SYLLABUS

OF

Ph.D.

PRE-REGISTRATION COURSEWORK

PROGRAMME

(Course Work in DUIET to be effective from the Session 2022)

DUIET

Dibrugarh University

2022-23

Annexure-I

COURSE STRUCTURE & EXAMINATION PATTERN OF THE Ph.D. PROGRAMMES

1. There shall be four Courses in One Semester Course work for the Ph.D. programmes conducted in Dibrugarh University comprising with the following components:

Course I : Research Methodology (Core)

Course II : Optional (to be offered by the prospective Supervisor concerned)

Course III : Optional (to be offered by the prospective Supervisor concerned)

Course IV : Assignment (under guidance of the prospective Supervisor Concerned)

Provided that, the total credit of the Ph.D. Pre-Registration Course Work should be within the range of 16-20 Credit.

2. The syllabus for the Ph.D. Course Work shall be prepared by the DRC and through the School Board concerned and shall come into effect after approval of the Post Graduate Board, Dibrugarh University.

3. The distribution of marks of the course work shall be as bellow:

Course	**Internal Assessment**	**End Semester Examination**	**Total Weightage**
Course I	40%	60%	100%
Course II	40%	60%	100%
Course III	40%	60%	100%
Course IV	80% (assignment writing)	20% (viva on the assignment)	100%
Total Credit (16-20)			

4. Candidates shall have to secure a minimum of 45% marks in aggregate to pass a paper individually.
5. The mode of Internal Assessment (IA)shall be decided and implemented by the Department /Centre concerned.
6. Examination & Declaration of Results:
   (a) The IA of a student shall be conducted by the course teacher of the student concerned. The marks of the IA shall be submitted to the Controller of Examinations, Dibrugarh University by the Director of the DUIET.
   (b) The End Semester examinations shall be conducted by the Controller of Examinations, Dibrugarh University in consultation with the Director of the DUIET.
   (c) The result shall be declared by the Controller of Examinations.
   (d) The examinations shall be conducted as per the existing examination ordinance of the University.

7. The result of the candidates appeared in the examination for Ph.D. Course Work shall be Awarded in the following Grade system:

Letter Grade with meaning		Grade Point
O	Outstanding	10 (Marks securing above 95%)
A+	Excellent	9 (Marks securing 90% - 95%)
A	Very Good	8 (Marks securing 80% - 90%)
B+	Good	7 (Marks securing 70% - 80%)
B	Above Average	6 (Marks securing 60% - 70%)
C	Average	5 (Marks securing 50% - 60%)
P	Pass	4 (Marks securing 45% - 50%)
B	Fail	0 (Marks securing below 45%)
Ab	Absent	0

A student obtaining Grade F shall be considered failed and will be required to reappear in the examination.

8. Every candidate shall be given a maximum of two consecutive chances (including the first regular chance) for passing the examination. Not appearing in an examination after becoming eligible to appear in the same amounts to losing a chance.

9. The candidates who have failed the examination in the first chance shall have to clear the same in the second and last chance, which shall be held within three months from the date of declaration of results.

   A candidate shall have to appear in the second chance only in the failed paper(s) to pass the examination.

10. The candidates passed in the Ph.D. Pre-registration Course work with not below the Latter Grade B shall be eligible to go for Ph.D. registration.

11. Matters not covered by the above Regulations shall be decided as per the other statutory provisions of the University.

DETAIL SYLLABUS FOR SIX-MONTH PRE-REGISTRATION COURSE WORK OF PH. D. PROGRAMMMES IN DUIET

COURSE I : RESEARCH METHODOLOGY (Core)

COURSE II : OPTIONAL (Any one of the following)

1. ADVANCED FLUID ENGINEERING
2. COMPUTATIONAL FLUID DYNAMICS
3. GAS DYNAMICS
4. ENERGY CONSERVATION & WASTE HEAT RECOVERY
5. ADVANCED THERMODYNAMICS
6. COMPOSITE MATERIALS
7. PRODUCTION ENGINEERING
8. RESERVOIR ENGINEERING-I

COURSE III : OPTIONAL

(Any one of the following, to be offered by the prospective Supervisor concerned)

1. ADVANCED INTERNAL COMBUSTION ENGINES
2. CONVECTIVE HEAT AND MASS TRANSFER
3. CONDUCTION AND RADIATION
4. OPTIMISATION TECHNIQUES
5. ADDITIVE MANUFACTURING
6. RIVER ENGINEERING AND SEDIMENT TRANSPORT
7. ENHANCED OIL RECOVERY (EOR)
8. PRODUCTION ENGINEERING- II
9. RESERVOIR ENGINEERING-II

COURSE IV : ASSIGNMENT

(Under guidance of the prospective Supervisor concerned)

Course-I

Course Code	Course Name	L-T-P-Credits
PhD-CO-101	RESEARCH METHODOLOGY	**3-1-0-4**

Course Contents

Unit I: Research Methodology –an introduction

Meaning and Objectives of Research, Motivation in Research, Types of Research, Significance of Research, Research Methods verses Methodology, Criteria of Good Research, Problems Encountered by Researchers in India, Research Problem, Features of Good Research Design.

