

भारतीय पेट्रोलियम और ऊर्जा संस्थान
INDIAN INSTITUTE OF PETROLEUM & ENERGY
आंध्र प्रदेश, विशाखापत्तनम - ५३०००३
ANDHRA PRADESH, VISAKHAPATNAM - 530003



Web-Based M. Tech in Data Science and Machine Learning

**Information Brochure
2024-25**

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1. About Institute

Indian Institute of Petroleum and Energy (IIPE), Visakhapatnam, a domain-specific Institute at par with IITs and IIMs, is established by the Government of India under the aegis of the Ministry of Petroleum and Natural Gas (MoPNG) in the year 2016. The Indian Institute of Petroleum and Energy Act, 2017 (No.3 of 2018) enacted by the Parliament and declared the Institute as an 'Institution of National Importance'. The Institute also enjoys a strong relationship with the industry regarding teaching, research, and student training & placement. A primary goal of research at IIPE has been to meet the country's fossil fuel and renewable energy demands. However, given its position as an energy institute, IIPE also has a great responsibility to contribute toward achieving the United Nations Sustainable Development Goals, i.e., ensuring access to affordable, reliable, and sustainable modern-day energy for all. The Institute has also embarked on an ambitious path to be the country's energy hub.

The Institute aims to produce skilled manpower to meet the quantitative and qualitative gap in Petroleum & Energy sectors and to boost the research activities needed for growth of these sectors by nurturing and promoting the quality and excellence in education and research in various areas of petroleum and energy through the programs leading to the award of the Bachelors, Masters and Doctoral degrees. Fulfilling this responsibility, IIPE is committed to realizing the "Panchamrita" concoction for the climate conundrum, the climate solution offered by the Hon'ble PM, Shri. Narendra Modi, at the COP26 convention in Glasgow. At IIPE, we strive to help foster Blue Zones, enabling a prosperous world to rise like a phoenix from the ashes of today's challenges. Let us join hands to remain relevant and excellent, focusing on removing India's impediments to achieving the goal of an Atmanirbhar Bharat in the energy sector and progress towards 'future ready India @2047'.



2. Program Overview

Organizations are increasingly relying on data-driven insights to make informed decisions, creating a strong demand for professionals with expertise in these areas. There is a significant demand for data scientists and machine learning engineers across various industries. The skills learned in data science and machine learning are applicable across various industries and domains to analyze customer behavior, optimize business processes, or develop recommendation systems. Individuals with these skills can contribute to cutting-edge technological developments and advancements in artificial intelligence, predictive analytics, natural language processing, and computer vision.

This program is aimed at working professionals seeking to transition to Data Scientist or Data Engineer roles. Software and IT professionals can pursue the program without any career break. The classes are conducted beyond office hours and on weekends. The IPE, Visakhapatnam would like to fulfill the ever-increasing demand by introducing 5-8 semesters, Web-based M. Tech. in Data Science and Machine Learning program.

This program allows working professionals to gain the skills needed to work as a Data Engineer or a Data Scientist. The curriculum was designed to provide a solid theoretical foundation and good hands-on exposure.

To summarize, the program aims to transform current professionals into the future workforce who can solve the industry and research problems using the Data Science and Machine Learning techniques.

3. About Library

- Library facility at IPE Visakhapatnam was named after Padmasree S. R. Ranganathan who was a librarian and mathematician, and noted as the Father of Library science in India.
- The library houses more than 30,000 books which cover more than 8000 titles.
- Library subscribes to International and National Journals and also subscribes to International and national Newspapers and Magazines along with Digital Library Facility.
- Journal articles and eBooks were provided for access to the students by I.P based and domain-based access for the benefit of the students.
- A total of 5.28 crores of e-resources are accessible through NDLI (Nation Digital Library of India), IIT Kharagpur.
- Library Services include Internet Browsing; Book Bank; Reference Services; Current Awareness Service; Inter Library Loan; Photocopying; Content Management Service.

