail water rating curve;

Self-Study: (14hrs)

- For various flow conditions (M1, M2, S1, S2, C1, etc.), sketch the GVF profiles based on bed slope, flow depth, and critical/normal depths
- Use the direct step method by Excel to compute the length of a water surface profile for a given trapezoidal or rectangular channel
- Create a comparison chart showing different tailwater conditions vs jump behaviour

MODULE IV: CONCEPTS OF BOUNDARY LAYER FLOW (9 hrs)

Unsteady flow through open channels – Surges- positive surges (problems) and concept of negative surges; Spatially varied flow, dynamic equation of spatially varied flow, Analysis of spatially varied flow profile.
Concepts of boundary layer flow: Introduction, boundary layer growth over a flat plate, Boundary layer thickness, laminar boundary layer, turbulent boundary layer, transition from laminar to turbulent flow

Self-Study: (14hrs)

- Create a **concept map or infographic** to explain the formation, characteristics, and practical implications of **negative surges**.
- Sketch typical **SVF profiles** for increasing (inflow) and decreasing (outflow) discharge conditions (e.g., side weirs, lateral spillways).
- Create a comparative table and annotated diagrams of: Laminar vs Turbulent boundary layer, Boundary layer growth on a flat plate, Boundary layer thickness equations

Textbooks

1. Hydraulics and Fluid Mechanics including Hydraulic machines, Modi P. N. and S. M. Seth, S.B.H Publishers, New Delhi, 22nd edition 2019
2. Flow in Open channels, Subramanya K, Tata McGraw-Hill 5th edition 2019
3. Open - Channel Flo, Hanif Chaudhary M Springer 2nd edition 2007
4. Fluid Mechanics and Hydraulic Machines R K Bansal Laxmi Publications 10th edition 2020
5. Fluid Mechanics John F Douglas, Janusz . Gasiorek, John A. Swaffield, Lynne B. Jack Pearson Publications 6 th edition 2011

Reference books

1. Fluid Mechanics Victor Streeter , E. Benjamin Wylie , K.W. Bedford Mc Graw Hill Publishers. 9th edition 2017
2. Munson, Young and Okiishi's Fundamentals of Fluid Mechanics Philip M. Gerhart John I. Hochstein, Andrew L. Gerhart John Wiley & Sons Inc 9 th edition 2020
3. Flow through Open Channels by Chow VT McGraw Hill, 1959
4. Flow through Open Channels Rangaraju K. G Tata McGraw Hill 1994
5. Flow through Open Channels, Srivastava R Oxford Publishers 2012
6. A First Course in Fluid Mechanics Narasimhan S. University Press (India) 2006
7. Fluid Mechanics and Fluid power Engineering Kumar.D.N. S.K.Kataria & sons 2013
8. Principles of Fluid Mechanics and Fluid Machines Narayana Pillai,N University Press 2011

NPTEL/SWAYAM Courses for reference

1. Dr. Suresh A Kartha- Advanced Hydraulics- IIT Guwahati https://archive.nptel.ac.in/courses/105/103/105103021/
2. Dr. C. S. P. Ojha- Advanced Hydraulics- IIT Roorkee- https://nptel.ac.in/courses/105107059

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours (36)
	MODULE I (9Hrs)	
1.1	Open channel flow, Uniform flow - Conveyance and section factor.	1
1.2	Computation of discharge through channels (Numerical problems)	2
1.3	Design of channels for uniform flow-Non erodible channel	2
1.4	Velocity distribution in open channels- Minimum permissible velocity-best hydraulic section.,	2
1.5	Pressure distribution in curvilinear flows	1
1.6	Flows through spillway crest and spillway bucket	1
	MODULE II (9Hrs)	
2.1	Momentum in open channel flow, Specific force.	2
2.2	Specific energy- specific energy diagram and discharge diagram	2
2.3	Critical flow and its computation	2
2.4	Application of Specific energy for channel transitions	2
2.5	Numerical Problems	1

MODULE III (9Hrs)		
3.1	Gradually varied flow- Dynamic equation of gradually varied flow different forms.	2
3.2	Computation of length of water surface profiles - direct step method.	2
3.3	Rapidly varied flow-Hydraulic jump - sloping and exponential channels, types based on tail water conditions	2
3.4	Uses of hydraulic jumps for energy dissipation below spillways	2
3.5	Jump height curve; tail water rating curve	1
MODULE IV(9Hrs)		
4.1	Unsteady flow through open channels	1
4.2	Surges- positive surges (problems) and concept of negative surges	2
4.3	Spatially varied flow, dynamic equation of spatially varied flow	1
4.4	Analysis of spatially varied flow profile.	2
4.5	Concepts of boundary layer flow: Introduction, boundary layer growth over a flat plate,	1
4.6	Boundary layer thickness, laminar boundary layer, turbulent boundary layer, transition from laminar to turbulent flow	2
CO Assessment Questions		
CO-1	**3-Mark Questions** 1. Define conveyance and section factor. How are they used in uniform flow computations? **[Understand]** 2. What are the conditions for achieving uniform flow in an open channel? **[Remember]** 3. State the criteria for selecting minimum permissible velocity in non-erodible channels.**[Analyse]** 4. Explain why the best hydraulic section is important in channel design. **[Apply]** **5.** Describe how pressure distribution changes in curvilinear flows over a spillway crest**[Understand]** **9-Mark Questions** 1. Derive the expression for the most economical section of a trapezoidal channel and explain how it achieves maximum discharge. **[Analyse]**	

	2. Explain how velocity varies vertically and laterally in open channel flow. What factors influence this distribution? **[Analyse]** 3. Discuss the pressure distribution in a flow over a spillway crest and bucket. How does this affect structural design? **[Apply]** 4. A compound channel consists of a main channel (b = 8 m, d = 2 m) and two floodplains (each 4 m wide, d = 1.2 m). Manning's n is 0.03 for the main channel and 0.04 for the floodplains. Compute the total discharge for a flow depth of 2 m. **[Analyse]** 5. Design a rectangular non-erodible channel to carry a discharge of 5 m^3/s. The channel is to be lined with concrete (Manning's n = 0.013), with a bed slope of 1 in 1000. Determine the width and depth of the best hydraulic section. **[Analyse]**
CO2	**3-Mark Questions** 1. Define specific energy in open channel flow and list its components. **[Remember]** 2. What is critical flow? State the condition for critical flow in terms of Froude number. **[Remember]** 3. Differentiate between subcritical and supercritical flow using the specific energy diagram. **[Understand]** 4. Explain the significance of the specific force in hydraulic jump analysis. **[Analyse]** **5.** What is the importance of critical depth in channel transitions (e.g., contractions or expansions)? **[Apply]** **9-Mark Questions** 1. Derive the condition for critical flow in a rectangular channel using the concept of specific energy. **[Apply]** 2. Draw and explain the specific energy diagram for a rectangular channel. What are its practical applications in channel design and control structures? **[Analyse]** 3. Explain the role of specific energy and specific force in the analysis of a hydraulic jump. How do they help in identifying flow regime changes? **[Apply]** 4. A rectangular channel 4 m wide carries a discharge of 10 m^3/s. Compute the specific energy for a flow depth of 1.2 m. Also, determine whether the flow is subcritical or supercritical. **[Analyse]** 5. In a horizontal rectangular channel of width 2 m, the flow has a specific energy of 1.8 m and a discharge of 4 m^3/s. Calculate the possible flow depths and identify the critical depth**[Analyse]**
CO3	**3-Mark Questions**