Unit II: Methods of Data Collection

Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Review of previous work and literature.

Unit III: Interpretation and Report Writing

Meaning and Technique of Interpretation, Precaution in Interpretation, Different Steps in Writing Report, Types of Reports, Oral Presentation, Precaution for Writing Research Reports, Reference & Bibliography, Citation index of Publication.

Unit IV: Role of Computer in Research

Computer Application
Software Application

COURSE II

Course Code	Course Name	L-T-P-Credits
PhD-ME-101	ADVANCED FLUID ENGINEERING	**3-1-0-4**

Course Contents

UNIT-I: Introduction Review of basic concepts .Integral analysis of flow Basic laws in integral form; transport theorem; continuity, momentum and energy equations in integral form and their applications. Differential analysis of flow Continuity equation; derivation of Navier Stokes equation and exact solution energy equation.

UNIT-II: Ideal fluid flow Kinematics of fluid flow; potential flow; Bernoulli's equation and applications; sources, sinks, doublets and vortices; superimposition of uniform stream with above; flow around comers; Rankine ovals; flow around uniform cylinders with and without circulation; pressure distribution on the surface of these bodies and D'Alemberts paradox.

UNIT-III: Viscous flow Exact solution; plane Poiselle and Coutte flows; Hagon-Poiselle flow through pipes; flows with very small Reynold's numbers; Stokes flow around a sphere; elements of hydrodynamic theory of lubrication. Flows with very large Reynold's numbers; elements of two dimensional boundary layer theory; displacement thickness and momentum thickness; skin friction; Blaussius solution for boundary layer on a flat plate without pressure gradient; Karman-Porausen integral method for obtaining approximate solutions. Drag on bodies; form drag and skin friction drag; profile drag and its measurement.

UNIT-IV: Transition flows Transition from laminar to turbulent flows, Reynold's stresses, turbulent boundary layer over a flat plate; transition for flat plate flow. Compressible fluid flows One dimensional isentropic flow; Fanno and Rayleigh lines; choking; shocks (normal and oblique). Vortex Motion Definitions; vortex lines; surfaces and tubes; vorticity; circulation; Kelvins circulation theorem; Helmholtzsvorticity theorem; Biot-savart law for induced vorticity; system of vortex filaments;

Reference Books:

a. I G Currie ,Fundamentals of Mechanics of Fluid, Fourth edition , CRC Press,2012
b. John. M. CimbalaYunus A. Cengel,Fluid Mechanics: Fundamentals and Applications, Fourth edition,McGraw Hill, 2019
c. Frank M White,Fluid Mechanics, 6th edition, Tata McGraw Hill, 2008

COURSE II

Course Code	Course Name	L-T-P-Credits
PhD-ME-102	**COMPUTATIONAL FLUID DYNAMICS**	**3-1-0-4**

Course Contents:

UNIT-I: Governing equations of fluid dynamics:
Substantial derivative,Divergence of velocity, continuity, momentum, energy equations.Physicalboundary conditions. Forms of governing equation suited for CFD- shock fitting and shock capturing approach. Mathematical behavior of Partial difference equations- hyperbolic, parabolic and elliptic equations.

UNIT-II: Discritization:
Finite difference method- Central, Forward, Backward difference for a uniform grid – Central difference expressions for a non-uniform grid - Numerical error - Accuracy of solution. Explicit and implicit approach.Errors and Stability analysis.

UNIT-III: Grid Transformation:
Direct and In-direct transformation, Metric and Jacobians. Stretched grids, boundary fitted grids. Structured and unstructured grids.

UNIT-IV: Heat transfer:
Conduction Heat Transfer- Applications of Heat conduction - Steady and Unsteady conductions – numerical solutions of one and two dimensional steady and unsteady state problems.

UNIT-V: Some simple CFD techniques:
Numerical solution of the incompressible Navier-Stokes equations: Stream function-vorticity formulation; Primitive variable formulation; Pressure correction techniques like SIMPLE, SIMPLER.

