Course Structure & Curriculum

1st Year

M.Tech in Petroleum Engineering

(For foreign and national Candidates)

भारतीय पेट्रोलियम एवं ऊर्जा संस्थान

Indian Institute of Petroleum and Energy

Visakhapatnam - 530003

First Year M.Tech in Petroleum Engineering

Course Structure

SEMESTER – I						
Sl. No	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Petroleum Geology	3	0	0	3
2		Applied Reservoir Engineering	3	0	0	3
3		Applied Hydrocarbon Production Engineering	3	0	0	3
4		Drilling Technology	3	0	0	3
5		Formation Evaluation	3	0	0	3
6		Petroleum Engineering Lab	0	0	3	2
7		Seminar	0	0	0	2
		Total				**19**

SEMESTER - II						
Sl. No	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Applied Reservoir Simulation	3	0	0	3
2		Elective I	3	0	0	3
3		Elective-II	3	0	0	3
4		Elective – III	3	0	0	3
5		Elective - IV	3	0	0	3
6		Modelling and Simulation Lab	0	0	3	2
7		Viva Voce/Summer Internship	0	0	0	2
		Total	**15**	**2**	**6**	**19**

ELECTIVES						
Sl. No	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Carbon Capture Storage and Utilization	3	0	0	3
2		Flow Assurance	3	0	0	3
3		Data Science	3	0	0	3
4		Big Data Management	3	0	0	3
5		Artificial Intelligence and Machine Learning	3	0	0	3
6		HPHT Drilling and Completion Fluids	3	0	0	3
7		Alternate Energy Resources	3	0	0	3
8		Hydrogen Energy	3	0	0	3
9		Environmental Engineering	3	0	0	3
10		Applied Gas Engineering	3	0	0	3
11		Applied Well Stimulation Techniques	3	0	0	3
12		Applied Numerical Modelling	3	0	0	3
13		Advanced Enhanced Oil Recovery	3	0	0	3

First Semester

Petroleum Geology	3-0-0	3 CH

Introduction to Petroleum Geology; Origin, Migration, and Accumulation of Hydrocarbons; Sedimentology and stratigraphy; Subsurface Environments; Petroleum Systems and Basin Analysis; Reservoir Rocks and Cap Rocks; Structural and Stratigraphic Traps; Environmental and Economic Aspects of Petroleum Geology.

References:

1. Selley, R.C. – Elements of Petroleum Geology
2. Tissot, B.P. & Welte, D.H. – Petroleum Formation and Occurrence
3. North, F.K. – Petroleum Geology
4. Levorsen, A.I. – Geology of Petroleum
5. Allen & Allen – Basin Analysis: Principles and Application to Petroleum Play Assessment

Applied Reservoir Engineering	3-0-0	3 CH

PRMS; material balance, Water influx models; Water flooding, Pressure Transient analysis, performance of unconventional reservoirs; unsteady, pseudo-steady and steady state flow, determination of well and reservoir parameters; applications to conventional and unconventional hydrocarbon producing wells.

References:

1. Ronald Terry, J. Rogers., 2007. Applied Petroleum Reservoir Engineering Pearson; 3rd edition (21 August 2014).

Applied Hydrocarbon Production Engineering	3-0-0	3 CH

Reservoir Deliverability (Inflow Performance Relationship, Single phase, Multiphase flow in porous media), Well Deliverability, Nodal Analysis, Production Challenges in Unconventional Hydrocarbon Resources, Equipment selection for production operations, design of production fluids processing systems, production forecasting, surface production facilities, production optimization, Well completion, Safety Systems

References:

1. Economides M.J., Hill A.D., Economides C.E., Zhu D., Petroleum Production Systems, Prentice Hall /Pearson Education India 2012.
2. Guo B., Lyons W.C., and Ghalambor A., Petroleum Production Engineering: a Computer Assisted Approach, Gulf Professional Publishing 2011
3. Renpu Wan. Advanced Well Completion Engineering. 2011. Elsevier.

Drilling Technology	3-0-0	3 CH

Well Planning and Well design

Objective, Drilling programme preparation, Type of well, Prospect, Geotechnical Order GTO, Introduction to wellbore pressures.

Rig Components and Drilling Systems

Rotary / top drive drilling, Types of onshore/offshore rigs, Rig Components, power generation system, Hoisting, Rotary system, Drilling Fluid circulation system, mud pumps, Well control system, Rig selection criteria, well tubular, drill string design

Drilling Bits and Mechanics

Drill bits and bit mechanics, Classification and design criteria; rock- tool interaction, methods of coring.

