Course Number: 28089

Course Name: Physics of turbulent flows

Course Type:	Type & Max Unit: 3
Prerequisite:	Corequisite:
Level: Graduate	First Presentation:
Group: Energy Conversion	Last Edition:

Objectives:

Topics:

1- Nature of turbulence
1-1- What is turbulence
1-2- The origin of turbulence
1-3- Physical nature of turbulence
1-3-1- Turbulence is irregular and unsteady
1-3-2- Turbulence contains a wide range of different scales
1-3-3- Turbulence contains irregular small scale eddies
1-3-4- Turbulence occurs at high Reynolds number
1-3-5- Turbulence dissipate energy
1-3-6- Turbulence is a continuum phenomena
1-3-7- Turbulence is 3-D in nature
1-3-8- Turbulence is highly diffusive
1-3-9- Turbulence is a flow characteristics

2- Important concepts in fluid dynamics
2-1- Introduction
2-2- Fluid properties
2-2-1- Kinematics properties
2-2-2- Transportive properties
2-2-2-1- Variation with rate of shear
2-2-2-2- Variation with pressure
2-2-2-3- Newtonian fluid flow
2-2-3- Thermodynamics properties
2-3- Stresses applied to a fluid element
2-3-1- state of stress
2-3-2- Fluid at rest or fluid flowing with uniform velocity
2-3-3- Inviscid fluid flow
2-3-4- Viscous fluid flow
2-4- Important properties of tensor stress
2-4-1- Symmetry in tensor stress
2-4-2- The average of normal stresses at a point are equal
2-5- Characteristics of laminar flow

3- The equations of fluid motion
3-1- Introduction
3-2- Material derivative
3-3- The physical concept of velocity vector divergence
3-4- Continuity equation
3-5- Momentum equations

4- Stability theory of laminar flows
4-1- Introduction
4-2- Background and history
4-3- Primary stability theory
4-3-1- problem formulation
4-3-2- Orr-sommarfeld equation
4-3-3- Boundary condition of Orr-sommarfeld equation
4-3-4- Conservatively unstable and absolutely unstable
4-3-5- Inviscid stability theory
4-3-6- Viscous stability
4-3-7- Boundary layer stability on a flat plate
4-3-8- Comparison of stability results with experimental data
4-3-9- Parametric effects in linear stability theory
4-4- Secondary stability theory
4-5- Nonlinear stability theory
4-6- Receptivity stability theory

5- Transition to turbulence
5-1- Introduction
5-2- transition
5-2-1- Tollmien-Schlichting waves
5-2-2- Development of transversal vortices
5-2-3- Turbulent spots
5-3- The effects of different parameters on transition
5-3-1- The effect of free stream on transition
5-3-2- The effect of wall roughness on transition
5-3-3- The effect of wall cooling on transition
5-3-4- The effect of pressure gradient and wall roughness together on transition
5-3-5- The effect of osculating free stream on transition
5-4- Transition in 3-D boundary layer
5-5-Prediction of transition point

6- Physics of turbulence
6-1- Introduction
6-2- The origin of turbulence
6-3- Eddies
6-4- Types of turbulent flows
6-5- Definition of turbulent flow
6-6- Definition of hemogenous and isotropic
6-7- Scales and dimensions in turbulent flows

8-6-2- Vorticity in viscous flows
8-6-3- Vorticity equation in turbulent flow
8-6-4- The effect of different eddies on each other

9-Homogenous and isotropic turbulence
9-1- Introduction
9-2- Homogenous turbulent flows
9-3- Isotropic turbulent flows
9-4- Taylor and integral length scales in isotropic flows
9-5- Eulerian micro and integral time scales
9-6- Taylor hypothesis

10- Bounded turbulent shear flows
10-1- Introduction
10-2- Turbulent flow in a 2D channel
10-2-1- Investigation of equations of motion
10-3- Equations of shear layers
10-3-1- Higher order approximations
10-3-2- Momentum equations in flow direction
10-3-3- Momentum equation normal to the flow direction
10-4- Turbulent boundary layers
10-4-1- External turbulent boundary layer
10-4-2- Internal turbulent boundary layer
10-5- Viscous sub-layer
10-5-1- Linear sub-layer
10-5-2- Constant stress sub-layers
10-5-3- Inertia sub-layer

11- Free turbulent shear flows
11-1- Introduction
11-2- equations of free shear layers
11-3- Turbulent jets
11-3-1- Similarity analysis in jets
11-4- Wakes

12- Spectral analysis of turbulence
12-1- Internal structure in wave number space
12-1-1- Equation of hemogenous turbulent dynamics in wave number space
12-1-2- Isotropic turbulent analysis in wave number space
12-1-3- Relation between $\overline{u'^2} f(\mathbf{r},t)$ and $E(\mathbf{k},t)$
12-1-4- One dimensional spectral theory
12-1-5- Taylor hypothesis
12-2- Kolmogrov universal equilibrium theory
12-2-1- Determination of $E(\mathbf{k},t)$ using Kolmogrov hypothesis
12-3- Transportation theories
12-3-1- Heisenberg transportation theory

References: