Course code	Course Name	L-T-P-Credits	Year of Introduction
ME361	**Advanced Fluid Mechanics**	**3-0-0-3**	**2016**

Prerequisite : ME203 Mechanics of fluids

Course Objectives: The main objectives of this course are to

- To provide knowledge regarding fluid-flow phenomena observed in mechanical engineering systems, such as potential flow, vortex flow, boundary-layer flows, etc.
- To undertake sustained learning in fluid mechanics to advance their knowledge in this field.
- To enhance the understanding of fluid mechanics, including the equations of motion in differential form and turbulence.

Syllabus

Basic Concepts and Fundamentals, Stream function and Potential function, Lagrangian and Eulerian approaches, Potential flow, Incompressible viscous flow, Boundary layer theory, Turbulent Flow.

Expected Outcome:

The students will be able to

i. Recognize the particular flow regime present in typical engineering system.
ii. Demonstrate the concept of stream function, potential function and boundary layer.
iii. Calculate the vorticity of a given velocity field and analyze the vorticity in idealized vortices: forced vortex and free vortex.
iv. Choose the appropriate fluid mechanics principles needed to analyze the fluid-flow situations.
v. Recognize how fluid flow theory can be employed in a modern mechanical engineering design environment.

Text books

1. Bansal R. K., A Text Book of Fluid Mechanics and Machines, Laxmi Publications, 2010.
2. Douglas J. F., Fluid Mechanics, Pearson Education, 2005.
3. Kumar D. S., Fluid Mechanics and Fluid Power Engineering, S. K. Kataria & Sons, 1987.
4. Muralidhar K., G. Biswas, Advanced Engineering Fluid Mechanics, Alpha Science International limited, 2005.
5. Rama D. D., Fluid Mechanics and Machines, New Age International, 2009.

Reference books

1. Schlichting H., K. Gersten , Boundary Layer Theory, 8/e, Springer 2000.
2. Shames I. H., Mechanics of Fluids, 4/e, McGraw-Hill, 2002.
3. Streeter V. L. and E. B. Wylie, Fluid Mechanics, McGraw-Hill, 1979.

Course Plan

Module	Contents	Hours	End Sem. Exam. Marks

I	Basic Concepts and Fundamentals: Fluid statics, Cartesian Tensors, Fluid Kinematics, and Description of fluid motion – Types of motion of fluid elements, Vorticity and circulation – Concept of rotational and irrotational flows. Equation of motion of forced and free vortex flow. Stream function and Potential function. Stream function and its relation with velocity field. Relation between stream function and stream lines - Relation between stream function and velocity potential for a 2-D irrotational and incompressible flow.	**7**	**15%**
II	Relation between stream lines and lines of constant potential. Sketching of stream lines. Lagrangian and Eulerian approaches, acceleration, temporal acceleration, convective acceleration. Reynolds transport theorem, derivation of continuity and momentum equations using Reynolds transport theorem. Problems on the application of momentum equation	**6**	**15%**
FIRST INTERNAL EXAMINATION			
III	Potential flow: Uniform flow, source flow, sink flow, free vortex flow and super imposed flow-source and sink pair, doublet, plane source in a uniform flow(flow past a half body), source and sink pair in a uniform flow(flow past a Rankine oval body), doublet in a uniform flow(flow past a circular cylinder). Pressure distribution on the surface of the cylinder. Flow past a cylinder with circulation, Kutta-Juokowsky's law. Complex flow potential, complex flow potentials for source, sink, vortex and doublet. Potential flow between two parallel plates, potential flow in a sector. Introduction to conformal transformation, conformal mapping.	**7**	**15%**
IV	Incompressible viscous flow. Concepts of laminar and turbulent flows . Stokes viscosity law. Navier Stoke's equation and significance (Derivation not necessary).Simplification of Havier stock equation for steady incompressible flows with negligible body forces. Parallel flow through straight channel and couette flow. Hagen - Poiseuille flow. Derivation of Hagen Poissuille equations for velocity and discharge through a pipe, derivation of friction factor for laminar flow, Couette flow for negative, zero and positive pressure gradients, flow in a rotating annulus, Viscometer based on rotating annulus.	**7**	**15%**
SECOND INTERNAL EXAMINATION			
V	Boundary layer theory, Boundary layer thickness, Displacement thickness, momentum thickness, Energy thickness and their calculation. Laminar Boundary Layers, Boundary layer equations; Boundary layer on a flat plate, Prandtl boundary layer equations, Blasius solution for flow over a flat plate, Von- Karman momentum integral	**8**	**20%**

	equations, Pohlhausen approximation solution of boundary layer for non-zero pressure gradient flow, favorable and adverse pressure gradients, Entry flow into a duct, flow separation and vortex shedding.		
V1	Turbulent Flow: Introduction to turbulent flow, Governing equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Fully developed Turbulent pipe flow for moderate Reynold's number, Prandtl mixing hypothesis, Turbulence modeling. Boundary layer control.	**7**	**20%**
END SEMESTER EXAMINATION			

Question Paper Pattern

Maximum marks: 100 **Time: 3 hrs**

The question paper should consist of three parts

Part A
There should be 2 questions each from module I and II
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part B
There should be 2 questions each from module III and IV
Each question carries 10 marks
Students will have to answer any three questions out of 4 (3X10 marks =30 marks)

Part C
There should be 3 questions each from module V and VI
Each question carries 10 marks
Students will have to answer any four questions out of 6 (4X10 marks =40 marks)

Note: Each question can have a maximum of four sub questions, if needed.