## MEG222 - Fundamentals of Fluid Mechanics (2 Units)

**Course Description:** This course provides a foundational understanding of fluid mechanics, a branch of physics that deals with the behavior of fluids (liquids and gases) at rest and in motion. The course covers fundamental concepts like fluid properties, kinematics (motion of fluids), dynamics (forces acting on fluids), and applications in various engineering fields.

**Target Audience:** This course is designed for undergraduate students in Mechanical Engineering or related disciplines with a strong foundation in calculus and physics.

**Course Prerequisites:** MTH121 - Calculus I, MTH122 - Calculus II, PHY101 - Mechanics

**Learning Objectives:** By the end of this course, students will be able to:

* Define and analyze the properties of fluids (density, viscosity, etc.)
* Apply concepts of fluid motion, including pathline, streamline, control volume, and system.
* Understand the distinction between uniform, steady, and unsteady flow.
* Apply the principles of mass conservation to fluid flow problems.
* Analyze forces acting on fluids and utilize the concept of a fluid element.
* Derive and apply the Bernoulli equation and Euler equations for fluid motion.
* Solve problems involving fluid motion in Cartesian and polar coordinates.
* Integrate Euler's equations to obtain flow characteristics.
* Understand the concept of substantial derivatives in fluid mechanics.
* Analyze various flow measurement techniques for pressure, velocity, and volume flow rate.
* Grasp the fundamentals of compressible flow and its governing equations.
* Apply continuity and momentum equations to one-dimensional compressible flow.
* Explain the non-superposition principle in compressible flows.

**Course Outline:**

**Module 1: Introduction to Fluid Mechanics (2 Weeks)**

* Subtopic 1.1: What is Fluid Mechanics? (1 Week)
  + Definition of fluids (liquids and gases) and their properties (density, viscosity, etc.)
  + Applications of fluid mechanics in various engineering fields (civil, mechanical, aerospace)
* Subtopic 1.2: Continuum Hypothesis and Fluid Statics (1 Week)
  + Continuum hypothesis and its limitations
  + Pressure at a point, hydrostatic equation, applications of fluid statics

**Module 2: Kinematics of Fluid Flow (2 Weeks)**

* Subtopic 2.1: Description of Fluid Motion (1 Week)
  + Local and convective velocity, pathline, streamline, streakline
  + Eulerian and Lagrangian descriptions of fluid motion
* Subtopic 2.2: Mathematical Description of Fluid Motion (1 Week)
  + Continuity equation (differential and integral forms)
  + Stream function and velocity potential
  + Types of flow (uniform, steady, unsteady, rotational, irrotational)

**Module 3: Dynamics of Fluid Flow (3 Weeks)**

* Subtopic 3.1: Forces Acting on Fluids (1 Week)
  + Types of forces acting on fluids (body forces, surface forces)
  + Normal and shear stresses
* Subtopic 3.2: Substantial Derivatives (1 Week)
  + Total and local derivatives, material derivative (substantial derivative)
  + Physical interpretation of the substantial derivative
* Subtopic 3.3: Euler's Equations of Motion (1 Week)
  + Derivation of Euler's equations in Cartesian coordinates
  + Bernoulli equation and its applications

**Module 4: Applications of Euler's Equations (2 Weeks)**

* Subtopic 4.1: Integration of Euler's Equations (1 Week)
  + Bernoulli's equation for steady, incompressible flow
  + Applications of Bernoulli's equation (e.g., Venturi meter)
* Subtopic 4.2: Euler's Equations in Polar Coordinates (1 Week)
  + Derivation of Euler's equations in polar coordinates
  + Applications of Euler's equations in polar coordinates (e.g., turbomachinery)

**Module 5: Flow Measurements (2 Weeks)**

* Subtopic 5.1: Pressure Measurement (1 Week)
  + Manometers (piezometer, differential manometer)
  + Pressure transducers and gauges
* Subtopic 5.2: Velocity and Flow Rate Measurement (1 Week)
  + Pitot tube, hot-wire anemometer, laser Doppler velocimetry (LDV)
  + Mass flow rate and volumetric flow rate

**Module 6: Introduction to Compressible Flow (2 Weeks)**

* Subtopic 6.1: Fundamentals of Compressible Flow (1 Week)
  + Definition of compressible flow, Mach number and its significance
  + Stagnation properties in compressible flow
* Subtopic 6.2: Governing Equations for Compressible Flow (1 Week)
  + Continuity equation and momentum equation for one-dimensional compressible flow