Texts/References:

1. K.Muralidhar, T.Sundararajan, “Computational Fluid flow and Heat Transfer", Edition-2nd, Narosa Publishing House, 2004
2. P.S.Ghoshdasdidar, “Computer simulation of flow and heat transfer", Edition-2nd,TataMcGraw – Hill, New Delhi, 1998
3. D. A. Anderson,J. L Tannehill, and R.H. Pletcher, “Computational fluid mechanics and Heat Transfer", Edition- 3rd, Hemisphere Publishing Corporation,New York,1984
4. J. D. Anderson, "Computational Fluid Dynamics: The Basics with Applications", McGraw Hill, Edition-4th, New York,2017

COURSE II

Course Code	Course name	L-T-P-C
PhD-ME-103	**GAS DYNAMICS**	**3-1-0-4**

Course Contents

Unit I: Introduction

Compressible flow, historical background and its importance.

Unit II: Governing equations

Continuity equation, momentum equation and energy equation in conservative flow.

Unit III: Normal shock

One dimensional flow equations, Mach number, speed of sound in perfect and real gas, Normal shock relations, Hugoniot equation, one-dimensional flow with heat addition.

Unit IV: Oblique shock and Expansion wave

Source of oblique shock, oblique shock relation, supersonic flow over wedge and cone, shock polar, normal shock reflection, pressure deflection diagram, interaction of shocks, Mach reflection, Detached shock, Prandtl-Meyer expansion waves, shock-expansion theory.

Unit V: Quasi- One-Dimensional flow

Governing equations for Quasi- One-Dimensional flow, area-velocity relation, isentropic flow relations for perfect gas through variable ducts, Diffuser, wave reflection from a free boundary.

Unit VI: Hypersonic flow and high-temperature flows

Hypersonic shock wave relation, frozen and equilibrium flows, variable specific heat, equilibrium speed of sound, chemical non-equilibrium flows, species continuity equations

Books

[1] E. Becker, *Gas Dynamics*, 1st ed.: Academic Press Inc., 1969.

[2] J. D. Anderson Jr., *Modern Compressible Flow: with Historical Perspective*, 2nd ed.: McGraw-Hill, 1990.

[3] J. D. Anderson Jr., *Hypersonic and high-temperature gas dynamics*, 2nd ed.: McGraw-Hill, 2006.

[4] G.Ben-Dor, *Shock wave reflection phenomena*, 2nd ed.: Springer, 2007.

COURSE II

Course Code	Course Name	L-T-P-Credits
PhD-ME-104	ENERGY CONSERVATION & WASTE HEAT RECOVERY	3-1-0-4

Course Contents

Unit I: Energy resources and use. Potential for energy conservation. Optimal utilization of fossil fuels. Total energy approach.

Unit II: Coupled cycles and combined plants. Cogeneration systems. Exergy analysis. Utilization of industrial waste heat. Properties of exhaust gas. Gas-to-gas, gas-to-liquid heat recovery systems. Recuperators and regenerators. Shell and tube heat exchangers. Spiral tube and plate heat exchangers. Waste heat boilers: various types and design aspects.

Unit III: Heat pipes: theory and applications in waste heat recovery. Prime movers: sources and uses of waste heat. Fluidized bed heat recovery systems. Utilization of waste heat in refrigeration, heating, ventilation and air conditioning systems.

Unit IV: Thermoelectric system to recover waste heat. Heat pump for energy recovery. Heat recovery from incineration plants. Utilization of low grade reject heat from power plants.

Unit V: Need for energy storage: Thermal, electrical, magnetic and chemical storage systems. Thermo-economic optimization

Texts/References:

1. J. H. Harlock, “Combined Heat and Power”, edition Pergaman Press, 1987.
2. F. Kreith and R. E. West, Energy Efficiency, CRC handbook, CRC Press,1999
3. Kays and London, Compact Heat Exchangers, edition 3rd edition, McGraw-Hill, New York, year.

COURSE II

Course Code	Course Name	L-T-P-Credits
PhD-ME-105	ADVANCED THERMODYNAMICS	3-1-0-4

Course Contents

UNIT-I: Review of basic thermodynamics: First & Second laws, Concept of entropy and entropy generation, Entropy balance for closed & open systems; Concept of exergy& irreversibility, Exergy analyses of open and closed system

UNIT-II: Thermodynamic property relations: Maxwell relations; Relations involving enthalpy, internal energy and entropy; Mayer relation, Clausius-Clapeyron equation, Joule-Thompson experiment.