4. Admission Process

1. About Program: The Web-based M. Tech Program ensures that professionals gain relevant and up-to-date knowledge. Industry/organizational professionals generally pursue further education while working full-time. This specialized M.Tech. program for professionals offers flexible scheduling options, such as evening/weekend classes, allowing individuals to balance their work and academic commitments. Further, such a program brings together professionals from diverse backgrounds and organizations. This provides valuable networking opportunities, allowing professionals to exchange ideas, collaborate on projects, and build relationships within their Industry/Organization. Completing this M.Tech program can enhance career prospects and open up new opportunities for advancement in career. Employers often value advanced degrees and specialized skills, recognizing the commitment to continuous learning and professional development. The Program offers a curriculum specifically tailored to the needs of the Industry/Organization, covering topics such as emerging technologies, industry trends, regulatory requirements, and best practices to ensure graduates are well-equipped to address the challenges and demands of their profession.

2. Objective of the Program : The IIPe Web-based M.Tech program for professionals provides targeted education, practical experience, and networking opportunities essential for career advancement and success in today's competitive job market.

3. Program Details

Courses (Core and Elective)	Nine courses, each of three credits, with a total of 27 credits.
Thesis Unit	Six courses, each of three credits, with a total of 18 credits.
Total Credits	45 Credits for award of M.Tech. Degree

S.No	Web- Based PG Program	Duration	Total intake
1.	Web-Based M. Tech in Data Science and Machine Learning	Self-paced over 5-8 Semesters	30

4. Course Work : The first three semesters encompass core and elective courses, leading to project work in the subsequent two semesters. The admitted students must complete the Thesis Unit (Project Work) at their respective Organizations. The course is designed as an online program tailored for Industrial Professionals, with final exams necessitating physical attendance. The courses include international and industrial electives. No Ph.D. Course waivers will be granted for candidates enrolled for Web-Based M.Tech. Program. Ph.D. Course waiver requests may be considered solely for Integrated Ph.D. programs (M.Tech.+ Ph.D.)

5. Duration : A maximum of three Courses can be registered each semester. The maximum duration of the Program is eight semesters. The Thesis Unit can be taken only after completing the coursework. The maximum duration to complete the coursework is five semesters. The candidate must have an Internal Supervisor from IPE and an optional External Supervisor from their parent organization where employed, for the Thesis Unit.

6. Multiple Exit Options : In line with the NEP-2020, the Web-Based M. Tech has Multiple Exit Options.

(a) Exit Option 1: On Completion of all the First Two Semester 6 courses (Eighteen Credits) will lead to a Certificate course named 'Web-Based Certificate Course in Data Science and Machine Learning.

(b) Exit Option 2: Completing all Nine Theory Courses (Twenty-Seven Credit) will result in a Web-Based PG Diploma in Data Science and Machine Learning.

(c) Completion of the Course : Completing 45 Credits (27 Credits for Theory and 18 Credits for Thesis Unit) will lead to a Web-Based M. Tech in Data Science and Machine Learning.

7. Program Approval : IPE is an institution of national importance that enjoys autonomous status under the Ministry of Petroleum and Natural Gas, Government of India. Though this Program is an online degree program, it is approved and offered within the Institute's charter. The UGC/AICTE guidelines do not apply to this Program. The Program and degree are and will remain valid.

The Program's minimum enrolment threshold has been set at five students, while the maximum capacity is capped at thirty students. Admissions will be conducted annually to maintain consistency and efficacy.

8. Qualification and Experience :

(i) Qualification: Bachelor's Degree (4 years program) or a Masters Degree with at least 55% marks (without round-off) or 5.5/10 CGPA (without round-off).

(ii) Experience: Minimum of One year of work experience.

(iii) Selection: Selection will be based on a written test/interview conducted online by the Institute.

