UTTARANCHAL
UNIVERSITY

UTTARANCHALUNIVERSITY

ArcadiaGrant,P.O.Chandanwari, Premnagar,Dehradun, Uttarakhand-

248007,INDIA

Detailed Course Structure & Syllabus

of

Pre Ph.D. (Mechanical Engineering)

Course Work

(As per CBCS system)

W.E.F Session 2022-23

Course Structure of the Pre-Ph.D (Mechanical Engineering) Course Work:
Applicable for Batch: 2022-23

SCHEME OF EXAMINATION

Ph.D(Mechanical Engineering)
(Effective from Academic Year 2022-23)

Under Choice Based Credit System (CBCS)

Course Structure of the Pre-Ph.D (Mechanical Engineering) Course Work:
Applicable for Batch: 2022-23

Scheme of Pre-Ph.D. Course Work

S.No	Course Code	Subject	Credits	Evaluation – Scheme							
				Period			Sessional			Examination	
				L	T	P	CT- I	CT- II	Total	ESE	Sub. Total
Courses											
1.	RM-101	Research Methodology	4	4	0	0	20	20	40	60	100
2.	RM-102	Computer & Stats Application in Research	2	2	0	0	20	20	40	60	100
3.	RPE-103	Research & Publication Ethics	2	2	0	0	20	20	40	60	100
4.	DSE-104	Discipline Specific Electives	3	3	0	0	20	20	40	60	100
5.	RS-105	Seminar Presentation	2	0	0	4	20	20	40	60	100
		Total	**13**	**11**	**0**	**4**	**100**	**100**	**200**	**300**	**500**

List of Electives

S. No.	Course Code	Course Name
1	IIOT-104	Industrial Internet of Things
2	ME-104 (1)	Finite Element Method
3	ME-104 (2)	Fracture Mechanics
4	ME-104 (3)	Computational Fluid Dynamics
5	ME-104 (8)	Mechanical Behaviour of Materials

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SYLLABUS

of

Ph.D(Mechanical Engineering)

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	RM-101	Credit	4
Year/Sem	1/1	L-T-P	4-0-0
Course Name	Research Methodology		

Objectives of the Course:

1. To Equip the Students with the Concept and Methodology of Research.
2. To provide knowledge about type of research, preparation of reports and thesis, designing of Research using Scientific Methods.

UNIT I (Total Topics- 7 and Hrs-12)

Introduction to Research: Definition, Nature and significance, Role and Objectives; Types of Research: exploratory, descriptive, experimental and diagnostic research, social and legal research and traditional, analytical, empirical & fundamental research, Doctrinal and non-doctrinal research methods; Various Research Designs; Scientific Research Process: Overview, Problem identification and formulation of research statement.

UNIT II(Total Topics- 7 and Hrs- 12)

Data Collection: sources, primary and secondary methods, significance of Primary and Secondary Data, questionnaire Vs. schedules; Data Processing: Editing, Coding Organization and Presentation; Attitude Measurement and scaling: Measurement Scales, Sources of Errors in Measurement, Techniques of Developing Measurement Tools, Classification and Testing (Reliability, Verification and Validity) Scales, Designing Questionnaires and Interviews.

UNIT- III (Total Topics- 5 and Hrs- 10)

Sampling, Sampling Methods, Sampling Plans, Sampling Error, Sampling Distributions: Theory and Design of Sample Survey, Census Vs Sample Enumerations, Objectives and Principles of Sampling, Types of Sampling, Sampling and Non-Sampling Errors, Concept of Permutation, Combination & Probability for research analysis.

UNIT-IV(Total Topics- 5 and Hrs- 10)

Interpretations and Report Writing: Meaning of Interpretation, Techniques of Interpretation, Precautions in Interpretation, Significance of Report Writing, Steps in Report Writing, Layout of Report and Precautions in Writing Research Reports. Limitations of RM: Ethics in Research, Philosophical Issues in Research.