	1. Define a hydraulic jump. What are the basic conditions for its occurrence in open channels? **[Remember]** 2. Differentiate between gradually varied flow (GVF) and rapidly varied flow (RVF). **[Understand]** 3. What is the significance of the tailwater curve in the formation of hydraulic jumps? **[Apply]** 4. Explain the purpose of using hydraulic jumps as energy dissipators below spillways. **[Understand]** 5. What is a jump height curve and how is it useful in analyzing hydraulic jumps? **[Apply]** **9-Mark Questions** 1. Derive the dynamic equation of gradually varied flow and explain its physical significance. Provide any two forms of the equation. **[Analyse]** 2. Explain the classification of water surface profiles (M1, M2, S1, etc.) based on flow and bed slope. Include neat sketches. **[Understand]** 3. Describe different types of hydraulic jumps based on tailwater conditions and Froude number. Discuss their characteristics and practical implications**[Apply]** 4. In a rectangular channel 3 m wide, a hydraulic jump occurs where the depth before the jump is 0.5 m and the discharge is 6 m^3/s. Compute the sequent depth, energy loss, and Froude number before the jump. **[Analyse]** 5. Using the direct step method, compute the length of a gradually varied flow profile from a depth of 1.2 m to 1.6 m in a trapezoidal channel (bottom width = 4 m, side slope = 1H:1V, slope = 0.001, n = 0.015, discharge = 10 m^3/s). Use one step with average values. **[Analyse]**
CO4	**3-Mark Questions** 1. Differentiate between positive and negative surges in open channel flow. **[Apply]** 2. Define spatially varied flow (SVF). Give one practical example. 3. What is boundary layer thickness? How does it change along a flat plate? **[Remember]** 4. State the key differences between laminar and turbulent boundary layers. **[Apply]** **5.** What causes the transition from laminar to turbulent flow in boundary layers? **[Apply]** **9-Mark Questions** 1. Explain the formation and propagation of positive and negative surges in open channels. How are these relevant to flood wave analysis? **[Apply]**

	2. Derive the dynamic equation for spatially varied flow and explain its terms. Discuss the assumptions involved. **[Apply]** 3. Describe the boundary layer development over a flat plate. Explain how velocity profiles vary in laminar and turbulent regions with sketches. **[Apply]** 4. A positive surge moves downstream in a rectangular channel of width 4 m. The initial depth is 0.6 m and the surge increases the depth to 1.2 m. Compute the surge velocity and flow velocity after the surge. Assume initial velocity is zero. **[Analyse]** 5. Water enters a rectangular channel of width 3 m with a lateral inflow of 0.05 $m^3/s/m$ along a 100 m reach. The flow depth is uniform at 1.2 m, bed slope is 0.001, and Manning's n = 0.015. Analyze the spatially varied flow profile assuming increasing discharge along the channel. Use the dynamic SVF equation qualitatively. **[Analyse]**

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24CEE414	ENVIRONMENTAL IMPACT ASSESSMENT	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble: The course will enable students to understand the need for EIA and evaluate socio-economic and environmental impacts of a proposed project or development. They will be able to assess the positive and negative impacts of a project and predict the environmental impacts in the pre-planning stage itself, so that decisions can be taken to reduce the adverse impacts. This course will help students develop a comprehensive knowledge of EIA through case studies in social, economic and environmental aspects.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO1	Understand the evolution and process of Environmental Impact Assessment in India**[Understand]**
CO2	Interpret relevant environmental legislation and regulatory frameworks of India **[Apply]**
CO3	Assess impacts on various environmental aspects **[Evaluate]**
CO4	Assess impacts on various environmental aspects. **[Apply]**
CO5	Describe Environmental Management Plan (EMP) and Environmental Audits **[Understand]**
CO6	Prepare reports on the prediction and assessment of the impacts of development projects on various environmental aspects **[Create]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	1					3	2				2
CO 2	1					3	2				2
CO 3	1					3	2				2
CO 4	1					3	2				2
CO5	1					3	2				2
CO6	1					3	2				2

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓	✓	✓
Understand	✓	✓	✓	✓
Apply	✓	✓	✓	✓
Analyze		✓	✓	✓
Evaluate		✓	✓	✓
Create		✓	✓	✓

Mark Distribution of CIA					
Course Structure L-T-P-R	**Attendance**	**Theory [L]**			**Total Marks**
		Assignment	**Test-1**	**Test-2**	
3-0-0-0	5	10	12.5	12.5	40

Total Marks distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	60	40	2.5 hrs

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	2 questions from each module. 8 Questions, each carries 3 marks. Marks:3x8=24 marks	2 questions will be given from each module, of which 1 should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9 marks. Marks: (4x 9 = 36 marks) Time: 2.5 hours	60

SYLLABUS

MODULE I: EVOLUTION AND TYPES OF EIA (9 hrs):

Evolution of EIA, Concepts, EIA Procedure-overview, Screening, Scoping, Baseline Studies, Impact identification, impact prediction and mitigation, and public participation. Initial Environmental Examination, Terms of Reference

Types of EIA-Rapid, Comprehensive, Strategic, Regional, Sectoral and Project level EIA Legal Policies & Regulatory Framework- Water Act 1974, Air Act 1981, EPA 1986, EIA notification 2006- Environmental Clearance Procedures in India as per EIA 2006, Generic structure of EIA Report.

Self - study (13 hours):

a) Prepare notes on Kyoto Protocol, Montreal Protocol and Paris Agreement on Climate Change
b) Study IS specification for water quality, air quality and noise
c) Write down Terms of Reference required for a Highway project

MODULE II: MEASUREMENT AND ASSESSMENT OF ENVIRONMENTAL IMPACTS (9 hrs)

Measurement of Environmental Impacts-Physical, social, and economic variables. Environmental indices. EIA methodologies- Criteria for selection, EIA methods- Adhoc, Matrices, Networks, Checklists, Overlay.

Assessment of Impacts - Soil and Groundwater, Surface water, Biological Environment, Air Environment, Noise, Socio-Economic and Human Health aspects, Cumulative Impact Assessment, Environmental risk assessment framework- Key steps

Self- study (14 hours):

a) Prepare checklist for a dam construction project
b) Prepare a detailed note on prediction of impacts on biological environment due to development projects
c) Prepare a Environment risk assessment for a dyeing industry

MODULE III: GIS in EIA (9 hrs)

GIS in EIA – Technical details of GIS and it's application to EIA
Environmental Management Plan - preparation, implementation and review – Mitigation and Rehabilitation Plans – Policy and guidelines for planning and monitoring programmes
Environment Audit: need for audit- audit types and benefits- environmental audit procedure
ISO 14001 standards: Importance, salient features - Stages in implementation- Benefits

Self-study (13 hours):

a) Prepare a chart showing application of GIS in various stages in EIA, EMP and EMoP
b) Prepare a sample Mitigation and Rehabilitation Plan for the airport project.
c) Describe the importance of ISO 14002, 14004 and 14006 in environmental management

MODULE IV: EIA CASE STUDIES (9 hrs)

EIA case studies (Indian)- a Highway project, a Textile Industry, a Dam construction project, an Airport project, a Quarry Mining project and a Solid Waste Management project

Self-study (14 hours):

a) Prepare a detailed EIA for the development of a chemical industry
b) Study and prepare an impact assessment report for a development project near your residential area
c) Prepare a disaster management plan for impacts due to development of an airport.