9. Fees :

For Indian Residents :

(i) Application Form Fees: Rs. 1,000/-

(ii) Admission Fees: Rs. 50,000/-

(iii) The fee for the Program is Rs. 30,000/- per course.

(iv) Total Course Fees for Web-based M.Tech Program : Rs. 5,00,000 /- (Rs. Admission fee Rs. 50, 000/- +Tuition Fees Rs. 4.50,000/-)

Foreign Nationals :

(i) Application Form Fees: \$ 50

(ii) Admission Fees: \$ 1000

(iii) The fee for the Program is \$ 700 per course.

(iv) Total Course Fees for Web-based M.Tech Program: \$11500 (Admission Fees \$1000 +Tuition Fees \$ 10500)

10. Fee-Waiver :

IPE Web-based Masters program offers incentives in the form of discounts to employees of government, defense, PSU, MSME, and other corporate employees. The concerned entity (Department/PSU/MSME/ Corporate) must agree with IPE or provide a formal/written document when sponsoring/nominating students for the Web-based Masters Program.

Table 1: Employees of Government, PSUs, or Defense Departments

S.No	Category	Nominated/ Sponsored*	Max Applicable Fee Waiver
1	Defense Personnel/ PSU/Govt. Depts/CFTIs	Sponsored	Fee waiver of Three Courses in Last Semester.
2	Defense Personnel/ PSU/Govt. Depts/CFTIS	Nominated	Fee waiver of Two Courses in Last Semester.

*The above waivers are applicable even if one candidate is nominated/sponsored by the concerned entities. Government includes constitutional bodies as well as non-constitutional bodies (i.e., all statutory, regulatory, and executive bodies) like Finance Commission, UPSC, SEBI, TRAI, CERC/SERCs, RBI, FSSAI, NHB, Niti Ayog, CBI etc.

*Fee Waiver is applicable for the people who opt for Web-Based M.Tech in Data Science and Machine Learning (Entire Course) and not for the Certificate Course & PG Diploma.

Table 2: Employees of Private Entities (MSMEs/Corporates)

S.No	Category	Min No. of Students#	Max Applicable Fee Waiver
1	MSME	3	Fee waiver of Two Courses in Last Semester.
2	Other Corporates	5	Fee waiver of Two Courses in Last Semester.

#The above waivers are applicable only if the minimum number of candidates are sponsored/nominated by the concerned entities.

*Fee Waiver is applicable for the people who opt for Web-Based M.Tech in Data Science and Machine Learning (Entire Course) and not for the Certificate Course & PG Diploma.

***Nominated:** Refers to candidates nominated by the concerned entity but who are self-funded.

***Sponsored:** Refers to candidates whose fee is funded by the concerned entity. Please note for sponsored candidates fees are directly paid by an organization.

Please note: The Institute reserves the right to modify, amend, or discontinue any discount program at any time. All decisions made by the Institute regarding discounts are final. There is no appeal process, and the Institute is under no obligation to provide explanations for its decisions.

5. Admission Important Dates & How to Apply

Commencement of Application Form	18 th June 2024
Last Date of the application submission	18 th July 2024
Written Test / Interview Dates	22 nd & 23 rd July 2024 (Tentative)
Declaration of Selected Candidates	26 th July 2024 (Tentative)
Last Date for paying Admission Fee	2 nd August 2024
Last Date for paying 1st Semester Tuition Fee	5 th August 2024
Commencement of the 1 st Semester Classes	12 th Aug 2024

STEP-I: Fill the Online application form

Register with Your Email Id and Login. FILL the appropriate data. Please note that you must upload your testimonials wherever required to validate your information along with your digital photograph and signature.

Application link:

https://erp.iipe.ac.in/IIPEApp/index?admiss_ch=04

STEP-II: Make PAYMENT and SUBMIT Application

The application fee payment must be made through Online payment gateway only.

STEP-III: Take PRINT

After the final submission of your Online application, keep the print out for further reference.