CO1. Acquire in-depth knowledge of various fundamentals, theories and principles related to the research and apply the acquired knowledge in carrying out research studies in the area of interest.

CO2. Identify, formulate and critically investigate research problems by applying research-oriented knowledge and analyze relevant data to reach certain conclusions in the form of alternative solutions to these problems.

CO3. Apply the acquired knowledge and skills to develop minds to think out of the box while carrying out research operations to conclude something.

CO4. Apply parametric and non-parametric statistical tests to verify the developed hypothesis to suggest innovative solutions to the problem being investigated.

Reference Books

1. William G. Zikmund, "Business Research Methods", Orlando: Dryden Press.
2. C. William Emory and Cooper R. Donald, "Business Research Methods", Boston, Irwin.
3. Fred N Kerlinger, "Foundations of Behavioural Research", New Delhi: Surjeet Publications.
4. Naresh Malhotra, Marketing Research : An Applied Orientation, Pearson publication David Nachmias and ChavaNachmias, "Research Methods in the Social Sciences", New York: St.Marlia's Press.
5. Bhattacharya, D. K. (2004) Research Methodology, New Delhi, Excel Books.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	RM-102	Credit	2
Year/Sem	1/1	L-T-P	2-0-0
Course Name	Computer & Stats Application in Research		

Objectives of the Course:

1. To appraise computational skills for research application.
2. To assess statistical method for research analysis.

UNIT I

Characteristics of Computers, Evolution of computers, computer memory, computer generations, Basic computer organization; System software, Application software, introduction to operating system, single user, multi-user, multi-tasking single tasking, application of computer for business and research, MS-windows, Linux .Application of Internet in research : INFLIBNET, Use of Internet, sights (DOAJ), Use of E Journals, Use of E library, use of EBSCO HOST online database of Academic Libraries. Subject/field specific tools on www.freeware.com

UNIT II

Computer Application in Research,. Basic concept of Computer, Use of Internet for Research Purpose: E-mail, WWW, Web browsing, technical skills, drawing inferences from data, Research publishing tools-MS Word, Adobe acrobat, Graphics tool-MS Excel, Presentation tool-MS Power, Data Analysis Software and Analysis Techniques point. Creating presentation and adding effects, Introduction to Data analysis software-SPSS: Definition, objectives and features, data analysis using SPSS.

UNIT- III

Statistical methods for research application in analysis of data,Measurement in Research , data interpretation, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), std deviation, Measures of Relationship, Simple Regression Analysis, Correlation and Regression, Partial Correlation.

UNIT-IV

Statistical Tools-Hypothesis and Hypothesis Testing: Parametric & Non-Parametric Tests, Important Parametric Tests ,Hypothesis Testing of Correlation Coefficients ,U Test, Chi Square Test, ,T-Test.Analysis of Variance (ANOVA) , The Basic Principle of ANOVA ,ANOVA Technique, Setting up Analysis of Variance Table, Short-cut Method for One-way ANOVA, Coding Method, Two-way ANOVA .

Course Outcomes:

CO1. Acquire knowledge of concept of computer with application in Research.
CO2. Apply acquired knowledge of computer for presentation skills.
CO3. Acquire knowledge of statistical methods for Research.
CO4. Apply acquired knowledge to describe the inductive nature of quantitative data analysis.

Reference Books

1. C. R. Kothari, "Research Methodology: Methods and techniques", New Delhi: Vishwa Prakashan.
2. Brymann, Alan and Carmer, D. (1995) Qualitative data analysis for social scientist, New York, Routledge Publication.
3.Jain, Satish: "Introduction to Computer Science and basic Programming." BPB Publications, New Delhi, 1990. • Rajaraman, V., "Fundamental of Computers", Prentice Hall of India, New Delhi, 1996.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	RPE-103	Credit	2
Year/Sem	1/1	L-T-P	2-0-0
Course Name	Research& Publication Ethics		

Objectives of the Course:
Its objectives to provide knowledge about ethics and code of research publication with concept of plagiarism.