Text Books:

1. Y. Anjaneyulu, Valli Manickam , Environmental Impact Assessment Methodologies, 2011
2. R. R Barthwal, Environmental Impact Assessment, New Age International Publishers, 2012
3. Prof. A. K. Shrivastava, Environmental Impact Assessment, APH Publishing Corporation, New Delhi, December 2003
4. Benard Adedotun Omoyeni , Principles and Application of Environmental Impact, 2015
5. Peter Morris, Riki Therivel, Methods of Environmental Impact Assessment ,2001
6. Michael F. Goodchild, Louis T. Steyaert, Bradley O. Parks ,GIS and Environmental

Modeling: Progress and Research Issues, 1996
7. Pasquale De Marco , Geographic Information Systems: A Guide for Decision-Makers, 2025

Reference Books:

1. Aaron J. MacKinnon, Peter N. Duinker, Tony R. Walker , The Application of Science in Environmental Impact Assessment, 2018
2. Anji Reddy Mareddy , Environmental Impact Assessment: Theory and Practice, 2017
3. Riki Therivel , Strategic Environmental Assessment in Action, 2013
4. Peter Wathern , Environmental Impact Assessment: Theory and Practice, 2013
5. M. Marchetti, V. Rivas , Geomorphology and Environmental Impact Assessment , 2001
6. Davide Geneletti , Multicriteria Analysis for Environmental Decision-Making, 2019

NPTEL/SWAYAM Courses for references

1. Prof. Harshit Sosan Lakra -Environmental Impact Assessment- IIT Roorkee https://archive.nptel.ac.in/courses/124/107/124107160/
2. Prof. Jyotsna Dutta Majumdar, Prof. Indranil Manna- Environmental Degradation and Surface Engineering - IIT Kharagpur: https://archive.nptel.ac.in/courses/113/105/113105105/
3. Prof. Pennan Chinnasamy-Remote Sensing and GIS for rural development- IIT Bombay : https://archive.nptel.ac.in/courses/105/101/105101221/
4. Prof. Bhola Ram Gurjar-Air pollution and Control- IIT Roorkee: https://archive.nptel.ac.in/courses/105/107/105107213/
5. Prof. Jyanta Bhattacharya Fundamentals of Environmental Pollution and Control : , IIT Kharagpur -https://archive.nptel.ac.in/courses/123/105/123105001/

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours (36)
	MODULE I (9 Hrs)	
1.1	Evolution of EIA, Concepts-EIA Procedure-overview, Screening, Scoping	1
1.2	Baseline Studies, Impact identification, Impact prediction and mitigation, public participation	1
1.3	Initial Environmental Examination, Terms of Reference	1
1.4	Types of EIA-Rapid, Comprehensive, Strategic, Regional, Sectoral and Project level EIA	1

1.5	Legal Policies & Regulatory Framework- Water Act 1974, Air Act 1981, EPA 1986,	2
1.6	EIA notification 2006	1
1.7	Environmental Clearance -Procedures in India as per EIA 2006	1
1.8	Generic structure of EIA Report	1
MODULE II (9 Hrs)		
2.1	Measurement of Environmental Impacts-Physical, social , economic variables. Environmental indices	1
2.2	EIA methodologies- Criteria for selection, EIA methods- Adhoc, Matrices,Networks, Checklists, Overlay.	1
2.3	Assessment of Impacts- Soil and Groundwater, Surface water	2
2.4	Assessment of Impacts- Biological Environment, Air Environment	2
2.5	Assessment of Impacts- Noise, Socio-Economic and Human Health aspects	2
2.6	Cumulative Impact Assessment. Environmental risk assessment framework- Key steps	1
MODULE III (9 Hrs)		
3.1	GIS in EIA – Technical details of GIS and it's application to EIA	2
3.2	Environmental Management Plan- preparation, implementation and review. Mitigation and Rehabilitation Plans	2
3.3	Policy and guidelines for planning and monitoring programmes	1
3.4	Environment Audit: need for audit- audit types and benefits- environmental audit procedure	2
3.5	ISO 14001 standards: Importance, salient features - Stages in implementation- Benefits	2
MODULE IV (9 Hrs)		
4.1	Highway project	1
4.2	Textile Industry	1
4.3	Dam construction project	2
4.4	Airport project	2
4.5	Quarry Mining project	1
4.6	Pharmaceutical industry	1
4.7	Solid Waste Management project	1
CO Assessment Questions		
CO-1	1. Explain the evolution of EIA in India. **[Understand]**	

	2. Why EIA is needed for developmental projects? **[Understand]** 3. Describe the significance of Screening in EIA. **[Understand]** 4. Explain Terms of Reference. **[Understand]**
CO2	1. The Environment (Protection) Act 1986, is called an umbrella legislation. Substantiate the statement. **[Apply]** 2. Explain the Environmental Clearance Procedures in India as per EIA 2006. **[Apply]** 3. Discuss the Environmental standards for Water, Air and Noise quality. **[Apply]** 4. Describe the duties of CPCB in the Prevention and Control of Air Pollution. **[Apply]**
CO3	1. Compare Matrix and Network methodologies for assessment of environmental impacts. **[Understand]** 2. Prepare a simple checklist for assessment of socio-economic impact due to the development of a highway. **[Understand]** 3. Describe overlay mapping as an EIA method**[Understand]** 4. Suggest a suitable methodology to predict the impacts due to a dam construction project. **[Understand]**
CO4	1. Give an account of various environmental aspects. **[Evaluate]** 2. Describe the methods to predict the impact on air quality. **[Evaluate]** 3. Demonstrate the procedure for assessing the impacts on water. **[Evaluate]** 4. Identify and explain the steps involved in the assessment of socio-economic impact due to a project**[Evaluate]**
CO5	1. Explain the purpose and importance of Environmental Management Plan. **[Understand]** 2. Discuss the role of Environmental Monitoring Program. **[Understand]** 3. Describe the different types of environmental audits and explain the benefits of environmental audit. **[Understand]** 4. Explain the features of ISO 14001 standards. **[Understand]**
CO6	1. Explain the Terms of Reference (ToR) for EIA report of a highway project. **[Evaluate]** 2. Prepare a detailed EIA report due to development of a hydroelectric project. **[Evaluate]** 3. Demonstrate the procedure for assessing the impact of an airport project. **[Evaluate]** 4. Discuss the baseline studies required for the development of a solid waste management plant. **[Evaluate]**

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24CEE415	ENVIRONMENTAL SCIENCE	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:
This course offers a foundational understanding of environmental science, focusing on major global concerns such as pollution, climate change, and sustainable resource management. It aims to equip students with the knowledge and awareness required to address environmental challenges through responsible practices and informed decision-making.

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basic concepts of environmental science, population dynamics, and the impact of resource consumption on environmental degradation. [**Understand**]
CO 2	Identify the sources, impacts, and control measures of various types of environmental pollution including air, water, noise, and soil. [**Remember / Understand**]
CO 3	Analyze the causes and consequences of climate change and evaluate the role of different renewable energy technologies in addressing environmental issues. [**Analyze / Evaluate**]
CO 4	Apply environmental management strategies for solid waste, water quality, and pollution control, and interpret key environmental policies and case studies relevant to environmental governance. [**Apply**]

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2					3					
CO2	3	2				3					
CO3	2	2	2			3					2
CO4	2	2				3					2

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test 1	Test 2	Other Tools	
Remember	✓	✓		✓
Understand	✓	✓		✓
Apply	✓	✓	✓	✓
Analyze	✓	✓	✓	✓
Evaluate		✓	✓	✓
Create				

Mark Distribution of CIA					
Course Structure [L-T-P-R]	**Attendance**	**Theory [L-T]**			**Total Marks**
		Assignment	**Test 1**	**Test 2**	
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hrs

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, Each question carries 3 marks (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub-divisions. Each question carries 9 marks. (9x4=36 marks)	**60**

SYLLABUS

MODULE 1: ENVIRONMENTAL CONCERNS AND POPULATION DYNAMICS (9 Hours)

Introduction to Environmental Science: Definition, scope, and importance - Environmental concerns in the modern world - Population growth and its environmental impact.

Resource consumption trends: water, energy, land - Ecological footprint and environmental degradation - Interrelationship between population, development, and environment.

Self-Study: (14 hours)

1. Detailed Case Studies on the impact of population growth on resource depletion in developing countries. (3 hours)
2. In-depth Analysis of Ecological Footprint Calculations and comparison of country-wise footprints. (3 hours)
3. Study on Sustainable Development Goals (SDGs) related to population and resource management. (2 hours)
4. Exploration of Population Policies in different countries and their environmental implications. (3 hours)
5. Reading Recent Research Articles on current environmental concerns (climate, pollution, biodiversity loss). (3 hours)

MODULE 2: ENVIRONMENTAL POLLUTION AND ITS TYPES (9 Hours)

Air Pollution: Sources (natural and anthropogenic), health and environmental impacts - Pollutants (PM, NOx, SOx, CO, etc.), control technologies.

