**Syllabi for Comprehensive Examination of Eligible Ph. D Scholars**

**Department:** Mechanical Engineering

**1) Research/Specialization Group: 1**

**(Name of the Group)**: **Thermal and Fluids Engineering**

**Syllabi for:** **P22ME017**

**Computational Fluid Dynamics [40 Marks]**

**Classification of Partial Differential Equations and Approximate Solutions:**

Mathematical classification of PDEs – parabolic, elliptic and hyperbolic equations, Role of characteristics in PDE.

**Fundamentals and Common Methods of Discretization:**

Principles of discretization – preprocessing, solution and post processing, Types of boundary conditions, Conservativeness, boundedness, transportiveness, Overview of finite difference, Overview of finite element and finite volume methods.

**Numerical Solutions:**

Numerical solution of parabolic partial differential equations using finite-difference and finite-volume methods: explicit and implicit schemes, consistency, stability and convergence, Numerical solution of systems of linear algebraic equations: general concepts of elimination and iterative methods, Gaussian elimination.

**Diffusion:** The finite volume method of discretization for diffusion problems: Discretization of transient one-dimensional diffusion problems, Discretization for multi-dimensional diffusion problems, Stability analysis of parabolic and hyperbolic equation, FTCS, FTFS, FTBS, schemes, Convection-diffusion problems: Central difference, upwind schemes, exponential, hybrid and power-law schemes, QUICK scheme.

**References**:

1. H. K. Versteeg and W. Malalasekera, “An introduction to computational fluid dynamics: The finite volume method”, Pearson Education, 2008

2. J. D. Anderson Jr., “Computational Fluid Dynamics”, McGraw-Hill International Edition, 2017

**Convective Heat Transfer and Mass Transfer [30 Marks]**

**Introduction to Convection**

Derivation of governing equations of momentum, energy and species transport, Order of magnitude analysis, Reynolds

analogy.

**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 fully developed flows.

**Thermally Developing Flows**

Concept of thermally fully developed flow and its consequences under constant wall flux and constant wall temperature conditions.

**References**:

1. L. C Burmeister,“Convective Heat Transfer”, John Wiley and Sons

2. F. P. Incropera and D. P. Dewitt, “Fundamentals of Heat and Mass Transfer”, John Wiley and Sons

**Measurement Systems in Mechanical Engineering [30 Marks]**

**Analysis of Experimental Data**

Measurements error and uncertainty analysis, design of experiments, order of Instruments and calibration, performance characteristics, frequency response.

**Sensors and Transducers**

Data sampling, Signal Conditioning and Computer data Acquisition. Error response characteristic of sensors, Measurement error.

**Measurement of Process Variables**

*Flow Measurement*: Positive displacement methods, flow obstruction methods, the sonic nozzle, hot wire and hot film anemometer, magnetic flow meter, flow visualization method, LDA.

*Temperature Measurement*: Temperature scales, the ideal gas thermometer, temperature measurement by mechanical effect, electrical effect, radiation, effect of heat transfer on radiation, transient response of thermal systems, thermocouples, temperature measurement in high-speed flow.

**References**

1. J. P. Holman, “Experimental methods for Engineers”, McGraw-Hill.
2. R. S. Sirohi and H. C. Radha Krishna, “Mechanical Measurements”, Wiley.

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**Signatures and Names of DRC Members:**

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Signature of DRC Chairman

Date