UNIT I (Total Topics- 2 and Hrs-8)
1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgments and reactions

UNIT II(Total Topics- 5 and Hrs- 5)
1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

UNIT- III (Total Topics-7 and Hrs-7)
1. Publication ethics: definition, introduction and importance
2. Best practices/ standards setting initiatives and guidelines: COPE, WAME,etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

UNIT- IV (Total Topics-4and Hrs-4)

Practice

Open Access Publishing
1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/ Journal suggestion tools viz. JANE, Elsevier Journal finder, Springer Journal Suggester, etc.

CO1. Recognize the basics of philosophy of science & ethics, research integrity, publication ethics and theories of research ethics.
CO2. Familiarize with important issues in research ethics, research integrity, scientific misconduct and misinterpretation of data.
CO3. Analyze the best practices for publications, publication ethics and identify the predatory publishers & journals.
CO4. Demonstrate &use plagiarism software tools, open-source software tools, citation databases and

research metrics.

CO5. Publish credible & scholarly publications in reputed peer-reviewed journals.

References-

Research and Publication Ethics, Dr Sumanta Dutta, Bharti Publications,2021
Research and Publication Ethics, Dr Santosh kumar Yadav, Anne Publications,2020

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	RS- 105	Credit	2
Year/Sem	1/1	L-T-P	0-0-4
Course Name	Seminar Presentation		

Objectives of the Course:
Main objective of this course is to develop presentation skills in the scholars and knowledge about review of literature so that they can review properly for utilisation in their research work.

Seminar Presentation-Candidate/Research Scholar has to go through the review of literature in the concerned field of research. Review of literature guidelines will be given by the concerned faculty/Dean of Department/School/College. Research Scholar has to prepare presentation on review of literature in the concerned field/ topic assigned by the department (DRC) periodically during course work. There will be minimum 3 presentations of review of literature during pre-Ph.D. course work.

- First presentation will be required in DRC/FRC for review of literature with concerned Department focus on area of research. It will be evaluated and assessment sheet will be sent from Department to Dean Research & Studies office.
- Similarly second presentation will be required by research scholar with extension of first presentation and more number of references would be added.

Internal & end term examination marks will be as per scheme. Each presentation is to be assessed by the department as per instructions from Dean-Research & Studies.

Final presentation would be required at the time of end term/sem. examination on proposed synopsis. General guidelines would be issued by Dean-Research for seminar presentation.

Course outcomes
CO1. Research Scholar would be able to develop & explore the review of literature in concerned area.
CO2. Analyze review of literature critically for finding the research gap.
CO3. Apply acquired knowledge in making systematic seminar presentations.
CO4. Apply acquired knowledge for improving development of all-round research.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	IIOT-104	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Industrial Internet of Things		

Objectives of the Course:

1. Its objectives to provide knowledge about Basics of IoT and its applications in different domains

UNIT I (Total Topics- 8 and Hrs- 8)

Introduction to Internet of Things

1. Introduction to embedded system, Challenges and design issues in embedded systems
2. Types of microcontrollers, General introduction of Arduino, NodeMCU, Raspberry Pi
3. Selection of microcontrollers
4. Definition of IoT, Components of IoT
5. Levels of IoT
6. Evolution of IoT, Challenges in IoT Design challenges
7. Introduction to Python
8. Introduction to AI & ML

UNIT II (Total Topics- 7 and Hrs- 7)

Communication Protocol

1. Machine to Machine, Difference between IoT and M2M
2. Software define Network Communication Protocols : ZigBee, RFID, Wi-Fi, Bluetooth
3. LoRA, CAN, Cellular network
4. NFC, SPI protocol, I2C protocol
5. Communication with Bluetooth devices: Bluetooth standard, AT commands, Setting Bluetooth in command mode
6. Cloud platforms : Overview of cots cloud platforms
7. Cloud services business models: SaaS, PaaS, IaaS.