Please note that you **NEED NOT SEND** the application by post. Your application will be considered based on your final submission through online. You can check submission, shortlisting, selection and other application related status from Application Status menu. You should remember your login id and password for the same.

Note

Candidates are requested to follow the IIFE website (www.iife.ac.in) regularly for results and admission related updates. No personal communication will be entertained for admission. If any person fails to follow details, it is totally at his/her risk and responsibility, and institute does not bear any liability.

Refund of Admission Fees

Application Fee and Admission Fee are Non-Refundable.

The entire course fee is Refundable before the start of the Program. After the start of the Program, no fee is refundable. No fee is transferrable.

Legal Jurisdiction

Visakhapatnam is the only Legal Jurisdiction for any dispute arising on the eve of admissions into IIFE. In case, if it is the High Court, Andhra Pradesh Hon'ble High Court at Amaravathi is the legal jurisdiction.

ADMISSION OFFICE

Indian Institute of Petroleum & Energy,

Visakhapatnam - 530003,

Andhra Pradesh

Email: mtech_online@iife.ac.in

6. Course Curriculum

SEMESTER – I					
S.No	Course Name	L	T	P	Credits
1	Mathematical foundations of Data Science	3	0	0	3
2	Optimization for Data Science	3	0	0	3
3	Python Programming for DS	3	0	0	3
Total		9	0	0	9

SEMESTER - II					
S.No	Course Name	L	T	P	Credits
1	Machine learning & its applications	3	0	0	3
2	Introduction to Statistical Techniques	3	0	0	3
3	Elective	3	0	0	3
Total		9	0	0	9

SEMESTER - III					
S.No	Course Name	L	T	P	Credits
1	Elective	3	0	0	3
2	Elective	3	0	0	3
3	Elective	3	0	0	3
Total		9	0	0	9

SEMESTER - IV					
S.No	Course Name	L	T	P	Credits
1	Project	9	0	0	9
Total		9	0	0	9

SEMESTER - V					
S.No	Course Name	L	T	P	Credits
1	Project	9	0	0	9
Total		9	0	0	9

7. Possible Electives

POSSIBLE ELECTIVES*					
S.No	Course Name	L	T	P	Credits
1	Reinforcement learning	3	0	0	3
2	Natural language processing	3	0	0	3
3	Image processing	3	0	0	3
4	Time series analysis	3	0	0	3
5	Bioinformatics	3	0	0	3
6	Computational methods for DE & applications	3	0	0	3
7	Numerical Linear Algebra	3	0	0	3
8	High performance computing	3	0	0	3
9	Graphs & Algorithms	3	0	0	3
10	Big data Analytics	3	0	0	3
11	Data Structures & Algorithms	3	0	0	3
12	Deep Learning	3	0	0	3

8. Syllabus

Semester - I					
Course Type	Name of Course	L	T	P	Credits
Core	Mathematical foundations of Data Science	3	0	0	0
Syllabus					
<p>Basics of Data Science: Introduction; Typology of problems; Importance of linear algebra, statistics and optimization from a data science perspective; Structured thinking for solving data science problems.</p> <p>Calculus and Optimization: Functions of a single variable, limit, continuity and differentiability, Taylor series, maxima and minima, optimization involving a single and multi-variable.</p> <p>Linear Algebra: Matrices and their properties (determinants, traces, rank, nullity, etc.); Solutions to systems of linear equations, Eigenvalues and eigenvectors; Matrix factorizations; Singular Value Decomposition, Inner products; Distance measures; Projections; Notion of hyperplanes; half-planes.</p> <p>Probability: Probability theory and axioms; Random variables; Probability distributions and density functions (univariate and multivariate); Expectations and moments; Independent Random Variables, Covariance and correlation.</p>					
<p>Text Books/ Reference:</p> <ul style="list-style-type: none"> • G. Strang. Introduction to Linear Algebra, Wellesley-Cambridge Press, Fifth edition, USA, 2016. • G. B. Thomas Jr, M. D. Weir, and J. R. Hass, Calculus, Pearson Education (2009) • Sheldon Ross, A first course in probability, Pearson publisher • Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier. • Cathy O’Neil and Rachel Schutt. Doing Data Science, O’Reilly Media, 2013 					