Water Pollution: Types of pollutants, point and nonpoint sources - Treatment methods (overview of primary, secondary, tertiary).

Noise Pollution: Sources, effects on humans and ecosystems, control measures.

Soil Pollution: Contaminants, impacts on agriculture and health, remediation strategies.

Self-Study: (13 hours)

1. Detailed Study on Advanced Air Pollution Control Technologies such as scrubbers, electrostatic precipitators, catalytic converters. (3 hours)
2. Case Studies on Major Water Pollution Incidents (e.g., Minamata disease, Yamuna River pollution). (3 hours)
3. In-depth Reading on Wastewater Treatment Methods with process flow diagrams. (3 hours)
4. Study of Recent Noise Pollution Surveys and WHO guidelines on noise levels. (2 hours)
5. Research on Soil Remediation Techniques (bioremediation, phytoremediation, soil washing). (2 hours)

MODULE 3: CLIMATE CHANGE AND RENEWABLE ENERGY (9 Hours)

Climate Change and Global Warming: Scientific basis, causes (GHG emissions), effects (sea level rise, extreme weather) - Mitigation and adaptation strategies.

Renewable Energy Technologies: Solar Energy - principles, PV systems, applications, Wind Energy - types of turbines, advantages & limitations, Hydropower, Bioenergy, Ocean, and Geothermal Energy - basic concepts and uses.

Environmental benefits and challenges of renewable energy adoption.

Self-Study: (14 hours)

1. Critical Review of IPCC Reports on climate change projections and mitigation pathways. (3 hours)
2. Comparative Study of Global Renewable Energy Policies and their success stories. (3 hours)
3. Study of Working Principles and Designs of Solar PV, Wind, and Hydropower Plants (case-based). (3 hours)
4. Detailed Reading on Biomass, Geothermal, Ocean Energy Technologies and their operational challenges. (3 hours)
5. Exploration of Climate Change Adaptation Strategies in Different Regions (coastal, desert, urban areas). (2 hours)

MODULE 4: ENVIRONMENTAL QUALITY MANAGEMENT AND POLICY (9 Hours)

Solid Waste Management: Types of solid waste (municipal, industrial, hazardous) - Collection, segregation, treatment, and disposal methods, E-waste and Biomedical Waste: sources, health hazards, management strategies, Water quality and management: parameters, pollution control, recycling, Introduction to Environmental

Laws and Regulations (brief), Case studies: Bhopal Gas Tragedy, Ganga River Pollution etc.

Self-Study Topics: (13 hours)

1. Study of Municipal Solid Waste Management Practices in Smart Cities (case-based). (3 hours)
2. Detailed Reading on Biomedical and E-waste Management Rules in India. (2 hours)
3. In-depth Study of Water Quality Standards and Pollution Control Case Studies. (3 hours)
4. Exploration of National and International Environmental Laws (Air Act, Water Act, EPA, Kyoto Protocol, Paris Agreement). (3 hours)
5. Case Study Analysis: Detailed Review of Bhopal Gas Tragedy and Ganga Action Plan. (2 hours)

Text Books:

1. Benny Joseph, Environmental Studies, 3rd Edition, McGraw Hill Education (India), 2017.
2. Anubha Kaushik & C.P. Kaushik, Perspectives in Environmental Studies, 7th Edition, New Age International Publishers, 2023.
3. Erach Bharucha, Textbook of Environmental Studies for Undergraduate Courses, 4th Edition, Orient Blackswan, 2025.

Reference Books:

1. R. Rajagopalan, Environmental Studies: From Crisis to Cure, 4th Edition, Oxford University Press, 2023.
2. William P. Cunningham & Mary Ann Cunningham, Environmental Science: A Global Concern, 16th Edition, McGraw-Hill Education, 2023.
3. Gilbert M. Masters & Wendell P. Ela, Introduction to Environmental Engineering and Science, 3rd Edition, Pearson Education, 2013.

NPTEL/SWAYAM:

Prof. Sudha Goel & Prof. Shamik Chowdhury- Environmental Science - IIT Kharagpur
https://onlinecourses.nptel.ac.in/noc23_hs155/preview

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours (36)
MODULE I (9 hrs)		
1.1	Introduction to Environmental Science: Definition, scope, and importance	2
1.2	Environmental concerns in the modern world	1
1.3	Population growth and its environmental impact.	1
1.4	Resource consumption trends: water, energy, land	2

1.5	Ecological footprint and environmental degradation	2
1.6	Interrelationship between population, development, and environment.	1
MODULE II (9 hrs)		
2.1	Air Pollution: Sources (natural and anthropogenic), health and environmental impacts	2
2.2	Pollutants (PM, NOx, SOx, CO, etc.), control technologies.	1
2.3	Water Pollution: Types of pollutants, point and nonpoint sources	1
2.4	Water Pollution: Treatment methods (overview of primary, secondary, tertiary).	2
2.5	Noise Pollution: Sources, effects on humans and ecosystems, control measures.	1
2.6	Soil Pollution: Contaminants, impacts on agriculture and health, remediation strategies.	2
MODULE III (9 hrs)		
3.1	Climate Change and Global Warming: Scientific basis, causes (GHG emissions), effects (sea level rise, extreme weather)	2
3.2	Mitigation and adaptation strategies.	1
3.3	Renewable Energy Technologies: Solar Energy - principles, PV systems, applications,	1
3.4	Wind Energy - types of turbines, advantages & limitations,	1
3.5	Hydropower, Bioenergy, Ocean, and Geothermal Energy - basic concepts and uses.	2
3.6	Environmental benefits and challenges of renewable energy adoption.	2
MODULE IV (9 hrs)		
4.1	Solid Waste Management: Types of solid waste (municipal, industrial, hazardous)	1
4.2	Collection, segregation, treatment, and disposal methods	2
4.3	E-waste and Biomedical Waste: sources, health hazards, management strategies, Introduction to	2
4.4	Water quality and management: parameters, pollution control, recycling	2

4.5	Environmental Laws and Regulations (brief), Case studies: Bhopal Gas Tragedy, Ganga River Pollution etc.	2
CO Assessment Questions		
CO 1	1. Define environmental science. Explain the scope and importance of its study. [**Understand**] 2. Discuss how population growth affects the environment with suitable examples. [**Analyze / Evaluate**] 3. Illustrate the trends in resource consumption and relate them to environmental degradation. [**Apply**] 4. Differentiate between ecological footprint and carbon footprint. [**Remember / Understand**] 5. Analyze the interrelationship between population, development, and the environment. [**Analyze / Evaluate**]	
CO 2	1. List the major air pollutants and their sources. [**Understand**] 2. Explain the treatment methods for wastewater with a flow diagram. [**Understand**] 3. Compare the impacts of noise pollution on human health and ecosystems. [**Apply**] 4. Suggest suitable control measures to prevent soil pollution in agricultural lands. [**Apply**] 5. Identify point and non-point sources of water pollution with examples. [**Apply**]	
CO 3	1. Define greenhouse gases and list the major ones contributing to climate change. [**Understand**] 2. Explain the scientific basis and effects of global warming. [**Remember / Understand**] 3. Compare solar and wind energy technologies in terms of working principles and applications. [**Apply**] 4. Illustrate the causes of sea level rise and extreme weather events due to climate change. [**Apply**] 5. Evaluate the environmental benefits and limitations of bioenergy and hydropower. [**Analyze / Evaluate**]	
CO 4	1. List the types of solid waste and explain any two methods of disposal. [**Remember / Understand**] 2. Describe the sources and risks associated with e-waste and biomedical waste. [**Understand**] 3. Explain the basic parameters for assessing water quality. [**Remember / Understand**] 4. Discuss the key features of any one Indian environmental legislation. [**Apply**]	