UNIT- III (Total Topics- 6 and Hrs- 7)

Introduction to Computing Platform

1. Getting Started with Arduino : Setting up Arduino board
2. Using the Integrated Development Environment (IDE) to prepare an Arduino Sketch

3. Uploading and Running the Blink Sketch
4. Creating and saving a Sketch, Installing Arduino IDE
5. Raspberry Pi
6. Edge & Fog Devices

UNIT- IV (Total Topics- 7 and Hrs- 7)
Interfacing of I/O Devices

1. Interfacing with LEDs
2. 7-segment interfacing
3. Interfacing LCD
4. Getting Input from Sensors : Detecting movement
5. Interfacing with ultrasonic sensor
6. Temperature and humidity sensor
7. Actuators : Interfacing DC motor, Controlling direction and speed of DC motor

UNIT- V (Total Topics- 4 and Hrs- 8)
Case Studies

1. Energy Management 4.0- Smart Metering, Smart Grid
2. Manufacturing
3. Agriculture 4.0
4. Automotive Applications

CO-1 Understand the concepts of Internet of Things

CO-2 Analyze basic protocols in wireless network

CO-3 Implement IoT in different domains and innovation

Reference Books

1. Vijay Madisetti, Arshdeep Bahga, "Internet of Things: A Hands-On Approach", University Press, 2015
2. Raj,kamal, Internet of Things : Architecture and Design Principles, Mcgraw Hills,2017
3. Rajesh Singh, Anita Gehlot, Bhupendra Singh, Chimata, Raghuveer Internet of Things in Automotive Industries and Road Safety. River Publishers, 2018.
4. Rajesh Singh, Anita Gehlot, Bhupendra Singh, Sushabhan Choudhury, Internet of Things Enabled Automation in Agriculture, New India Publishing Agency (NIPA)

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Programme Name	**Pre-PhD Course Work**	Programme Code	23-40
Course Code	ME-104 (1)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	**Finite Element Method**		

Objectives of the Course:

1. To learn basic principles of finite element analysis procedure.
2. To learn the theory and characteristics of finite elements that represent engineering structures.
3. To learn and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses.

Unit-1:(Total Topics-15and Hrs-10)

Introduction and Direct Approach FEM

Concept of FEM, History, Packages, Range of applications, Steps in FEM, Approaches of FEM, Development of Elemental Equations for simple systems (i) Single dof problems-Spring Network, Hydraulic Network and Resistance Network (ii) Two dof problems- Plane Trusses and Frame structures; Assembly Procedure, Application of Boundary Conditions; Solver Technology: Linear direct solver, Iterative solvers, Eigen solver, Nonlinear equation solver.

Unit-2:(Total Topics-14and Hrs-10)

Galerkin's and Rayleigh-Ritz FEM for 1-D and Radially Symmetric Scalar Field Problems

Concept of Galerkin's and Raleigh-Ritz Mathematical Approaches, Governing Equation andBoundary Conditions for Heat Transfer-Rod and Fin, Solid Mechanics-Bar extension and Beambending; Fluid Dynamics-parallel wall flow; Electrostatics and Magnetostatic problems; WeakFormulation and Functional, Polynomial Approximation, Standard 1-D Shape Functions of C0 andC1 Continuity Elements, Derivation of Element Matrices and Vectors, Assembly, Imposition ofBoundary Conditions and Nodal Solution; Co-ordinate Transformation and Numerical Integration.Transient and Eigen Value Problems

Unit-3:(Total Topics-11and Hrs-10)

Galerkin's and Rayleigh-Ritz FEM for Plane (2-D) and Axisymmetric SINGLE VARIABLE Problems

Governing Equation and Boundary Conditions-Heat Transfer, Solid mechanics-Rod Torsion, Fluid Dynamics-Stream function and Velocity potential formulation, Electrostatics and Magnetostatic Problems, Weak Formulation and Functional, Polynomial Approximation, Standard 2- D Shape Functions of C0 Continuity Elements, Derivation of Element Matrices and Vectors, Assembly, Imposition of Boundary Conditions and Nodal Solution; Mapping and Numerical Integration; Transient and Eigen Value Problems.