UNIT-III: Properties of gas mixtures: Multi-component and multi-phase systems, Equations of states and properties of ideal and real gas mixtures, Change in entropy in mixing.

UNIT-IV: Irreversible thermodynamics: Finite time thermodynamic principle, Optimization of various thermodynamic systems, Principles of entropy generation minimization.

UNIT-V: Thermodynamics of reactive systems: Combustion and thermochemistry, Reactant and product mixtures, Adiabatic flame temperature, Chemical equilibrium, Equilibrium products of combustion.

UNIT-VI: Chemical Kinetics: Global versus elementary reactions, Elementary reaction rates, Rates of reaction for multistep mechanisms.

UNIT-VII: Flames: Types of flames, Simplified analyses of premixed & diffusion flames, Factors influencing flame velocity and thickness, Quenching, flammability and ignition, Flame stabilization.

Texts/References:

1. Adrian Bejan, Advanced Engineering Thermodynamics, John Wiley & Sons, 4th Edition, 2016
2. Stephen R. Turns, An Introduction to Combustion: Concepts & Applications, McGraw-Hill Education, 3rd Edition, 2012.
3. Kenneth K. Kuo, Principles of Combustion, Wiley India Pvt. Ltd, 2nd Edition, 2012.
4. Michael J. Moran & Howard N. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley & Sons, 6th Edition, 2010
5. .Mark W. Zemansky& Richard H. Dittman, Heat & Thermodynamics, McGraw Hill, 8th Edition, 2017.

COURSE III

Course Code	Course Name	L-T-P-Credits
PhD-ME-106	ADVANCED INTERNAL COMBUSTION ENGINES	**3-1-0-4**

Course Contents

UNIT-I: Cycle Analysis Thermodynamic properties of gases and combustion products, combustion charts, Fuel-air cycle, calculations for Otto, Diesel and dual cycles, Losses due to dissociation, burning time and heat flow. Combustion processes for SI and CI engines; flame propagation and spray burning processes; energy release calculations; actual Vs fuel air cycle, effects of various operating conditions, two and four stroke engine cycles.

UNIT-II: Heat Transfer Instantaneous heat transfer calculations, engine heat transfer equations, overall heat lossradiative and convective heat transfers. Gas Exchange Generalised equations for in-flow and outflow processes; filling and emptying methods and wave action calculations; two stroke engines, gas exchange processes; types and phases of scavenging, Kadney effect. Super charging of SI 7 CI engines; super charger and turbocharger systems, matching of atomization and spray formation; pump characteristics.

UNIT-III: Fuel Injection Fuel injection: fuel line hydraulics; compressibility effects; wave and nozzle ends; mechanism of atomization and spray formation; pump characteristics.

UNIT-IV: Flow Processes Characterisation of flow in the cylinder, Swirl, Squish and turbulence calculations. Fuels Petroleum fuels, Gasoline grades, desirable properties of SI & CI engines fuels, rating of fuels.

Reference Books:

1. John Heywood, Internal Combustion Engine Fundamentals,2nd edition, McGraw Hill, 2018
2. Richard Stone , Introduction to Internal Combustion Engines,4th edition,Palgrave Macmillan, 2012
3. CR ferguson and A Tkirpatirick, I.C.Engine Applied Themosciences, 3rdedition, wiley, 2016

COURSE III

Course Code	Course Name	L-T-P-Credits
PhD-ME-107	**CONVECTIVE HEAT AND MASS TRANSFER**	**3-1-0-4**

Course Contents

UNIT-I

Introduction to convection

Derivation of governing equations of momentum, energy and species transport, order of magnitude analysis, Reynolds analogy.

UNIT-II

Convective heat transfer in external and internal flows

Derivation of hydrodynamic and thermal boundary layer equations, Similarity solution techniques, Momentum and energy integral methods and their applications in flow over flat plates with low and high Prandtl number approximations. Introduction to turbulence, Reynolds averaging, Eddy viscosity and eddy thermal diffusivity. Concept of developing and fullydeveloped flows.

UNIT-III

Thermally developing flows

Graetz problem, Concept of thermally fully developed flow and its consequences under constant wall flux and constant wall temperature conditions, Steady forced convection in Hagen Poiseuille flow, Plane Poiseuille flow, and Couette flow and analytical evaluation of Nusselt numbers in limiting cases.

UNIT-IV

Free convection

Free convection boundary layer equations: order of magnitude analysis, similarity andseries solutions, concept of thermal stability and Rayleigh Benard convection.