	5. Analyze the environmental lessons learned from the Bhopal gas tragedy. [**Analyze / Evaluate**]

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24CEE416	ADVANCED CONCRETE TECHNOLOGY	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble: The objective of this course is to provide the scientific basis for the understanding the development of concrete mixes, its development and effective use. This course is aimed at exposing the students to fundamental properties of concrete materials and their destructive and non-destructive testing procedures. After the course the student should be able to test and predict the results, defects and design appropriate concrete mixes for different uses

Prerequisite: 24EST124 Introduction to Civil Engineering, 24CE304R2024 Concrete Technology and Building Planning.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Recall the properties and testing procedures of concrete materials as per IS code. **[Understand]**
CO 2	Describe the procedure of testing fresh and hardened concrete. **[Understand]**
CO 3	Design concrete Mixes using IS codes. **[Apply &Analyse]**
CO 4	understand the methods and procedures of Non-Destructive tests. **[Understand]**
CO5	Describe various types of special concretes. **[Understand]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3										
CO2	3	3									
CO3	3		3								
CO4	3		3			2					
CO5	3	3	3								

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓	✓	✓
Understand	✓	✓	✓	✓
Apply	✓	✓	✓	✓
Analyze	✓	✓	✓	✓
Evaluate	✓	✓	✓	✓
Create				

Mark Distribution of CIA					
Course Structure L-T-P-R	**Attendance**	**Theory [L]**			**Total Marks**
		Assignment	**Test-1**	**Test-2**	
3-0-0-0	5	10	12.5	12.5	40

Total Marks distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hrs

End Semester Examination [ESE]: Pattern 1			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	2 questions from each module 8 Questions, each carries 3 marks. Marks:3x8=24 marks	2 questions will be given from each module, of which 1 should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9 marks. Marks: (4x 9 = 36 marks)	60

SYLLABUS

MODULE I: MATERIALS OF CONCRETE (9Hrs)

Cement -Review of manufacturing process- Chemical composition of ingredients and function, Bogue's compounds and their functions and limitations, mechanism of hydration-heat of hydration-Aggregate-Review of types, sampling and testing, artificial aggregates - Water -Chemical Admixtures- types, uses, mechanism of action - effects on properties of concrete - Mineral admixtures- types, chemical composition - physical characteristics - effects on properties of concrete - Rheology – basic concepts – Bingham model

Self-study: **(13 Hrs)**

a) Prepare a sampling table of aggregates based on gradation
b) Identify the heat of hydration and justify it is an exothermic reaction.
c) Practice with different admixtures and infer the difference on workability

MODULE II: PROPERTIES OF FRESH AND HARDENED CONCRETE (9Hrs)

Properties of fresh concrete- workability-factors affecting workability - slump test, compaction factor test- Vee Bee consistometer test, flow tests - Properties of hardened concrete - modulus of elasticity, compressive strength, split tensile strength, flexural strength- effect of water cement ratio – maturity concept- Creep - factors affecting creep - effect of creep-Shrinkage- factors affecting shrinkage - plastic shrinkage, drying shrinkage, autogenous shrinkage, carbonation shrinkage.

Self-study: **(13 Hrs)**

a) Practice with different admixtures and infer the difference on workability.
b) Identify the difference on workability with the passage of time
c) Identify the shrinkage characteristics with different cement, aggregate and water

content.

MODULE III: MIX PROPORTIONING (9Hrs)

Mix design - Nominal mix- design mix – concept of mix design - variables of proportioning - general considerations - factors considered in the design of concrete mix- various methods of mix design - design of concrete mix as per IS 10262-2019 -Design of Smart concrete- Statistical quality control of concrete – mean strength – standard deviation – coefficient of variation – sampling - testing acceptance criteria

Self-study: (14 Hrs)

a)Prepare design mixes by testing the available materials and test to find target strength.

MODULE IV: DURABILITY & NDT OF CONCRETE (9Hrs)

Durability of concrete- Factors affecting durability - permeability- cracking-reinforcement corrosion; carbonation, chloride penetration, sulphate attack, acid attack, fire resistance; frost damage, alkali silica reaction, concrete in sea water - Non-destructive testing of concrete- surface hardness test- ultrasonic pulse velocity method - penetration resistance- pull-out test- core cutting - measuring reinforcement cover.

Special concretes - lightweight concrete-heavy weight concrete - high strength concrete – high

performance concrete - self compacting concrete -roller compacted concrete– fibre reinforced concrete - polymer concrete-pumped concrete - ready mix concrete - green concrete. Special processes and technology - sprayed concrete; underwater concrete, mass concrete; slip form construction, prefabrication technology- 3D concrete printing

Self-study: **(14 Hrs)**

a) Prepare special concrete with fibers, admixtures, polymers.
b) Visit to sites using special concrete and different mechanisation equipment for application and finishing.

Textbooks

1. Neville A.M., Properties of Concrete, Trans-Atlantic Publications, Inc.; 5e, 2016
2. R. Santhakumar , Concrete Technology, Oxford Universities Press, 2018
3. Shetty M. S., Concrete Technology", S. Chand & Co., 2018

Reference books

1. Mehta and Monteiro, Concrete-Micro structure, Properties and Materials, McGraw Hill Professional 2017
2. Neville A. M. and Brooks J. J., Concrete Technology, Pearson Education, 2019
3. Lea, Chemistry of Cement and Concrete", Butterworth-Heinemann Ltd, 5e, 2017

NPTEL/SWAYAM Courses for reference:

1. Prof. Ravindra Gettu ,Prof.Aslam Kunhi Mohamed- Modern Construction Materials- IIT Madras- **https://archive.nptel.ac.in/courses/105106053**
2. Prof. B. Bhattacharjee -Concrete Technology - IIT Delhi- https://nptel.ac.in/courses/105102012
3. Dr. Sudhir Misra- Concrete Engineering and Technology- IIT Kanpur- https://nptel.ac.in/courses/105104030

COURSE CONTENTS AND LECTURE SCHEDULE		
No.		No. of Hours (36)
MODULE I - 9 hours		
1.1	Cement -Review of manufacturing process-	1
1.2	Chemical composition of ingredients, composition and its relevance	1
1.3	Bogue's compounds chemical equations, formation, function , merits and demerits mechanism of hydration- heat of hydration	2
1.4	Aggregate-Review of types, sampling and testing, artificial aggregates	1
1.5	Chemical Admixtures- types, uses, mechanism of action - effects on properties of concrete - Mineral admixtures- types, chemical composition -	2
1.6	Physical characteristics - effects on properties of concrete	1
1.7	Rheology – basic concepts Bingham model	1
MODULE II - 9 hours		
2.1	Properties of fresh concrete- workability-factors affecting workability - slump test, compaction factor test- Vee Bee consistometer test, flow tests	2
2.2	Properties of hardened concrete - modulus of elasticity, compressive strength, split tensile strength, flexural strength-	2
2.3	Effect of water cement ratio – maturity concept-	2
2.4	Creep - factors affecting creep - effect of creep	2
2.5	Shrinkage- factors affecting shrinkage - plastic shrinkage, drying shrinkage, autogenous shrinkage, carbonation shrinkage.	1
MODULE III (9 Hours)		
3.1	**Mix design** - Nominal mix- design mix – concept of mix design - variables of proportioning -	2
3.2	General considerations - factors considered in the design of concrete mix-	2
3.3	Statistical quality control of concrete – mean strength – standard deviation – coefficient of variation – sampling - testing acceptance criteria	1
3.4	Various methods of mix design	2