Unit-4:(Total Topics-7and Hrs-10)

Galerkin's and Rayleigh-Ritz FEM for Plane (2-D) and Axisymmetric MULTI VARIABLE Problems

Governing equation and Boundary conditions- Stress Analysis and Fluid Flow AnalysisProblems: Weak Formulation and Functional, Polynomial Approximation, Derivation of ElementMatrices and Vectors, Assembly, Imposition of Boundary Conditions and Nodal Solution, Postprocessing of solutions

Course Outcomes (CO)

1. ME-104 (1)-CO1: Understand the concepts behind formulation methods in FEM.
2. ME -104 (1)-CO2: Identify the application and characteristics of FEA elements such as bars, beams, plane and iso-parametric elements.
3. ME -104 (1)-CO3: Develop element characteristic equation and generation of global equation.
4. ME -104 (1)-CO4: Able to apply suitable boundary conditions to a global equation for bars, trusses, beams, circular shafts, heat transfer, fluid flow, axi symmetric and dynamic problems and solve them displacements, stress and strains induced.

References:

1. Energy and Finite Element Methods in Structural Mechanics: I. H. Shames and C. L. Dym.
2. Concepts and Applications of Finite Element Analysis: R. D. Cook, D. S. Malkus and M. E Plesha.
3. The Finite Element Method Vol. I-II: O.C. Zienkiwicz and R.L. Taylor.
4. Finite Element Procedures: K. J. Bathe.
5. An Introduction to Finite Element Methods: J.N. Reddy.
6. Finite Element Methods in Engineering: S.S. Rao.

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Programme Name	**Pre-PhD Course Work**	Programme Code	23-40
Course Code	ME-104 (2)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	**Fracture Mechanics**		

Objectives of the Course:

1. This course familiarizes the student with relevant fracture mechanics concepts, procedures for understanding materials behavior with respect to short and long fatigue cracks.
2. This course provides an understanding of various factors including metallurgical factors that control the fracture resistance of engineering alloys and that should help to develop a facility with the methods of predicting the failure of structural components.
3. Based on an understanding of the mechanisms controlling the strength and fracture resistance of structural materials, this course seeks to develop an appreciation of the procedures used to make rational choices in the selection of materials for structural applications.

Unit-1(Total Topics-12 and Hrs-14)

Introduction: Modes of loading, Crack growth and fracture mechanismsNeed for fracture mechanics, Linear elastic fracture mechanics and elastic plastic fracture mechanics.

Energy Release Rate : Surface Energy, Resistance, Griffith Theory of fracture, Extension of Griffith Theory by Irwin and Orowan, R-Curve, Pop-in phenomena, Crack branching. Necessary and sufficient conditions for fracture.

Unit-2(Total Topics-7and Hrs-12)

Crack - Tip Stress and Displacement Fields: Airy's stress function, Westergaard's approach, Generalized **Westergaard's** approach, William's Eigen function approach, Multi-parameter stress field equations, **Influence** of **the** T-stress and higher order terms, Role of photoelasticity on the development of stress field equations in fracture **mechanics**.

Unit-3 (Total Topics-5and Hrs-12)

Stress Intensity Factor: Equivalence between SIF andG**,** Variousmethods for evaluating Stress Intensity Factors.

Crack Tip Plastic Zone: Modeling plastic zone at the crack-tip, Irwin and Dugdale models.

Unit-4(Total Topics-10and Hrs-12)

Fracture Toughness Testing: Qualitative toughness testing, KICtesting, K–R curve testing, JIC measurements, J-R curve testing, CTOD testing.

Micromechanics of Fracture: Cohesive strength of solids, Cleavage fracture, Intergranular fracture, Ductile fracture, Crack detection methods.