UNIT-V

Concept of boiling heat transfer and regimes in pool boiling condensation

Nusselt film condensation theory, drop wise condensation and condensation inside tubes, effects of non-condensable.

Texts/References:

1. L. C. Burmeister “Convective Heat Transfer”, 2nd Edition, John Wiley and Sons, 1993.
2. F. P. Incropera and D. P. Dewitt, “Fundamentals of Heat and Mass Transfer”, 7th Edition, John Wiley and Sons, 2011.
3. Y. Cengel& A. Ghajar, “Heat and Mass Transfer”, 5th Edition, Mc-Graw Hill (India) Pvt. Ltd., 2014.

COURSE III

Course Code	Course Name	L-T-P-Credits
PhD-ME-108	**CONDUCTION AND RADIATION**	**3-1-0-4**

Course Contents

UNIT-I: Introduction

Basic modes of heat transfer, heat transfer mechanisms and the governing laws.

UNIT-II: Steady-state Conduction: **One Dimensional Problems**

Fourier's law of heat conduction in Cartesian, cylindrical and spherical coordinates, heat conduction equations in isotropic and anisotropic materials: in Cartesian, cylindrical and spherical coordinate system, Initial and boundary conditions, 1D conduction problems without and with heat generation: plane wall, hollow cylinder, composite tube, hollow sphere, etc.

UNIT-III: Steady-state Conduction: **Two and Three Dimensional Problems**

Steady 2-D problem in Cartesian, analytical methods, problems in cylindrical and spherical coordinate system, steady 3-D conduction in Cartesian coordinate, graphical methods and conduction shape factor., Method of superposition, Stationary and moving heat sources and sinks, Moving boundary problems, Duhamel's theorem.

UNIT-IV: Unsteady-State Conduction

One dimensional transient problem, solution methods, Lumped system analysis, Semi-infinite media, Laplace transform, Duhamel's theorem, example problems.

UNIT-V: Radiation

Mechanism of energy transport in thermal radiation, laws of radiation: Planck's law, Wien's displacement law, Stefan-Boltzmann law, Intensity of radiation, Irradiation vs. radiosity, Diffuse vs. specular surfaces, absorptivity, reflectivity, transmissivity, black body radiation, grey body, Kirchhoff's law, view factor, radiation in presence of participating medium, solid angle, radiation in infinite parallel planes with and without participating medium, Radiation exchange among gray diffuse surfaces, Two surface network, three surface network, Derivation of radiation transport equations (RTE), Radiative equilibrium, Divergence of radiative heat flux.

Texts/References:

1. F. P. Incropera and D. P. Dewitt,"Fundamentals of Heat and Mass Transfer", 7th Edition, John Wiley and Sons, 2011.
2. M. N. Ozisik, "HeatTransfer- A Basic Approach", Mc-Graw Hill, 1984.
3. M. F. Modest,"Radiative Heat Transfer", 3rd Edition, Academic Press, 2013.

COURSE III

Course Code	Course Name	L-T-P-Credits
PhD-ME-109	**OPTIMISATION TECHNIQUES**	**3-1-0-4**

Course Contents

UNIT-I: Linear Programming: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Case Studies of LPP, Graphical Methods to Solve Linear Programming Problems, Applications, Advantages, Limitations

UNIT-II: Graphical Analysis of Linear Programming Problems: Introduction, Graphical Analysis, Some Basic Definitions, Graphical Methods to Solve LPP, Some Exceptional Cases, Important Geometric Properties of LPP

UNIT-III: Simplex Method: Introduction , Standard Form of LPP, Fundamental theorem of LPP, Solution of LPP – Simplex Method, The Simplex Algorithm, Penalty Cost Method or Big M-method, Two Phase Method, Solved Problems on Minimisation

UNIT-IV: Duality in Linear Programming Problem: Introduction, Importance of Duality Concepts, Formulation of Dual Problem, Economic Interpretation of Duality, Sensitivity Analysis

UNIT-V: Transportation Problem: Introduction, Formulation of Transportation Problem (TP), Transportation Algorithm (MODI Method), the Initial Basic Feasible Solution, Moving Towards Optimality

UNIT-VI: Assignment Problem: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Routing Problem, Travelling Salesman Problem

UNIT-VII: Project Scheduling and PERT-CPM: Introduction, Basic Difference between PERT and CPM, PERT/CPM Network Components and Precedence Relationship, Project Management – PERT

Texts/References:

1. A Muhlemann, J Oakland and K Lockyer, 'Productions and Operations Management', 6th Edition , Pearson publisher,2007.
2. H A Taha, 'Operations Research - An Introduction', 10th edition , Prentice Hall of India. 2012.
3. 3.J K Sharma, 'Operations Research', 6th edition , Macmillan Indian Ltd 2006.
4. P Kumar ,'Industrial Engineering and Management' , 1st edition ,Pearson India. 2015.