Course Type	Name of Course	L	T	P	Credits
Core	Optimization for Data Science	3	0	0	3
Syllabus					
<p>Basic concepts of optimization-convex and concave functions, Necessary and sufficient conditions for stationary points, constrained and unconstrained optimization, local vs. global optimum, gradient, role of convexity, linear and non linear programming, Lagrange functions, KKT optimality conditions, gradient descent and stochastic gradient descent, Mini-batch gradient descent, linear and quadratic programming, hyperparameter tuning, applications of optimization in machine learning.</p>					
<p>Text Books/ Reference:</p> <ul style="list-style-type: none"> • J.Nocedal and S. J. Wright, Numerical Optimization. New York, 2006 • Ravindran, A., Ragsdell, K. M.,Reklaitis, G. V., Engineering Optimization - Methods and Applications, John Wiley, 2006 • Linear Algebra and Its Applications by Gilbert Strang • S. Chandra, Jayadeva, A. Mehra, Numerical optimization with applications, Narosa, 2009. • David M. Himmelblau and Thomas F. Edgar Optimization of Chemical Processes. 					

Course Type	Name of Course	L	T	P	Credits
Core	Python Programming for DS	3	0	0	3
Syllabus					
<p>Introduction to Python: Install Python and Environment Setup, Python Identifiers, Keywords and Indentation, Getting User Input, Python Data Types, Control Statements, Functions, Modules, Packages, List, Tuples, Dictionaries, and Sets. File I/O, Exception handling, Python Object Oriented, Python Multithreaded Programming.</p> <p>Data Science libraries: NumPy, Pandas. Data Visualization.</p>					
Text Books/ Reference:					
<ul style="list-style-type: none"> • Eric Matthes, Python Crash Course: A Hands-On, Project-Based Introduction to Programming, 2nd Edition, No starch Press, 2019. • Martic C Brown, Python: The Complete Reference, 4th Edition, McGraw Hill Publishers,2018. • Charles Dierbach, Introduction to Computer Science using Python: A Computational Problem Solving Focus,2nd Edition, Wiley India Edition, 2017. • Python for Data Analysis,(2013), Wes Mc Kinney, O'Reilly Media, 2012. 					

Semester - II

Course Type	Name of Course	L	T	P	Credits
Core	Machine learning & its applications	3	0	0	0

Syllabus

Introduction, Learning Paradigms, Concept Learning, Decision Tree, Bayes Classifier, Bayesian Networks, k-Nearest Neighbor, Support Vector Machines, Kernel Machines, Neural Networks, Perceptron, Multilayered Perceptron, Classifier Evaluation, Ensemble Learning, Boosting, Unsupervised Learning, Clustering, Dimensionality Reduction, Reinforcement Learning, Introduction to Learning Theory.

Text Books/ Reference:

- Machine Learning - Tom Mitchell (TM)
- Pattern Classification - Duda, Hart and Stork (DHS)
- Introduction to Machine Learning - E. Alpaydin (EA)
- The Elements of Statistical Learning -Hastie, Tibshirani, Friedman (HTF)

Course Type	Name of Course	L	T	P	Credits
Core	Introduction to Statistical Techniques	3	0	0	0

Syllabus

Sampling distributions: Chi-square, t and F distributions, random sample, sample mean and sample variance, the central limit theorem, distributions of the sample mean and the sample variance for a normal population

Estimation: Unbiasedness, consistency, the method of moments and the method of maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for properties, problems

Testing of Hypotheses: Null and alternative hypotheses, the critical and acceptance regions, two types of errors, power of the test, the most powerful test and Neyman-Pearson fundamental lemma, tests for one sample and two sample problems for normal population (t, F, Z tests), tests for proportions, Chi-square goodness of fit test and its applications, problems.