Drilling fluids and Mud Hydraulics

Drilling fluids functions and classifications, additives, hydraulic models, mud flow rate and pressure calculations.

Cements and Casing Design

Cements classifications, cementing methods and calculations, casing design practices, casing seat selection, casing while drilling.

Well Problems and Solutions

Fatigue failure, Pipe sticking, Lost-circulation, Sloughing shale, Swabbing, surge, gas cap drilling. Oil Well Fishing: Fish classification, tools and techniques.

Well Kick, Blow out and Well Control method

Causes of well kicks and early detection; Blowout prevention methods, Well control techniques (driller's method, wait-and-weight, volumetric method), well control calculations, kill sheet

References:

Text Books:

1. Petroleum Engineering: Drilling and Well Completion: Carl Gatlin.
2. Applied Drilling Engineering: Adams T Bourgoyane.
3. Drilling Engineering: A complete Well Planning and approach.

References:

1. Well Control Problems Solutions: Neal A J.dams.
2. Oil Well Drilling: H Rabia.
3. Oil Well Drilling Technology: Mc. Gray& Cole.

Formation Evaluation	3-0-0	3 CH

Introduction to formation evaluation; Core analysis and petrophysical properties; Well logging fundamentals and borehole environments; Resistivity logging and saturation analysis; Porosity and lithology logging; nuclear magnetic resonance (NMR) and dielectric logging; Formation pressure and production logging; Integrated formation evaluation (Log-Derived Permeability Estimation Methods, Water Saturation Models in Carbonates and Clastics, Well Log Interpretation for Pay Zone Identification, Integration of Log, Core, and Seismic Data for Reservoir Characterization)

References:

1. "Well Logging and Formation Evaluation" – Toby Darling
2. "Petrophysics: Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties" – Djebbar Tiab & Erle C. Donaldson
3. "Fundamentals of Well Log Interpretation" – Oberto Serra

Petroleum Engineering Lab	0-0-3	2 CH
To be updated Later		

Second Semester

Applied Reservoir Simulation	3-0-0	3 CH

Fundamentals of reservoir simulation and Numerical model; The physical laws governing fluid flow in porous media; Formulation of single-phase and multi- phase flow; Techniques to solve the governing partial differential equations using finite difference methods; Interpret the potential numerical errors; Treatment internal and external boundary conditions and initial conditions; Iterative solvers; The fully implicit and IMPES solution; Well modeling in reservoir simulation; History matching and Waterflooding concepts.

References:

- Ertekin, Turgay, Jamal H. Abou-Kassen, and Gregory R. King. Basic Applied Reservoir Simulations. Society of Petroleum Engineers, 2001.
- Aziz, Khalid, and Antonin Settari. Petroleum reservoir simulation. 2002.
- Peaceman, Donald W. Fundamentals of Numerical Reservoir Simulation. 1977

Modelling and Simulation Lab	0-0-3	2 CH
To be updated Later		

CCUS	3-0-0	3 CH

CCUS requirement, carbon credits & carbon footprint, global warming, subsurface geology for CCUS, CO_2 transport in porous media, CCUS in depleted reservoir, CO_2 sequestration; infrastructure requirements,

References:

1. Eduardo G. Pereira, Alberto J. Fossa, Thomas L. Muinzer Carbon Capture Utilization and Storage. Palgrave Macmillan Cham.
2. Malti Goel, M Sudhakar and R V Shahi., Carbon Capture, Storage, and Utilization.

Flow Assurance	3-0-0	3 CH
Flow assurance in offshore, design and analysis of tubulars, flow assurance problems and solutions, phase behaviour, thermodynamics of gas hydrate formation and dissociation, inhibitors, Crude oil composition & analysis, WAT, wax and asphaltenes management, role of downhole conditions on asphaltenes & wax deposition, inhibition and remediation; Scale and corrosion problems. **References:** 1. Applied Multiphase Flow in Pipes and Flow Assurance: Oil and Gas Production, Elsa M. Al-Safran and James P. Brill, SPE Text Book Series, 2017. 2. Flow Assurance Solids in Oil and Gas Production, Jon Steinar Gudmundsson, CRC Press, 2017. 3. E. Dendy Sloan, Carolyn A. Koh.,2007. Clathrate Hydrates of Natural Gases. CRC Pr I Llc; 3rd edition.		