COURSE III

Course Code	Course Name	L-T-P-Credits
PhD-ME-110	**ADDITIVE MANUFACTURING**	**3-1-0-4**

Course Contents

Unit-I: Reverse engineering, Different AM processes and relevant process physics, AM process chain, Application level: Direct processes – Rapid Prototyping, Rapid Tooling.

Unit-II: Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing, Materials science for AM - multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship,

Unit-III: AM technologies - Powder-based, droplet based, extrusion based, object stereolithography, Micro- and nano-additive processes, Mathematical models for AM, Selection of AM technologies using decision methods, AM process plan, Monitoring and control of defects, transformation. Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting. involvement). Printing processes (droplet based 3D Solid-based AM processes - extrusion based fused deposition modelling object Stereolithography Micro- and nano-additive

Texts/References:

1. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer,2010.
2. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling,rapid manufacturing, Hanser Publishers, 2011.
3. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3-642-28359-8.
4. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 200 I.
5. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech, 2012.
6. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010

COURSE II

Course Code	Course Name	L-T-P-Credits
PhD-CE-101	**COMPOSITE MATERIALS**	**3-1-0-4**

Course Contents

Unit I: Introduction to composite materials, What is a composite material, Current and potential advantages of fibre reinforced composites, Applications of composite material, military, civilk, space, automotive and commercial applications.

Unit II: Macro and micro mechanical behavior of a lamina: Stress strain relations for anisotropic materials, Restrictions on engineering constants, Strengths of an orthotropic lamina, Biaxial strength criteria for orthotropic lamina.

Unit III: Micro mechanical behavior of lamina and laminates: Mechanical of material approach to stiffness, Elasticity approach to stiffness, Classification lamination theory, Special cases, strength of laminates.

Unit IV: Bending, Buckling and Vibration of laminated plates: Governing equations for bending buckling and vibration of laminated plates, Deflection of simply supported laminated plates, Vibration of simply supported laminated plates.

Unit V: Design of composite structures: Introduction**,** design philosophy, anisotropic analysis, Bending extension coupling, micromechanics, Non linear behavior, Interlaminar stresses, transverse shearing,Laminate optimization.

Texts/References:

1. Ronald F. Gibson, Principles of composite material mechanics, CRC Press, 2011.
2. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 2000.
3. Lawrence E. Nielsen, Nielsen, Paul Nielsen, Mechanical Properties of Polymers and Composites, Second Edition, CRC Press, 2000.

COURSE-III

Course Code	Course Name	L-T-P-Credits
PhD-CE-102	RIVER ENGINEERING AND SEDIMENT TRANSPORT	3-1-0-4

Course Contents

Unit 1: Hydraulics of Open Channels: A Review, Ability to analyze uniform flow problems, Ability to analyze basic gradually varied flowproblems, Properties of Water and Sediment, Ability to describe properties of sediment particles, Ability to describe bulk properties of sediment
Unit 2: Bed forms, Develop familiarity with bed form types andcharacteristics, Ability to use Einstein's, and Englund and Hansenapproach for estimating flow resistance in channelswith moveable boundaries.
Unit 3: Incipient Motion and Stable Channel Design, Ability to recognize factors that increase the risk of flooding, Ability to analyze problems involving floodplainencroachment
Unit 4: Sediment Transport Processes: Incipient motion of sediment particles; Regimes of flow; Resistance to flow and velocity distribution in alluvial streams; transport of bed, suspended and total load.

Unit 5: River Morphology: Plan form variations and river channel pattern; Meandering and braided stream characteristics; River equilibrium, river dynamics and adjustments to stream power.

Unit 6: River Training Techniques: Principles of Stabilization and rectification of rivers, river bank stability analysis, spur / groyne, stream bank armoring, guide banks, submerged vanes, porcupine and jack jetty systems, gabions; Bandalling, surface and bottom panels. Inland Navigation Channel Development: Fairway dimensions and maintenance, canalization, navigation locks and terminals.

Unit 7: River Models: Mathematical modeling - types, mathematical formulation, numerical procedures, calibration and validation; Scale modeling – types, principles of similitude and dimensional analysis, model verification, limitations.

Unit 8: Flood Management: Flood control planning, flood plain zoning and other non – structural measures, use of satellite imagery and toposheets for DEM generation for flood plain zone mapping.