Regression Analysis: Simple linear regression (Description of the model, Least squares estimation, properties of the least square estimators, confidence interval and hypothesis testing for the model parameters, correlation); Multiple linear regression model (Description of the model, matrix approach of Least squares, properties of the least square estimators, confidence interval and hypothesis testing for the model parameters)

Text Books/ Reference:

- Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier.
- J. S. Milton & J. C. Arnold, Introduction to Probability and Statistics, McGraw Hill.
- D C Montgomery, Design and Analysis of Experiments, Wiley 2014.
- Alexander Mood, Franklin Graybill D. Boes, Introduction to the theory of Statistics, McGraw Hill.

Course Type	Name of Course	L	T	P	Credits
Elective	Data Structures & Algorithms	3	0	0	3

Syllabus

Review of problem-solving using computers, Abstraction, Elementary Data Types. Algorithm design- Correctness via Loop invariants as a way of arguing correctness of programs, preconditions, post conditions associated with a statement. Complexity and Efficiency via model of computation (notion of time and space), mathematical preliminaries, Elementary asymptotics (big-oh, big-omega, and theta notations).

ADT Array -- searching and sorting on arrays: Linear search, binary search on a sorted array. Bubble sort, Insertion sort, Merge Sort and analysis; Emphasis on the comparison based sorting model. Counting sort, Radix sort, bucket sort.

ADT Linked Lists, Stacks, Queues: List manipulation, insertion, deletion, searching a key, reversal of a list, use of recursion to reverse/search. Doubly linked lists and circular linked lists.

Stacks and queues as dynamic data structures implemented using linked lists. Analyse the ADT operations when implemented using arrays.

ADT Binary Trees: Tree representation, traversal, application of binary trees in Huffman coding. Introduction to expression trees: traversal vs post/pre/infix notation. Recursive traversal and other tree parameters (depth, height, number of nodes etc.)

ADT Dictionary: Binary search trees, balanced binary search trees - AVL Trees. Hashing - collisions, open and closed hashing, properties of good hash functions.

ADT Priority queues: Binary heaps with application to in-place sorting

Sorting: merge, quick, radix, selection and heap sort

Graphs: Representations (Matrix and Adjacency List), basic traversal techniques: Depth First Search + Breadth First Search (Stacks and Queues), directed acyclic graphs and topological sort.

Text Books/ Reference:

- Data Structures and Algorithm Analysis in C++, by Mark Allen Weiss (Pearson 2007).
- Data structures and Algorithms in C++ -- by Adam Drozdek (1994 2001).
- How to solve it by Computer -- by R G Dromey (PHI 1982, Paperback 2008).
- Fundamental of Data Structures in C – by Horowitz, Sahni and Anderson-Freed (Silicon Press 2007).
- Data Structure Using C and C++ -- by Y. Langsam, M. J. Augenstein and A. N. Tanenbaum (Pearson Education, 2nd, Edition, 2015).

Semester-III

Course Type	Name of Course	L	T	P	Credits
Elective	Deep Learning	3	0	0	3

Syllabus

Introduction to Deep Learning, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss, Optimization Techniques, Gradient Descent, Batch Optimization, Introduction to Neural Network, Multilayer Perceptron, Back Propagation Learning, Unsupervised Learning with Deep Network, Autoencoders, Convolutional Neural Network, Building blocks of CNN, Transfer Learning, Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam, Effective training in Deep Net- early stopping, Dropout, Batch, Normalization, Instance Normalization, Group Normalization, Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN etc., Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, Object Detection etc, LSTM Networks, Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Optimizers.

Text Books/ Reference:

- Deep Learning- Ian Good fellow, Yoshua Benjio, Aaron Courville, The MIT Press
- Pattern Classification- Richard O. Duda, Peter E. Hart, David G. Stork, John Wiley & Sons Inc.

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