3.5	Design of concrete mix as per IS 10262-2019 - Examples of different grades and different material properties.	1
3.6	Design of Smart concrete	1
MODULE IV- (9Hours)		
4.1	Durability of concrete- Factors affecting durability - permeability-cracking-	1
4.2	Reinforcement corrosion; carbonation, chloride penetration, sulphate attack, acid attack,	1
4.3	Fire resistance; frost damage, alkali silica reaction, concrete in sea water	1
4.4	Non-destructive testing of concrete- surface hardness test- ultrasonic pulse velocity method - penetration resistance- pull-out test- core cutting - measuring reinforcement cover	2
4.5	Special concretes - lightweight concrete-heavy weight concrete - high strength concrete high performance concrete - self compacting concrete -roller compacted concrete–	2
4.6	Special processes and technology - sprayed concrete; underwater concrete, mass concrete; -slip form construction, prefabrication technology- 3D concrete printing	2
CO Assessment Questions		
CO1	1. Explain any one test to determine the strength of the aggregate. **[Understand]** 2. List out any three uses of chemical admixtures in concrete with one example for each. **[Apply]** 3. Compare the properties of Bogue's compounds highlighting its influence on rate of hydration and strength gain. **[Analyse]** 4. Explain the role of mineral admixtures with the help of one example for each. **[Understand]** 5. Briefly explain the classification of aggregates based on size, specific gravity, availability, shape and texture. **[Understand]**	
CO2	1. Define (i) shrinkage (ii) creep. **[Understand]** 2. List out any three properties and tests for hardened concrete. **[Understand]** 3. Explain the most common test adopted in the field to determine the workability of concrete and also mention it's IS specification. **[Apply]**	

	4. Explain the procedure to find the split tensile strength of concrete and also mention it's IS specification. **[Understand]** 5. Explain the procedure of Vee Bee consistometer test and also mention it's IS specification. **[Apply]** 4. Explain the procedure to find the flexural strength of concrete and also mention it's IS specification. **[Understand]**
CO3	1. Enumerate the objectives of concrete mix design. **[Apply]** 2. Explain the factors to be considered in mixture proportioning. **[Apply]** 3. Design a concrete mix for the following data as per IS 10262: 2019. Grade of concrete: M30, Cement - OPC of 33 grade, moderate exposure, ZoneII sand, workability- 100mm (slump), 20mm maximum sized rounded coarse aggregate. Specific gravity of cement – 3.15; Specific gravity of coarse aggregate – 2.6; Specific gravity of fine aggregate – 2.65; Assume all aggregates in SSD condition. Any other missing data may be assumed suitably. **[Analyse]** 4. Explain the step-by-step procedure of BIS method of concrete mix design. **[Apply]** 5. Describe the statistical quality control measures of concrete. **[Apply]**
CO4	1. Explain the uses of pull-out test. **[Understand]** 2. Explain the procedure of the non-destructive test to be adopted to find surface hardness of concrete. **[Apply]** 3. Explain the effect of sea water in concrete and suggest methods to reduce the effects**[Understand]** 4. Explain any two non-destructive tests of concrete highlighting the main use of each of them. **[Understand]** 5. List out the objectives of the ultrasonic pulse velocity method. **[Understand]**
CO5	1. Enlist six factors affecting durability of concrete. **[Apply]** 2. Describe the factors affecting the properties of fibre reinforced concrete. **[Understand]** 3. Explain 3D concrete printing and its uses. **[Understand]** 4. Describe the ways in which light weight concrete can be made. List out any two of its advantages. **[Apply]** 5. Describe the applications and uses of sprayed concrete 6. Explain the types of polymer concrete highlighting its properties and applications. **[Understand]**

	7. Enlist the advantages of prefabricated concrete**[Apply]**

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24CEE417	NUMERICAL METHODS FOR ENGINEERS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble: The course Numerical Methods for Engineers introduces computational techniques to solve complex mathematical problems encountered in various Civil Engineering domains. It emphasizes the practical application of these methods in structural analysis, geotechnical modelling, fluid flow, traffic simulation, and environmental forecasting.

Prerequisite: 24MAT121 - Linear Algebra, Differential Equations & Laplace transforms, 24EST124 - Introduction to Civil Engineering.

Course Outcomes: After the completion of the course the student will be able to

CO1	Describe and apply basic numerical methods to obtain approximate solutions of mathematical problems. **[Apply]**
CO2	Obtain numerical solution of linear and nonlinear algebraic equations. **[Apply]**
CO3	Perform numerical integration for Civil Engineering problems **[Apply & Analyze]**
CO4	Apply numerical solutions of differential equations to Civil Engineering problems **[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2			3						1
CO2	2	2			3						1
CO3	2	2			3						1
CO4	2	2			3						1

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	✓	✓	✓	✓
Understand	✓	✓	✓	✓
Apply	✓	✓	✓	✓
Analyse	✓	✓	✓	✓
Evaluate				
Create				

Mark Distribution of CIA					
Course Structure [L-T-P-R]	**Attendance**	**Theory [L]**			**Total Marks**
		Assignment	**Test-1**	**Test-2**	
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 Hrs

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each Question carries 2 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub-divisions. Each question carries 9 marks. Marks: (9x 4 = 36 marks)	60

SYLLABUS

MODULE I:
LINEAR AND NONLINEAR SYSTEMS; EIGENVALUE PROBLEMS (9hrs)

Introduction to numerical methods - Errors in numerical computation System of linear algebraic equations –Ill-conditioned systems – Symmetric and Banded systems. Elimination methods –Gauss Elimination (review), Gauss Seidel iteration, Factorization method-Choleski's method. System of nonlinear equations – Newton-Raphson method. Eigen value problems - largest and smallest Eigen values- Power method, Jacobi's transformation

Self-study – 13hrs

a) Errors in Numerical Computation-Compare true and approximate solutions of a known civil engineering problem (e.g., beam deflection or settlement of soil). Compute absolute, relative, and percentage errors.
b) Plot convergence of Gauss-Seidel and Newton-Raphson methods graphically in a civil problem using software tools.

MODULE II
APPROXIMATION AND NUMERICAL INTEGRATION (9hrs)

Approximation - Lagrangian and Hermite interpolation, Spline interpolation - Quadratic and Cubic splines (example of equal intervals). Data smoothing by least squares criterion-

non-polynomial models like exponential model and power equation using Civil Engineering data.
Multiple linear regression - Regression analysis of traffic flow data and Modelling rainfall-runoff relations.
Numerical integration - Newton–Cotes open quadrature formulae, Trapezoidal rule and Simpson's rules.

Self-study – 14hrs

a) **Interpolation Techniques-** Use Lagrangian and Hermite interpolation to estimate missing values in a dataset representing groundwater levels at different depths**.**
b) **Multiple Linear Regression-** Traffic Flow & Rainfall-Runoff Modeling
c) **Numerical Integration-** Estimate area under a river cross-section or sediment depth curve using: Trapezoidal Rule, Simpson's 1/3 Rule, Open Newton-Cotes (for uneven data)

MODULE III:
ORDINARY DIFFERENTIAL EQUATIONS IN CIVIL ENGINEERING SYSTEMS (9hrs)

Numerical solution of first-order ODEs: Taylor series, Euler's method, Modified Euler's method, Fourth-order Runge-Kutta method. Higher-order ODEs and systems using Runge-Kutta method Ordinary differential equations of the boundary value type – Finite difference solution.
Applications: Water flow modelling in open channels and pipelines and Structural dynamics under time-varying loads.

Self-study – 14hrs

a) Numerical Solution of First-Order ODEs- Solve the velocity profile of water in a gradually varied open channel using: Euler's method, Modified Euler's method, Fourth-order Runge-Kutta method (RK4)
b) **Water Flow Modeling**:
Model unsteady flow in an open channel using Saint-Venant equations (simplified form).
Solve using time-marching Runge-Kutta method with given initial conditions.
c) **Structural Dynamics**:
Simulate time-dependent structural response under dynamic loading (e.g., wind or earthquake) using RK4 for a mass-spring-damper system.