Course Outcomes (CO)

1. ME-104 (2) -CO1: Explain the basic concepts of fracture mechanics for both linear elastic and elastic-plastic regimes.
2. ME -104 (2) -CO2: Describe the fracture mechanics characterization of fatigue crack growth sustained load fracture and dynamic crack growth.
3. ME -104 (2) -CO3: Identify various fracture mechanisms and explain the influence of material behavior on fracture mechanics characterization of crack growth.
4. ME -104 (1) -CO4: Identify initiation and growth of fatigue crack.

References:

1. Elementary Engineering Fracture Mechanics: D. Broek.
2. Elements of Fracture Mechanics: Prashant Kumar.
3. Fracture Mechanics - Fundamentals and Applications: T. L. Anderson.
4. Introduction to Fracture Mechanics: Kare Hellan.

5. Fracture Mechanics- With an Introduction to Micromechanics: Dietmar Gross and Thomas Seelig.
6. Fracture Mechanics- An Introduction: E.E. Gdoutos.

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Programme Name	**Pre-PhD Course Work**	Programme Code	23-40
Course Code	ME-104 (3)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	**Computational Fluid Dynamics**		

Objectives of the Course:

1. Study the governing equations of fluid dynamics.
2. Learn how to formulate and solve Euler's equation of motion.
3. Become skilled at Representation of Functions on Computer
4. Solve computational problems related to fluid flows.

Unit1-1(Total Topics-14and Hrs-14)

Basic ideas of CFD: Introduction to CFD, role of CFD and its applications, future of CFD.

Governing equations (GE's) of Fluid dynamics*:* Modeling of flow, control volume concept, substantial derivative, physical meaning of the divergence of velocity. Continuity equation, momentum equation, energy equation and its conservation form. Equations for viscous flow (Navier-Stokes equations), equations for inviscid flow (Euler equation). Different forms of GE's, initial and boundary conditions.

Unit-2(Total Topics-10and Hrs-12)

FVM for Diffusion Problems: FVM for 1D steady state diffusion, 2D steady state diffusion, 3d steady state diffusion. Solution of discretised equations- TDMA scheme for 2D and 3D flows.

FVM for Convection-Diffusion Problems: FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D and 3D convection-diffusion, Power-law scheme, QUICK scheme.

Unit-3(Total Topics-9and Hrs-12)

Solution Algorithm for Pressure-velocity Coupling in Steady Flows: Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.

FVM for Unsteady Flows: 1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit mecthods for 2D and 3D problems, Discretization of transient convection-diffusion problems, solution procedure for transient unsteady flow calculations (transient SIMPLE, transient PISO algorithms).

Unit-4(Total Topics-10and Hrs-12)

Grid Generation: General transformation of the equations. Metices and Jacobians. Types of grids- structured and unstructured grids, grid generation methods- algebraic, differential and hybrid methods. Coordinate stretching, boundary-fitted coordinate systems. Elliptic and hyperbolic grid generation methods, orthogonal grid generation for Navier-Stokes equations, Multi-block grid generation.

Latest development in CFD techniques and newer applications.

Course Outcomes (CO)

1. ME-104 (3) -CO1: Understand mathematical characteristics of partial differential equations.
2. ME -104 (3) -CO2: Explain how to classify and computationally solve Euler and Navier-Stokes equations.
3. ME -104 (3) -CO3: Make use of the concepts like accuracy, stability, and consistency of numerical methods for the governing equations.
4. ME -104 (3) -CO4: Identify and implement numerical techniques for space and time integration of partial differential equations.
5. ME-104 (3) -CO5: Acquire basic skills on programming of numerical methods used to solve the

Governing equations.

