SEMESTER 4

VISCOUS FLOW THEORY

Course Code	PEAOT412	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. The objective of this course is to provide a comprehensive understanding of viscous flow phenomena and their impact on aircraft design, performance, and operation. The course aims to equip students with the theoretical knowledge and practical skills necessary to analyze, model, and optimize viscous flow effects in various aerodynamic applications

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SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals Of Viscous Flow** Introduction to Viscous Flow: Definition and significance of viscosity. Newtonian and non-Newtonian fluids. Governing Equations: Continuity equation. Navier-Stokes equations: derivation and physical interpretation. Boundary conditions.: Reynolds number, Froude number, and others. Flow similarity and modelling. Exact Solutions of Navier-Stokes Equations: Couette flow. Poiseuille flow. Stokes' first and second problems	9

2	**Laminar Flow** Laminar Flow in Pipes and Channels: Fully developed flow. Hagen-Poiseuille law. Laminar flow in circular and non-circular ducts. Boundary Layer Theory: Concept of boundary layer. Derivation of boundary layer equations. Blasius solution for flat plate. Heat Transfer in Laminar Flow: Energy equation for viscous flows. Thermal boundary layers. Laminar flow heat transfer in tubes.	9
3	**Turbulent Flow** Characteristics of Turbulent Flow: Nature and characteristics of turbulence. Reynolds decomposition and averaging. Turbulent Boundary Layers: Turbulent boundary layer equations. Law of the wall. Empirical correlations for turbulent flow. Turbulent Flow in Pipes and Channels: Fully developed turbulent flow. Moody chart and friction factor. Turbulent flow in non-circular ducts. Mixing and Heat Transfer in Turbulent Flow: Turbulent mixing and diffusion. Heat transfer in turbulent flows. Empirical correlations for heat transfer	9
4	**Advanced In Viscous Flow In For Aircraft Applications** Computational Fluid Dynamics (CFD) for Viscous Flow: Introduction to CFD. Discretization methods: finite difference, finite volume. CFD applications for viscous flows. High Reynolds Number Flows: Characteristics of high Reynolds number flows in aerodynamics. Challenges in modelling and simulation. Practical implications for aircraft design. Heat Transfer in Viscous Flows: Energy equation in viscous flow. Convective heat transfer in boundary layers. Thermal management in aircraft systems. Flow-Induced Vibrations and Aeroelasticity: Interaction of viscous flows with flexible structures. Aero elastic phenomena: flutter, divergence. Mitigation and control strategies.	9

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Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
2 Questions from each module. Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	Each question carries 9 marks. Two questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

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Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand Viscous Flow Fundamentals	**K2**
CO2	Analyze Boundary Layer Behavior: and Evaluate Viscous Effects on Aerodynamic Performance	**K3**
CO3	Apply Flow Control Techniques:	**K3**
CO4	Integrate Knowledge in Real-World Applications	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	-	-	-	-	-	-	-	-
CO2	3	2	-	1	-	-	-	-	-	-	-	-
CO3	3	2	2	1	-	-	-	-	-	-	-	-
CO4	3	1	1	1	-	-	-	-	-	-	-	-

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Boundary-Layer Theory"	Hermann Schlichting and Klaus Gersten	Hermann Schlichting and Klaus Gersten	-
2	Aircraft Aerodynamic Design:	András Sóbester and Alexander I.J. Forrester	-	-

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