Books Recommended:

1. Sediment Transport: Theory and Practice, C. T. Yang, 1996, McGraw-Hill (or Krieger Reprint Ed. 2003).
2. Open Channel Flow, V.T. Chow

COURSE- II

Course Code	Course Name	L-T-P-Credits
PhD-PE-101	**PRODUCTION ENGINEERING -I**	**3-1-0-4**

Course Contents

Unit-I: Characteristics of Crude Oil and Natural Gas, classification of crude and its physicochemical properties.

Unit-II: Well Performance, Well Completion, Well Completion Methods, Well Activation, Well Perforation, Well Perforating Methods, Perforating Gun Types, Shaped Charge, Type, Size, Depth and Orientation of perforation holes, Shot Density, Standoff, Explosives in perforation, Explosive Train.

Unit-III: Oil and Gas Processing: Introduction to Oil & Gas Separation, Flash & Differential Separation, Stage Separation, Two Phase Separator, Three Phase Separator; Scrubber, Treater, Wash Tank, Sand Removal, Desalting, Gas Dehydration, Gas Sweetening, formation of Gas Hydrates.

Unit-IV: Crude Oil Storage Tank: Types & Features of Storage Tanks, Tank Accessories, Metering of Oil & Gas, Sampling of Crude Oil, Gauging Equipment and Methods, Vapor Recovery System.

Text Book References:

1. Principles of Oil Well Production- T. E. W. Nind.
2. Applied Petroleum Reservoir Engineering- Craft and Hawkins.
3. Petroleum Engineering Handbook-Howard B. Bradley.
4. Oil and Gas Filed Development Techniques: Well Completion and Servicing- Denis Perrin, Michel Caron and Georges Gaillot.
5. Production Operations: Well Completions, Workover and Stimulation, Volume 1- Thomas O. Allen and Alan P. Roberts.
6. Production Operations: Well Completions, Workover and Stimulation, Volume 2- Thomas O. Allen and Alan P. Roberts.
7. Gas-Liquid and Liquid-Liquid Separators- Maurice Stewart and Ken Arnold.
8. Oilfield Processing, Volume Two: Crude Oil- Francis S. Manning and Richard E. Thompson.
9. Petroleum and Gas Filed Processing- H. K. Abdel-Aal,Mohamed Aggour and M. A. Fahim.
10. Dictionary of Petroleum Exploration, Drilling & Production- Norman J, Hyne.

COURSE- II

Course Code	Course Name	L-T-P-Credits
PhD-PE-102	**RESERVOIR ENGINEERING-I**	**3-1-0-4**

Course Contents

Unit I: Fundamentals of petroleum, petroleum reservoir and reservoir engineering.

Unit II: Reservoir rock properties and fluid properties.

Unit III: Reservoir drive mechanics and recovery factors; generalized MBE.

Unit IV: Reserve estimation: resource and reserve concept, estimation of petroleum reserve, latest reserve classification.

Unit V: Flow of Fluids through Porous Media: Darcy's law, assumptions and applications, single and multiphase flow, Types of fluid- compressible fluid, incompressible and slightly compressible fluid; radial and spherical flow, steady state and unsteady state flow.

Unit VI: Productivity Index, Injectivity Index, Formation Damage, Skin Effect, GOR, WOR equations, principles of fluid flow for steady state, semi steady state and unsteady state conditions.

Text/Reference Books -

1. Reservoir Engineering Handbook- Tarek Ahmed
2. Advanced Reservoir Engineering- Tarek Ahmed, Paul D. Mcinney
3. Phase Behavior of Petroleum Reservoir Fluid- Pederson, Chrisgtensen
4. Estimation and Classification of Reserves of Crude oil, Natural Gas & Condensate- Chapman Corrnquist
5. Fundamental of Reservoir Engineering- L. P. Dake
6. Applied Petroleum Reservoir Engineering- Craft and Hawkins

COURSE- III

Course Code	Course Name	L-T-P-Credits
PhD-PE-103	**ENHANCED OIL RECOVERY (EOR)**	**3-1-0-4**

Course Contents

Unit-I: Introduction to EOR, Basic principles and mechanism of EOR, Mobility ratio concepts, Screening of EOR process.

Unit-II: Thermal Recovery Techniques: Steam Stimulation, Hot Water Flooding, Steam Flooding, In-situ combustion.

Unit-III: Chemical Flooding: Polymer Flooding, Surfactant Flooding, Caustic Flooding.

Unit-IV: Miscible Flooding: First Contact Miscibility, Multiple Contact Miscibility, Condensing Gas Drive, Vaporizing Gas Drive.

