Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NMEC514	Advanced Fluid Dynamics	3	1	0	4

Course Objective

Prerequisite: Basic knowledge in fluid mechanics is essential

- To broaden the perspectives of fluid dynamics that the students were introduced to in their first level undergraduate course of Fluid Mechanics.
- 2. To introduce new and advanced topics in details to the students that will increase their curiosity, improve their ability to explain fluid flow through physics supported by mathematical analysis besides enhancing the understanding of theoretical fluid dynamics.

Learning Outcomes

- Students will be writing or expanding differential equations using indicial notations. This will certainly help them in their journey through research papers during the Masters research.
- Strong foundation of the viscous, incompressible flow equations and their forms.
- Understanding of the close coupling between Fluid Mechanics and Thermodynamics.

Unit No.	Topics to be Covered Lecture	Lecture Hours	Learning Outcomes
1	Generalized curvilinear coordinates, Introduction to tensors, Reynolds Transport Theorem (RTT), derivation of the continuity and momentum equations, the conservation equations in vector and tensor forms, conservation equations in Cartesian, cylindrical polar and spherical polar coordinates	9L + 1T	Bridging the particle and point approaches of mechanics, express any conservation equation using vector or tensor notations, express the conservation equations in various alternate forms, i.e. conservative, non-conservative, stress-divergence, etc
2	Analytical solutions of Navier-Stokes equations of motion	3L +1T	To identify the scant cases of viscous flow where closed form solutions of momentum equations are possible. Simplification of full Navier-Stokes equations under these special cases
3	The concept of boundary layer, Prandtl's boundary layer theory and its limitations, boundary layer equations over a flat plate at zero incidence and similarity solution by Blasius, momentum integral equation, Karman-Pohlhausen method, separation of boundary layer, similarity solution for boundary-layer, free-shear layer and wake	7L + 3T	To perform scale analysis and reduce a differential equation to its simplified form, identify similarity variable and perform similarity solution, numerically solve a non-linear ODE, explain fluid forcing based on separation phenomenon
4	Forces on immersed bodies – drag and lift	3L +1T	Calculation of global fluid force from distributed fluid forces over a surface, to explain the contributions of surface pressure, body shape and separation points in controlling fluid loading
5	Transition to turbulence, concepts of turbulence modeling, space and time scales of turbulence, space correlation and cross-correlation, Reynolds form of the continuity and momentum equations.	6L+2T	To distinguish between the laminar and turbulent flows with further depth and insight, to familiarize with the basic approximate equations employed in analyzing turbulence
6	Compressible Flow, Thermodynamic relations of Perfect gases, Stagnation properties	2L+1T	Students will have clear idea of the coupling of compressible fluid flow with the fundamentals of

			thermodynamics
7	Isentropic flow with variable area duct and Flow with normal shock waves	4L + 2T	Ability to distinguish between pure one-dimensional and quasi-one dimensional flows. Understanding of the normal shock theory
8	Supersonic wind tunnels, Flow with oblique shock waves, oblique shock relations from normal shock equations, Mach waves, Reflection and intersection of shocks, Prandtl-Meyer expansion fan. Flow in constant area ducts with friction and flow with heat transfer	8L + 3T	Understanding of the oblique shocks as well as thermodynamic relations of oblique shocks. Control volume treatment of one dimensional Rayleigh-line and Fanno line flow
	Total	42L+14T	

Text Books

1. F. M. White, Viscous Fluid Flow, McGraw-Hill, New York, 2nd Edition, 2012.

2. Philip J. Pritchard and John W. Mitchell, Introduction to Fluid Mechanics, Fox and McDonald's, John Wiley & Sons, 9th Edition, 2016.

Reference books

1. R. L. Panton, Incompressible Flow, John Wiley & Sons, 4th Edition, 2013.

2. H. Schlichting, Boundary Layer Theory, Springer, 8th revised Edition, 2001.

3. W. Yuan, Foundation of Fluid Mechanics, PHI, S.I. unit Edition, 1988.

4. V. Babu, Fundamentals of Gas Dynamics, Wiley-Blackwell, Chennai, 2nd Edition, 2015.

5. P. H. Oosthuizen and W. E. Carscallen, Compressible Fluid Flow (Engineering Series), McGraw-Hill Science/Engineering/Math, 1st Edition, 2003.

6. S. M. Yahya, Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion, New Age International, 2018.