GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Construction Engineering & Management

Course / Subject Code: ME01076031

Subject Name : Numerical Methods & Artificial Intelligence in Geotechnical Engg

w.e.f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	Knowledge of Geotechnical Engineering, Mechanics of Solids
Rationale:	This subject numerical methods and artificial intelligence is introduced with a view that student with the necessary skills and knowledge to tackle contemporary challenges in the field. This combination of advanced analytical techniques and cutting-edge technology ensures that future geotechnical engineers are well-prepared to design safe, efficient, and sustainable solutions. The Finite Element Method is a critical tool in geotechnical engineering, offering precise and adaptable solutions for complex problems. Its ability to handle non-linear analysis, complex geometries, and dynamic loads makes it indispensable for designing safe, efficient, and cost-effective geotechnical structures. AI enhances data analysis, predictive modeling, design optimization, real-time monitoring, and innovation, leading to safer, more efficient, and cost-effective geotechnical solutions.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Learning basic concept of the numerical methods. Knowledge of variational methods helps understanding variational approach to finite element method and application of finite difference method to Geotechnical problems
02	Learning theoretical basic understanding of the finite element method, and apply finite element method to consolidation, seepage, foundation etc problems and learning of boundary element method.
03	Comprehend the basic principles of artificial intelligence (AI) and machine learning (ML) algorithms
04	Derive the need and benefits of using AI/ML algorithms for developing applications in Geotechnical Engineering using big-data analysis.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No.of Hours	%of Weightage
1.	Introduction to variational calculus and Various Numerical Methods: Linear equations and eigen value problems, Accuracy of approximate calculations, Nonlinear equations, interpolation, differentiation and evaluation of single and multiple integrals, initial and boundary value problems by finite difference method, Newton's method, variation and weighted residual methods.	12	25
2.	Finite Element Method: Finite element descritization, , displacement models, Natural and general co-ordinate systems, Derivation of properties of one and two dimensional elements, Isoparametric elements, Stiffness matrix and load vectors, Numerical integration, Assembly and solution techniques	10	25
3.	Machine Learning Basics: Data Collection, Data Management, Big data, taxonomy of machine learning algorithms, Supervised Learning: Classification – Bayesian Classifier, K-nearest Neighbours, Regression- Linear Regression, Multivariate Regression, Logistic regression. Support Vector Machine (SVM) Algorithm. Unsupervised Learning: Clustering- K-means clustering algorithm and Hierarchical clustering algorithm. Reinforcement Learning: Q-Learning algorithm.	13	25
4.	Introduction- Classification of artificial intelligence-expert systems-artificial neural networks basic concepts-uses in functional approximation and optimization applications in the design and analysis, building construction. Fuzzy logic-basic concepts-problem formulation using fuzzy logic-applications.	10	25
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
16	14	12	10	10	8

WhereR:Remember;U:Understanding;A:Application,N:AnalyzeandE:EvaluateC:Create(as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Scarborough, J.B., Numerical mathematical analysis, Oxford & IBH Publishing CO Pvt., 2000
2. Jain, K.K., Iyengar, S.R.K and Jain, R.K., Numerical methods-problem and solutions, Wiley eastern limited, 2001
3. Hamming, R.W., Numerical methods for scientist and engineers, McGraw Hill, 1998.
4. Mathews, J.H. and Fink, K.D., Numerical methods using MATLAB, Pearson Education, 2004
5. Hayter, A.J., Probability and statistics, Duxbury, 2002.
6. Rumelhart, D.E and McClelland, J.L., Parallel distributed processing Vol. 1, M I T Press, 1986.
7. Patyra, M.J. and Mlynek, Fuzzy logic implementation and applications, Wiley, 1996.
8. David M Potts. And Lidija, Zdravkovic, Finite Element Analysis in Geotechnical Engineering, Vol 1 & 2. Thomas Telford, London.
9. J.S.R.Jang, C.T.Sun and E.Mizutani - Neuro-Fuzzy and Soft Computing , Pearson Education.
10. Simon O. Haykin , Artificial Neural Network, PHI.

(b)Open source software and website:

1. NPTEL lecture series
2. MIT open source material
3. .Finite Element Procedures for Solids and Structures on MIT OCW

Suggested Course Practical List:

List of Tuts:

1. Preparing report on AI, Expert system, ANN, GA and their applications
2. Developing VBA programs for numerical methods used in Geotechnical Foundation analysis
3. Developing VBA programs for soil-structure interaction analysis and design (footings, rafts, retaining walls, etc)

List of Laboratory/Learning Resources Required:

1. Computer Lab enabled with Machine Learning tools/software's

Suggested Project List:

1) Simulation and Modeling of various geotechnical scenarios, such as slope stability, settlement analysis, and bearing capacity.

2) Predictive Analytics: Developing AI algorithms which can predict geotechnical failures, such as landslides and foundation settlements, with high accuracy, allowing for proactive measures to be taken.

Suggested Activities for Students:

1) Learning/exploring geotechnical software's i.e. PLAXIS 2D & 3D, GeoSlope, ABAQUS, FLAC, etc.
2) Referring tools of ANN, Genetic Algorithm

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