Data Science	3-0-0	3 CH
Basics of Data Science and its relevance to Petroleum Engineering; Structured and Unstructured data in Oil & Gas; Data Preprocessing and Cleaning; Data Visualization Tools; Descriptive and Inferential Statistics; Correlation and Regression Analysis; Regression Models in Reservoir Characterization; Supervised vs. Unsupervised Learning; Clustering Techniques; Time Series Analysis and Forecasting; Case Studies and Practical Applications **References:** • Sankaran, S., Matringe, S., Sidahmed, M., Saputelli, L., Wen, X. H., Popa, A., & Dursun, S. (2020). Data analytics in reservoir engineering. Richardson, Texas, USA: Society of Petroleum Engineers. • Blum, A., Hopcroft, J., & Kannan, R. (2020). Foundations of data science. Cambridge University Press. • Mishra, S., & Datta-Gupta, A. (2017). Applied statistical modeling and data analytics: A practical guide for the petroleum geosciences. Elsevier. • Belyadi, H., & Haghighat, A. (2021). Machine learning guide for oil and gas using Python: A step-by-step breakdown with data, algorithms, codes, and applications. Gulf Professional Publishing. • Khosravanian, R., & Aadnøy, B. S. (2022). Methods for petroleum well optimization.		

Big Data Management	3-0-0	3 CH
Characteristics of Big Data in Petroleum engineering; Data Warehousing Concepts; Distributed Storage; Databases for Big Data; Processing Technologies: Hadoop, Spark; Deep Learning with Big Data; Application: Real-time processing and monitoring; Predictive maintenance. **References:** 1. Baesens, B. (2014). Analytics in a big data world: The essential guide to data science and its applications. John Wiley & Sons. 2. Leskovec, J., Rajaraman, A., & Ullman, J. D. (2020). Mining of massive data sets. Cambridge university press.		

3. Balusamy, B., Kadry, S., & Gandomi, A. H. (2021). Big data: concepts, technology, and architecture. John Wiley & Sons.

4. Keith R. Holdaway, Harness Oil and Gas Big Data with Analytics: Optimize Exploration and Production with Data-Driven Models (Wiley and SAS Business Series) 1st Edition.

5. White, T. (2012). Hadoop: The definitive guide. " O'Reilly Media, Inc.".

6. Guller, M. Big Data Analytics with Spark: A Practitioners Guide to Using Spark for Large Scale Data Analysis. Apress, New York (2015).

7. Blum, A., Hopcroft, J., & Kannan, R. (2020). Foundations of data science. Cambridge University Press.

8. Mishra, S., & Datta-Gupta, A. (2017). Applied statistical modeling and data analytics: A practical guide for the petroleum geosciences. Elsevier.

9. Kepner, J. and H. Jananthan. Mathematics of Big Data: Spreadsheets, Databases, Matrices, and Graphs. MIT Press, 2018. ISBN: 9780262038393

Artificial Intelligence and Machine Learning	**3-0-0**	**3 CH**

Fundamentals of AI, ML, and Deep Learning; Linear and Non-Linear Regression Models; Decision Trees, Random Forest, and XGBoost; Predictive Modeling in Reservoir and Production Forecasting; Clustering Techniques; PCA for Dimensionality Reduction; Neural Networks: ANN, CNN and RNN; AI-Driven Optimization Techniques; AI for Predictive Maintenance and Smart Reservoir Management.

References:

1. Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning, Cambridge: MIT press. Hemmati-Sarapardeh, A., Larestani, A., Menad, N. A., & Hajirezaie, S. (2020). Applications of artificial intelligence techniques in the petroleum industry. Gulf Professional Publishing.
2. Bishop, C. M., & Nasrabadi, N. M. (2006). Pattern recognition and machine learning (Vol. 4, No. 4, p. 738). New York: springer.
3. De Prado, M. M. L. (2020). Machine learning for asset managers. Cambridge University Press.

HPHT Drilling & Completion Fluids	**3-0-0**	**3 CH**

HPHT environment & classification; drilling fluid design analysis for HPHT conditions (composition & properties), selection of drilling fluids (oil based, water based, synthetic based); additives, material selection & fluid compatibility, fluid rheology & modelling, HPHT filtration characteristics, types of completion fluids, selection of additives, pressure control, Troubleshooting fluid-related problems in HPHT wells; wellbore stability, Safety & environmental concerns.

References:

1. Ryen Caenn, HCH Darley, George R. Gray 2011. Composition and Properties of Drilling and Completion Fluids. Gulf Professional Publishing, Elsevier.
2. Bernt S. Aadnoy; Iain Cooper; Stefan Z. Miska; Robert F. Mitchell; Michael L. Payne.