References:

1. "An Introduction to Computational Fluid Dynamics: the Finite Volume Method", H.K Versteeg and W. Malalasekara, 2nd edition, Pearson Education, England, 2007.
2. "Computational Fluid Dynamics for Engineers" B. Andersson & others, 1st edition, Cambridge University Press, U.K., 2012.
3. "Computational Fluid Flow and Heat Transfer" (2nd edition), K. Muralidhar and T. Sundararajan, NarosaPublishing, 2004.
4. "Numerical Heat Transfer and Fluid Flow", S.V. Patankar, McGraw-Hill, New York, 1980.
5. "Principles of Computational Fluid Dynamics", P. Wesseling, Springer-Verlag.
6. "Computational Techniques for Fluid Dynamics Volume I & II" (2nd edition), C.A.J. Fletcher, Springer-Verlag, 1991.
7. "Computational Fluid Mechanics and Heat Transfer" (2nd edition), J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Taylor and Francis, 1997.
8. "Numerical Computation of Internal and External Flows" (Vols. I & II), C. Hirsch, Wiley International, 1988.
9. "Computational Fluid Dynamics for Engineers" (Vols. I & II), K. Hoffmann and S. T. Chiang, Engineering Education System, 1993.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-40
Course Code	ME-104 (8)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	**Mechanical Behaviour of Materials**		

Objectives of the Course:

1. The description of the physical mechanisms and/or mechanical behavior of monocrystals and polycrystals under elastic & plastic deformation.
2. The different mechanisms of material failures (fracture, fatigue and creep) and their relationship with the different types of stress.

UNIT I (Total Topics-12 and Hrs-10)

Introduction, overview of the subject and fundamentals of the atomic structure and types of bonding in different classes of materials and its relation to the physical and mechanical properties.

Elasticity - Analysis of stress, State of stress at a point, Normal and shear stress components, Stress components on an arbitrary plane, Principal stresses, Plane stress & amp; Plane strain, Generalized Hooke's law, Atomic equivalent of Hooke's law, Elastic behavior of anisotropic and isotropic materials.

UNIT II(Total Topics- 14 and Hrs-10)

Plastic deformation in single & amp; polycrystalline, semi crystalline materials, strengthening mechanisms in solids, Work hardening, Solid solution strengthening, Grain boundary strengthening, Particle hardening, High temperature deformation of amorphous; crystalline materials, Mechanical testing- A review, Common states of stress in real life, Tension, Indentation, Compression, Torsion, Bending.

UNIT- III (Total Topics- 9 and Hrs- 10)

Fracture of solids/Fracture mechanics - Linear elastic stress field in cracked bodies – Crack deformation modes, - Singular stress field and displacement fields, Stress intensity factor solutions - Crack growth based on energy balance - Griffith's criterion for brittle fracture - Strain energy release rate, Stress intensity factor equivalence - Crack stability, R curves.

UNIT-IV (Total Topics-7 and Hrs- 10)

J integral concepts – Critical stress intensity factor fracture criterion -Fracture criterion - Experimental determination of fracture toughness (K_{IC})- Non-linear fracture - Toughening mechanisms (in ceramics).

Creep, mechanisms of creep, Creep of pure metals, solid solutions, MMCs, Creep of ceramics and polymers, creep asymmetry. Super plasticity in materials.

Course Outcomes (CO)

1. ME-104 (8) -CO1: Eexplain the fundamentals of various properties of materials and their application for engineering design.
2. ME -104 (8) -CO2: Understand the different strengthening mechanism and plastic deformation process of the single crystal and amorphous materials.
3. ME -104 (8) -CO3: Recognize the type of fracture in different materials and analysis of different crack growth.
4. ME -104 (8) -CO4: understand the different parameters involve in the plastic deformation of the materials.
5. ME -104 (8) -CO5: Analyse the fatigue failure in different engineering materials and the mode of failures and their classification.

Reference Books

1. Mechanical Behavior of Materials, Engineering methods for Deformation, Fracture and Fatigue, 4th Edition. Norman E. Dowling
2. Mechanical Behavior of Materials, 2nd Edition. Marc Meyers and Krishan Chawla
3. Mechanical Behavior of Materials, 2nd Edition, Thomas H. Courtney