Approval: 9th Senate Meeting

Course Name: **Introduction to Turbulence and its Modelling**

Course Number: **ME 625**

Credit: **3-0-0-3**

Prerequisites: UG: **ME 210 Fluid Mechanics, IC 110 Engineering Mathematics/ ME 504 Numerical Methods for Engineering Computation**

Students intended for: UG/PG

Elective or Compulsory: Elective

Semester: **Odd/Even**

Preamble: Special and important topic in the fluid mechanics and thermal sciences is the investigation of turbulent fluid flows. The topic is important in understanding transport in highly disordered flows and other advanced topics, e.g. turbulent mixing and combustion. This course rightly blends theory of turbulence with the advanced modelling aspects of it. Few lectures are also devoted to the measurements aspects in turbulence. The course is very useful for research scholars and advanced learners.

Course Outline:
The course extends understandings of fluid mechanics to chaotic flows in nature. The course introduces nature of turbulence and basic equations of turbulent flows. It also emphasizes on the modelling procedures and closures for turbulent flows.

Course Modules:

Introduction to Turbulence
Nature of turbulence, origin of turbulence, laminar and turbulent boundary layers, diffusion of turbulence, concept of eddy viscosity, enstrophy

[4]

Statistics of Turbulence
Statistical aspects of turbulence, scales in turbulence, spectrum of turbulence, energy cascade in isotropic turbulence, Kolmogorov hypotheses, dissipation spectrum

[6]

Mathematical Theory of Turbulence
The Reynolds equation, Reynolds decomposition, equations for the mean flow, Reynolds stress, mixing length model, turbulent heat transfer, limitations of mixing length theory

[6]

Dynamics of Turbulence
Dynamics of turbulence, Taylor microscale, Reynolds stress and vorticity, the vorticity equation

[4]

Boundary-free and Wall-bounded Turbulence
Turbulent wakes, turbulent jets and mixing layers, turbulent flows in pipes and channels, experimental techniques for turbulence characteristics

[8]

Introduction to Turbulence Modelling

Turbulence modelling and closure problem, algebraic models, modern variants of the mixing length model, one equation models, k-ε and k-ω models, Spalart–Allmaras turbulence model

[8]

Numerical Techniques for Turbulence

Direct numerical simulations (DNS), large eddy simulations (LES) and Reynolds averaged Navier-Stokes (RANS) modelling techniques, spectral methods, Current practises for turbulent flow computations including DES, IDDES, MILES, Implicit LES and particle based methods

[8]

Text Books:

1. Tennekes H. and Lumley J., A first course in turbulence, M.I.T. Press.
2. Tritton D.J., Physical Fluid Dynamics, Oxford University Press.
3. Davidson P.A., Turbulence: An Introduction for Scientists and Engineers, Oxford University Press.

Reference Books:

1. Pope S.B., Turbulent flows, Cambridge University Press., 2000
2. Townsend A.A., The structure of turbulent shear flow, Cambridge University Press., 1980.
3. Wilcox D.C., Turbulence modeling for CFD, DCW Industries, Incorporated, 1994.
4. Doering C.R. and Gibbon J.D., Applied analysis of the Navier-Stokes equations, Cambridge University Press., 1995.