2009. Advanced Drilling and Well Technology. SPE. Renpu Wan.
3. Advanced Well Completion Engineering. 2011. Elsevier.

Alternate Energy Sources	3-0-0	3 CH

Introduction to Renewable Energy; Solar Energy; Wind Energy; Ocean Energy; Geothermal Energy; Hydropower; Biomass Energy; Impact of energy technologies on the environment; Energy economics, market dynamics, and sustainability considerations.

Hydrogen Energy	3-0-0	3 CH

Introduction to Hydrogen Energy
Basics of hydrogen as an energy carrier, Physical and chemical properties of hydrogen, Hydrogen in the global energy transition Hydrogen vs. other fuels: efficiency and sustainability
Hydrogen Production
Fossil fuel-based hydrogen production (Steam Methane Reforming, Partial Oxidation), Electrolysis: Alkaline, PEM, SOEC electrolysis, Biomass and bio-hydrogen production, Thermochemical and photochemical hydrogen production, Green hydrogen and its potential **Hydrogen Storage and Transportation**
Compressed and liquefied hydrogen storage, Solid-state storage: Metal hydrides, chemical storage, Hydrogen pipelines and transport via ammonia/methanol carriers, Safety concerns in hydrogen storage and handling
Hydrogen Utilization & Applications
Fuel cells: Types, working principles, and efficiency, Hydrogen in transportation: Hydrogen vehicles, aviation, and marine applications, Hydrogen in power generation and grid balancing, Hydrogen use in industrial applications (Steel, ammonia, refineries)
Hydrogen Economy, Policies, and Safety
Hydrogen economy and global initiatives, Government policies and funding for hydrogen research, Hydrogen safety, risk assessment, and regulatory frameworks, Future challenges and prospects of hydrogen energy.

References:

1. Hydrogen and Fuel Cells: Emerging Technologies and Applications – B. Sorensen
2. Hydrogen as an Energy Carrier: Technologies, Systems, Economy – W. Hautz & J. Nitsch
3. Hydrogen Energy and Vehicle Systems – S. Basu
4. Reports & White Papers: IEA Hydrogen Report, DOE Hydrogen Program

Environmental Engineering	3-0-0	3 CH

Earth and Environment; System Analysis and Management; Computational Method and Probability Statistics; Environmental Geology; Groundwater Contamination and Remediation Industrial Waste Water Treatment; Circular Waste Management System and Greenhouse Gases Reduction; Hazardous Waste Management; Environment Quality Management; Integrated Environmental Technologies for Waste Management; Sustainable Development and Renewable Energy.

Applied Well Stimulation Techniques	3-0-0	3 CH

Formation damage, stimulation techniques and requirements, stimulation cycle; Matrix treatments, acidizing, fracturing, other matrix treatments (solvents, surfactants to remove wax etc), fluid selection criteria, treatment design and analysis for different rocks; Reaction kinetics, additives for stimulation fluids, other stimulation techniques, Well stimulation Economics

References:

1. Robert Schechter. Oil well stimulation. Prentice Hall (1 December 1991)
2. A. Richard Sinclair. Well Stimulation Treatments, 2nd Ed. 2012. The University of Texas, Austin.
3. Faruk Civan.2015. Reservoir Formation Damage: Fundamentals, Modeling, Assessment, and Mitigation.

Applied Numerical Modelling	3-0-0	3 CH

Solution of linear system of equations; nonlinear algebraic; linear and non-linear regression; Statistical Aspects of Least Squares Theory; Statistical Distributions; Initial and boundary value problems; Solution of partial differential equations: Parabolic, elliptic and hyperbolic partial differential equations; Taylor Series and Numerical Schemes; Finite-Volume Method Representations of Flow Equations; FVM Representations and solution techniques of Single-Phase Flow Equations, Multiphase Flow: Black-Oil Equations and Compositional Equations; Representation of Natural fractures; concept of dual porosity and dual permeability; Numerical modelling: Hydraulic Fracture initiation and Propagation, Fluid-rock-fracture interaction in deformable porous and permeable rocks.

References:

1. Ertekin, T., & Ayala, L. F. (2019). Reservoir Engineering Models: Analytical and Numerical Approaches. McGraw-Hill Education.
2. Trefethen, L. N., & Bau, D. (2022). Numerical linear algebra. Society for Industrial and Applied Mathematics.
3. Phillips, G. M., & Taylor, P. J. (1996). Theory and applications of numerical analysis. Elsevier.
4. Ertekin, Turgay, Jamal H. Abou-Kassen, and Gregory R. King. Basic Applied Reservoir Simulations. Society of Petroleum Engineers, 2001.
5. Shen, B., Stephansson, O., & Rinne, M. (2020). Modelling Rock Fracturing Processes: Theories, Methods, and Applications. Springer International Publishing.
6. Shen, X., & Standifird, W. (2017). Numerical simulation in hydraulic fracturing: multiphysics theory and applications. CRC Press.

