GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: Aeronautical Engineering
SUBJECT NAME: Boundary Layer Theory
SUBJECT CODE: 2170106
B.E. 7thSEMESTER

Type of course: Engineering Science

Prerequisite: Basics of Fluid Mechanics, Aerodynamics I, Computational Fluid Dynamics

Rationale: Boundary Layer Theory is one of the core areas in the field of aviation. The concepts of Boundary Layer Theories are vitally important to the aeronautical engineer

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**BASIC CONCEPTS OF VISCOUS FLOWS:** Viscous flow characteristics, introduction to hydrodynamic and thermal boundary layer theory, governing equations with effect of viscosity, flow over the flat plate at zero incidences, boundary layer thickness, displacement thickness, momentum thickness, energy thickness, boundary layer equation and their general properties.	**4**	10
2	**SOLUTIONS TO BOUNDARY LAYER FLOWS:** Flat plate at zero angle of incidence, method of exact solution- Blassius solution to boundary layer problems, Approximate solutions - Vonkarman solution to boundary layer flows over the flat plate, flow with pressure gradient, flow over a cylinder, plane Couette flow, circular Couette flow, flow between parallel plates, numericals	**8**	20
3	**THERMAL BOUNDARY LAYERS:** Heat transfer from heated surface. Heat transfer from cold surface, thermal boundary layer growth over the hot and cold surface, flow over the flat plate with different flow conditions with heat transfer, exact and approximate solutions to thermal boundary layer flows,	**8**	20

	relation between thermal and hydrodynamic boundary layer theories, Reynolds analogy and Colburn analogy, non dimensional numbers governing boundary layer flows, numericals		
4	**TRANSITION:** Pipe flow and flow over a flat plate, critical Reynolds number, turbulent spots, principles of theory of stability of Laminar flows, Summerfield equation, factors effecting transition, Laminar aero foils.	**4**	10
5	**TURBULENT BOUNDARY LAYERS:** Fundamentals of turbulent flow, Mean motion fluctions, Reynolds Equations, Reynolds stresses, wind tunnel turbulence, Prandtls mixing length theory, velocity distribution laws, numericals	**8**	15
6	**TURBULENT FLOW THROUGH PIPE:** Flow thorough pipe, governing equations and velocity profile for fully developed flow through pipe, effect of roughness, smooth pipes, relation between laws of friction & velocity distribution, numericals	**8**	15
7	**BOUNDARY LAYER CONTROL:** Need of boundary layer control, causes of boundary layer separation, flow over the cylinder and aerofoil for different flow conditions leads separation	**4**	5
8	**UNSTEADY VISCOUS FLOW:** Startup of plane Couette flow, unsteady flow over a cylinder	**4**	5

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10%	**35%**	**25%**	**25%**	**5%**	**0%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Fluid mechanics by Bansal
2. Heat transfer R.K.Rajput
3. Introduction to fluid mechanics by deward shaughnessy
4. Boundary layer theory by h. Schlichting

5. Further aerodynamics for engg. Students by houghton and boswell

Course Outcome:

After learning the course the students should be able to:

To know about the basic fundamentals of Different types of Boundary layer thickness
To understand the behavior of the fluid flow under static condition
To understand the basics of Different types of flow such as Laminar, turbulent and compressible flow, Incompressible flow, Viscid and Inviscid flow
To know about the basics of Boundary layer Control
To know about the flow through pipe foe different types of flow

List of Experiments:

1. Introduction to boundary layer theory & CFD
2. Introduction to Hydrodynamic Boundary layer flow over the flat plate
3. Introduction to Thermal Boundary layer flow over the flat plate
4. Introduction to Wind Tunnel.
5. To measure the velocity of air test section using Pitot tube.
6. Verification of Reynolds No. for laminar and turbulent flow.
7. To measure the coefficient of friction for the pipe flow
8. Experimental investigation of pressure distribution over the Flat Plate and force acting on that in a uniform flow with the use of subsonic wind tunnel.
9. Flow over the Flat Plate using CFD Software & Compare with Practical data

Design based Problems (DP)/Open Ended Problem:

Apart from above experiments a group of students has to undertake one open ended problem/design problem.
Few examples of the same are given below.

1. Develop a Small Scale Windtunnel

Major Equipment:

Windtunnel, Pipe friction apparatus, Reynolds's experiment setup

List of Open Source Software/learning website: http://nptel.iitm.ac.in/courses.php

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.