MODULE IV
PARABOLIC EQUATIONS AND WEIGHTED RESIDUAL METHODS (9hrs)

Parabolic equations – Explicit finite difference method – Bender-Schmidt method. Crank-Nicholson implicit method. Elliptic equations - Finite difference method.
Weighted residual methods for initial value problems and boundary value problems – Collocation method, Method of least squares, Galerkin's method.

Self-study – 13hrs

a) Use the finite difference method to solve steady-state seepage through an earth

dam using the 2D Laplace equation

b) Solve a 1D beam deflection problem using: Collocation method, Least squares method, Galerkin's method

Applications of the methods shall be based on Civil Engineering problems such as Structural analysis problems to determine member forces, traffic simulations, weather prediction, water flow estimation, fluid dynamics simulations, and geotechnical modelling of groundwater movement

Text Books:

1. Numerical Methods for Engineering Problems, N Krishna Raju, K U Muthu, Macmillan Publishers India Limited.
2. Numerical Methods for Engineers & Scientists, Grewal B. S, Khanna Publishers
3. Numerical Methods in Science and Engineering, Rajasekharan S, S Chand & Company 2003
4. Numerical methods, Babu Ram, Pearson.

Reference Books:

1. Numerical Methods for Engineers, Chapra S. C. and R. P. Canale, McGraw Hill.
2. Numerical solutions for Differential Equations, Smith G. D, McGraw Hill.
3. Modern Methods for Engineering Computations, Ketter and Prawel, McGraw Hill
4. Numerical Methods for Initial and Boundary value problems, Rajasekharan S, Khanna Publishers.

NPTEL/SWAYAM Courses for reference:

1. Prof. Niket Kaisare - Numerical Methods for Engineers- IIT Madras https://onlinecourses.nptel.ac.in/noc20_ge20
2. Prof. Ameeya Kumar Nayak & Prof. Sanjeev Kumar - Numerical Methods - IIT Roorkee -https://archive.nptel.ac.in/courses/111/107/111107105

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours (36)
	MODULE 1 (9 Hours)	
1.1	Introduction to numerical methods	1
1.2	Ill-conditioned systems – Symmetric and Banded systems.	1
1.3	Errors in numerical computation System of linear algebraic equations Elimination methods	1
1.4	Gauss Elimination (review)	1
1.5	Gauss Seidel iteration	1
1.6	Factorization method - Choleski's method	1

1.7	System of nonlinear equations - Newton-Raphson method.	1
1.8	Eigen value problems - largest and smallest Eigen values	1
1.9	Power method, Jacobi's transformation	1
MODULE II (9 Hours)		
2.1	Approximation - Lagrangian and Hermite interpolation,	1
2.2	Spline interpolation - Quadratic and Cubic splines (example of equal intervals).	1
2.3	Data smoothing by least squares criterion-	1
2.4	Non-polynomial models like exponential model and power equation using Civil Engineering data.	2
2.5	Multiple linear regression - Regression analysis of traffic flow data and Modelling rainfall-runoff relations.	1
2.6	Numerical integration	1
2.7	Newton–Cotes open quadrature formulae	1
2.8	Trapezoidal rule and Simpson's rules	1
MODULE III (9 Hours)		
3.1	Numerical solution of first-order ODEs: Taylor series	1
3.2	Euler's method, Modified Euler's method	2
3.3	Fourth-order Runge-Kutta method.	1
3.4	Higher-order ODEs and systems using Runge-Kutta method	1
3.5	Ordinary differential equations of the boundary value type	1
3.6	Finite difference solution.	1
3.7	Applications: Water flow modelling in open channels	1
3.8	Applications: Pipelines and Structural dynamics under time-varying loads.	1
MODULE IV (9 Hours)		
4.1	Parabolic equations	1
4.2	Explicit finite difference method	1
4.3	Bender-Schmidt method.	1
4.4	Crank-Nicholson implicit method.	1
4.5	Elliptic equations	1

<table>
<tr><td>4.6</td><td>Finite difference method.</td><td>1</td></tr>
<tr><td>4.7</td><td>Weighted residual methods for initial value problems and boundary value problems</td><td>1</td></tr>
<tr><td>4.8</td><td>Collocation method, Method of least squares</td><td>1</td></tr>
<tr><td>4.9</td><td>Galerkin's method.</td><td>1</td></tr>
<tr><td colspan="3">CO Assessment Questions</td></tr>
<tr><td>CO 1</td><td colspan="2">A system of equations is given as:
3x + y + z = 1
x + 4y + 2z = 2
2x + y + 5z = 3
Use the Gauss-Seidel Iteration Method to obtain the solution up to two iterations. Comment on the convergence of the solution. [Apply]</td></tr>
<tr><td></td><td colspan="2">Consider the matrix:
$A = \begin{bmatrix} 4 & 1 \\ 1 & 3 \end{bmatrix}$
Use the Power Method to estimate the largest eigenvalue and its corresponding eigenvector after three iterations with an initial vector $[1, 1]^T$. [Apply]</td></tr>
<tr><td>CO 2</td><td colspan="2">Using Lagrangian interpolation, estimate the settlement of a soil layer at 25 kPa pressure from the following data:
<table>
<tr><th>Pressure (kPa)</th><th>Settlement (mm)</th></tr>
<tr><td>20</td><td>10</td></tr>
<tr><td>30</td><td>18</td></tr>
<tr><td>40</td><td>28</td></tr>
</table>
[Apply & Analyze]</td></tr>
<tr><td></td><td colspan="2">Fit an exponential model of the form $y = ae^{bx}$ to the following traffic data using the least squares method:
<table>
<tr><th>Time (min)</th><th>Vehicle Count</th></tr>
<tr><td>1</td><td>100</td></tr>
<tr><td>2</td><td>150</td></tr>
<tr><td>3</td><td>225</td></tr>
<tr><td>4</td><td>330</td></tr>
</table></td></tr>
</table>

	Interpret the trend in the context of traffic flow increase. **[Apply & Analyze]**
CO 3	Using the Fourth-order Runge-Kutta method, solve the first-order differential equation: $\frac{dy}{dx} = x + y, \quad y(0) = 1$ for x=0.1 with step size h=0.1 Interpret the result in the context of water level rise in an open channel due to inflow. **[Apply & Analyze]**
	Apply the Modified Euler's method to solve the ODE $\frac{dy}{dx} = -2xy^2, \quad y(0) = 1$ from x=0 to x=0.2 with a step size of 0.1. Relate the form of the equation to a pipe flow velocity decay model. **[Apply & Analyze]**
CO 4	A soil heat transfer problem is modelled by the parabolic equation: $\frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2}$ Use the Bender-Schmidt method (explicit scheme) to solve the equation for the first two-time steps. Assume appropriate initial and boundary conditions. **[Apply & Analyze]** Explain how such numerical modelling helps in predicting subsoil temperature variation. **[Apply & Analyze]**
	Solve the 1D heat conduction problem using the Crank-Nicholson method for the first time step with given thermal diffusivity and mesh sizes. Compare its stability and accuracy with the explicit method. Relate this to thermal analysis in RCC structures. **[Apply & Analyze]**

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24CEE418	SUBMISSION DRAWING PREPARATION FOR BUILDINGS	L	T	P	R	C	Year of Introduction
		3	0	3	0	5	2024

Preamble: This course introduces students to the regulatory, architectural, and structural aspects involved in preparing submission drawings required for obtaining building permits. It emphasizes understanding building bylaws, municipal regulations, and digital drafting standards. Students will learn to develop submission drawings for residential, commercial, and mixed-use buildings using CAD tools, ensuring alignment with local development rules, safety norms, and environmental considerations.