Unit-V: Smart Water Flooding: Principles of Smart Water Flooding, Low Salinity Water Flooding (LSW), Effects of the Injection Water Chemistry on Oil Recovery.

Unit-VI: Hybrid EOR: Principles of Hybrid EOR, Hybrid EOR Techniques.

Unit-VII: Microbial EOR: Principles and Applications.

Text/Reference Books -

1. Principles of Petroleum Reservoir Engineering- Gian Luigi Chierici
2. Enhanced Oil Recovery Textbook Vol-6- Don W. Green G. Paul Willhite
3. The Reservoir Engineering Aspects of Water flooding- Forrest F. Craig, Jr.
4. The Design Engineering Aspects of Water flooding- Stephen C. Rose, John F. Buckwalter and Robert J. Woodhall
5. Improved Recovery, Oil and Gas Production- Nicholas J. Const
6. Improved Oil Recovery by Surfactant and Polymer Flooding- D. O. Shah, R. S. Schechter

COURSE- III

Course Code	Course Name	L-T-P-Credits
PhD-PE-104	**PRODUCTION ENGINEERING- II**	**3-1-0-4**

Course Contents

Unit-I: Artificial Lift Technology: Basic principles and descriptions of Artificial Lift Methods, Continuous and Intermittent Flow Gas Lift, Plunger Lift, Chamber Lift, Sucker Rod Pumping (SRP), Electrical Submersible Pumping (ESP), Hydraulic Pumping (HP).

Unit-II: Well Stimulation Techniques: Importance of Well Stimulation, Acid Solutions for Acidizing, Matrix Acidizing, Fracture Acidizing, Hydraulic Fracturing, Wave Technology, Microbial Stimulation.

Unit-III: Sand Control: Sand Control Techniques, use of Screens, Gravel Packing, Formation Sand size analysis, optimum Gravel-Sand Ratio, Gravel Selection, Gravel Packing Fluid, Gravel Placement Techniques, Chemical Method of Sand Control.

Unit-IV: Water Flooding: Introduction to Water Flooding, Flood Pattern, Fractional Flow Curve, Injection Water Treatment.

Unit-V: Core Analysis: Importance of Core Analysis, Conventional Core Analysis, Special Core Analysis, Core Flooding.

Text Book References:

1. Principles of Oil Well Production- T. E. W. Nind.
2. Introduction to Petroleum Production, Volume I- D. R. Skinner.
3. Introduction to Petroleum Production, Volume-II- D. R. Skinner.
4. Petroleum Engineering Handbook-Howard B. Bradley.
5. Introduction to Oil and Gas Production, Vocational Training Series-American Petroleum Institute.
6. The Technology of Artificial Lift Methods, Volume 1- Kermit E. Brown.
7. Modern Sandface Completion Practices, First Edition-William K. Ott and Joe D. Woods.
8. Dictionary of Petroleum Exploration, Drilling & Production- Norman J, Hyne.

COURSE- III

Course Code	Course Name	L-T-P-Credits
PhD-PE-105	RESERVOIR ENGINEERING-II	3-1-0-4

Course Contents

Unit I: Water influx in reservoir, different water influx models.

Unit II: Water and gas coning.

Unit III: Reservoir Management: Concepts of Reservoir Management and its Application.

Unit IV: Introduction to Oil and Gas Well Testing, Steady State and Unsteady Flow Tests, Diffusivity Equation, its derivation & Solution, Reservoir Pressure Measurements and Significance; Techniques of pressure measurement, Wellbore storage effects.

Unit V: Oil Well Testing: Pressure Transient Tests: Draw-down and Buildup test analysis, Horner's approximation.

Unit VI: Gas Well Testing: Flow after flow testing, Isochronal testing, Modified Isochronal testing.

Text/Reference Books -

1. Reservoir Engineering Handbook- Tarek Ahmed
2. Advanced Reservoir Engineering- Tarek Ahmed, Paul D. Mcinney
3. Fundamental of Reservoir Engineering- L. P. Dake
4. Applied Petroleum Reservoir Engineering- Craft and Hawkins
5. Basics of Reservoir Engineering- R Cosse
6. Pressure Transient Test- SPE
7. Well Testing- John Lee
8. Pressure Buildup and Flow Tests in Wells – C. S. Matthews and D. G. Russell
9. Advances in Well Test Analysis – Robert C. Earlougher

COURSE IV

Course Code	Course Name	L-T-P-Credits
PhD-CO-102	ASSIGNMENT	3-1-0-4