Applied Well Stimulation Techniques	3-0-0	3 CH

Importance of EOR; EOR performance indicators - Capillary Number, mobility ratio, fractional flow curves, wettability alteration from relative permeability curves; recovery factor; Mathematical formulation of water flooding process; IMPES method for solving waterflooding equations, Numerical discretization and solving of waterflooding equations.

Surfactant flooding and polymer flooding EOR processes – Overview, field implementation, performance evaluation and screening of surfactants and polymers; Mathematical modelling and numerical simulation of surfactant flooding and polymer flooding EOR processes; Numerical solution procedure for solving governing equations in surfactant flooding and polymer flooding EOR processes.

Overview and field implementation of low salinity waterflooding and microbial flooding EOR processes; Mathematical modelling and numerical simulation of low salinity waterflooding and microbial flooding EOR processes.

Oil recovery mechanism of immiscible and miscible gas flooding EOR process with ternary phase diagrams; Field implementation and oil recovery mechanism of: continuous gas injection, WAG, SWAG, SSWAG EOR process; Mathematical modelling and numerical simulation of immiscible and miscible gas flooding EOR processes. Overview and numerical modelling of CO_2 sequestration mechanisms in saline aquifers and in hydrocarbon reservoirs.

Oil recovery mechanism, field implementation and numerical modelling of thermal EOR methods – Hot water flooding, steam flooding, cyclic steam flooding or huff & puff steam flooding, steam assisted gravity drainage, in-situ combustion oil recovery techniques.

References:

1. *Enhanced Oil Recovery* by Don W. Green and G. Paul Willhite. 2018. Published by Society of Petroleum Engineers.
2. *Fundamentals of Enhanced Oil Recovery* by Larry W. Lake, Russell Johns, Bill Rossen, Gary Pope. 2015. Published by Society of Petroleum Engineers.
3. *Petroleum Reservoir Simulation: The Engineering Approach* by J.H. Abou-Kassem, M. Rafiqul Islam, S.M. Farouq-Ali. 2nd Edition, 2020. Published by Gulf Professional Publishing.
4. *Basic Applied Reservoir Simulation* by Ertekin, Abou-Kassem and King. 2001. SPE Textbook Series Vol. 7.

Course Structure

(2 Year M.Tech in Petroleum Engineering)

SEMESTER – I						
Sl. No	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Petroleum Geology	3	0	0	3
2		Applied Reservoir Engineering	3	0	0	3
3		Applied Hydrocarbon Production Engineering	3	0	0	3
4		Drilling Technology	3	0	0	3
5		Formation Evaluation	3	0	0	3
6		Petroleum Engineering Lab	0	0	3	2
7		Seminar	0	0	0	2
Total						**19**

SEMESTER - II						
Sl. No	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Applied Reservoir Simulation	3	0	0	3
2		Elective I	3	0	0	3
3		Elective-II	3	0	0	3
4		Elective – III	3	0	0	3
5		Elective - IV	3	0	0	3
6		Modelling and Simulation Lab	0	0	3	2
7		Viva Voce/Summer Internship	0	0	0	2
Total			**15**	**2**	**6**	**19**

SEMESTER - III						
Sl. No	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Thesis -1	0	0	0	18

SEMESTER - IV						
Sl. No	**Faculty**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Thesis - 2	0	0	0	20
		CUMULATIVE TOTAL				**76**

ELECTIVES						
Sl. No	**Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1		Carbon Capture Storage and Utilization	3	0	0	3
2		Flow Assurance	3	0	0	3
3		Data Science	3	0	0	3
4		Big Data Management	3	0	0	3
5		Artificial Intelligence and Machine Learning	3	0	0	3
6		HPHT Drilling and Completion Fluids	3	0	0	3
7		Alternate Energy Resources	3	0	0	3
8		Hydrogen Energy	3	0	0	3
9		Environmental Engineering	3	0	0	3
10		Applied Gas Engineering	3	0	0	3
11		Applied Well Stimulation Techniques	3	0	0	3
12		Applied Numerical Modelling	3	0	0	3
13		Advanced Enhanced Oil Recovery	3	0	0	3