Prerequisite: 24CEL308-Computer Aided Building Drawing Lab, 24CER304-Concrete Technology and Building Planning

Course Outcomes: After the completion of the course the student will be able to

CO1	Interpret and apply relevant building rules, regulations, and codes in the preparation of submission drawings. **[Apply]**
CO2	Prepare detailed submission drawings for residential and commercial buildings using appropriate CAD software. **[Create]**
CO3	Analyze the architectural and structural components required for municipal approval. **[Apply]**
CO4	Develop comprehensive submission packages incorporating site layout, floor plans, elevation, sections, and service drawings**. [Create]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2		2	3	2	2			1
CO2	2	1	3		3	2	1	1			1
CO3	2	2	3		3	3	2	2			1
CO4	3	1	3		3	2	2	1			1

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Mini Project	
Remember	✓	✓		✓
Understand	✓	✓		✓
Apply	✓	✓	✓	✓
Analyse	✓	✓	✓	✓
Evaluate			✓	✓
Create			✓	✓

Mark Distribution of CIA						
Course Structure [L-T-P-R]	**Attendance**	**Theory [L-P]**				**Total Marks**
		Assignment	**Test - 1**	**Test - 2**	**Mini Project**	
3-0-3-0	5	10	12.5	12.5	10	50

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2.5 Hrs

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 2	2 Questions from each module, 8 Questions, Answer any 6 Questions, Each question carries 3 marks. Marks: (6 x 3 = 18 marks)	2 Questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 8 marks. Marks: (4 x 8 = 32 marks)	50

SYLLABUS

MODULE I
BUILDING BYELAWS AND APPROVAL PROCESS (9 hrs)

Introduction to building byelaws (e.g., Kerala Municipality Building Rules (KMBR) and National Building Code (NBC)). Zoning regulations and land use classification. Floor Area Ratio (FAR), Floor Space Index (FSI), setbacks and height restrictions.
Steps in obtaining building permit and occupancy certificate.
Overview of submission drawing requirements in different jurisdictions
Self-study: (28 Hrs)
Review of local development authority guidelines and submission checklists.

MODULE II
PREPARATION OF ARCHITECTURAL SUBMISSION DRAWINGS (9 hrs)

Site plan preparation with north direction, approach road, site dimensions
Preparation of layout plan, floor plans (minimum one residential and one commercial building)
Elevation and sectional drawings with essential annotations
Area calculations – carpet area, built-up area, FAR area
Incorporating scale, dimensioning, and line conventions
Self-study: (28 Hrs)
Study real approved submission drawings from local authority archives.

MODULE III
USE OF CAD SOFTWARE IN SUBMISSION DRAWINGS (9 hrs)

Overview of AutoCAD/Revit/ArchiCAD interface
Layer management, blocks, hatching, text styles
Drafting submission-quality plans, elevations, and sections in CAD
Printing and layout setting for A1/A2 submission formats
Introduction to BIM-based submission drawing workflows

Self-study: (29 Hrs)

CAD practice: students prepare building drawings using CAD software.

MODULE IV
COMPILATION OF COMPLETE SUBMISSION DRAWING SET (9 hrs)

Site and layout plan
Floor-wise building plans, elevation, section
Septic tank/soak pit/water supply & drainage layout
Area statement table and building detail report
Statutory forms, declaration, and compliance checklist for submission

Self-study: (29 Hrs)

Compilation of all drawings into one final submission file (digital and print format).

Text Books:

1. Bindra, S.P. & Arora, S.P. (2020). *Building Construction: Planning Techniques and Methods*. Dhanpat Rai Publications.
2. Shah, M.G., Kale, C.M., & Patki, S.Y. (2014). *Building Drawing: With an Integrated Approach to Built Environment*. Tata McGraw-Hill Education.
3. Krishnamurthy, D. & Sathyanarayana, K.A. (2015). *Civil Engineering Drawing*. Charotar Publishing House.
4. Bhatt, N.D. (2021). *Building Drawing*. Charotar Publishing House.

Reference Books:

1. National Building Code of India (Latest Edition). Bureau of Indian Standards.
2. Kerala Municipality Building Rules (KMBR) or Kerala Panchayat Building Rules (KPBR) (Latest Amendments).
3. IS: 962 – 1989. Code of Practice for Architectural and Building Drawings. Bureau of Indian Standards.
4. CAD Folks or Tutorial Books. (2023). AutoCAD 2023 for Beginners.
5. Ching, Francis D.K. (2014). Architectural Graphics. Wiley.

NPTEL/SWAYAM Courses for reference:

1. Prof. Uttam Kumar Roy- Housing Policy & Planning, IIT Roorkee https://nptel.ac.in/courses/124107001
2. Prof. P.S. Robi - Engineering Drawing, IIT Guwahati, https://nptel.ac.in/courses/112103019

COURSE CONTENTS AND LECTURE SCHEDULE		
No.		No. of Hours (36)
MODULE 1 (9 Hours)		
1.1	Introduction to building byelaws (e.g., Kerala Municipality Building Rules (KMBR) and National Building Code (NBC)).	3
1.2	Zoning regulations and land use classification.	2
1.3	Floor Area Ratio (FAR), Floor Space Index (FSI), setbacks and height restrictions.	1
1.4	Steps in obtaining building permit and occupancy certificate.	2
1.5	Overview of submission drawing requirements in different jurisdictions	1
MODULE II (9 Hours)		
2.1	Site plan preparation with north direction, approach road, site dimensions	1
2.2	Preparation of layout plan, floor plans (minimum one residential and one commercial building)	4
2.3	Elevation and sectional drawings with essential annotations	2
2.4	Area calculations – carpet area, built-up area, FAR area	1
2.5	Incorporating scale, dimensioning, and line conventions	1
MODULE III (9 Hours)		
3.1	Overview of AutoCAD/Revit/ArchiCAD interface	2
3.2	Layer management, blocks, hatching, text styles	2
3.3	Drafting submission-quality plans, elevations, and sections in CAD	2
3.4	Printing and layout setting for A1/A2 submission formats	1
3.5	Introduction to BIM-based submission drawing workflows	2
MODULE IV (9 Hours)		
4.1	Site and layout plan	1
4.2	Floor-wise building plans, elevation, section	3
4.3	Septic tank/soak pit/water supply & drainage layout	3
4.4	Area statement table and building detail report	1
4.5	Statutory forms, declaration, and compliance checklist for submission	1

CO Assessment Questions	
CO 1	1. Given a residential plot of 240 m^2 in a municipal area, identify the minimum setbacks, FSI, and permissible built-up area as per KMBR norms. Draw a basic sketch layout following these parameters. **[Apply]**
	2. Explain the importance of the Kerala Municipality Building Rules (KMBR) in the preparation of submission drawings. List and describe at least four mandatory components of a building submission drawing. **[Apply]**
CO 2	1.Given a floor plan of a small commercial building, draw the front elevation and longitudinal section. Label key architectural and structural components appropriately. **[Apply]**
	2. Prepare a submission drawing (plan, elevation, and section) for a two-storey residential building with a built-up area of 180 m^2. Ensure that the drawing follows BIS code recommendations and includes all necessary symbols and line conventions. **[Create]**
CO 3	1.Using AutoCAD/Revit, prepare a submission drawing set for a G+1 residential building including site plan, floor plan, elevation, and section. The drawing must comply with local development authority norms. **[Create]**
	2.Create a digital submission drawing in Revit for a commercial building that includes a ramp for differently-abled access. Add annotations, dimensions, and schedules as per standard municipal submission requirements. **[Create]**
CO 4	1.Prepare a complete set of submission drawings (site plan, floor plans, elevation, section, and drainage layout) for a proposed residential building on a 300 m^2 plot for submission to a local municipality. **[Create]**
	2. Create a drawing set that includes all submission components for a small apartment block (3 units per floor, G+2). Include rainwater harvesting layout, electrical routing schematic, and parking layout. **[Create]**

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