TECHNIQUES IN WIND TUNNEL TESTING

VII Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AAEC36	Elective	3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

Prerequisite: Aerodynamics

I. COURSE OVERVIEW:

Techniques In Wind Tunnel Testing deals with development of tools employed in low speed aerodynam- ics and high speed aerodynamics for measuring parameters such as Pressure, Velocity and Temperature Measurements. It is multi-disciplinary subject and useful in environmental engineering, civil engineer- ing, Automobile engineering in designing vehicle and construction and building and bridges by using low speed wind tunnel balance. so that students get exposure to the various aspects of the subject related issues to measuring techniques, wind tunnel design, method and practical applications used. A number of problems/examples will be cited to enhance the understanding of the subject matter and besides, many unsolved problems will be provided with answers to further test the student's learning. This subject will help the students to develop the tool by using multidisciplinary techniques.

II. COURSE OBJECTIVES:

The student will try to learn:

I	The constructions of low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels and geometric similarity, kinematic similarity and dynamicsimilarity experiment techniques used for analysis aerodynamic problems.
II	The description, design constraints and loss coefficients, and estimation andcorrection of blockages in wind tunnels for receiving precise values while conducting experiments.
III	The principles and applications of Load measurement, Pressure, Velocity, Temperature and flow visualization techniques used in wind tunnel for validatingthe results experimentally.
IV	The necessity of wind tunnel experiments in the fields of automobile andaerospace for the analysis of aerodynamic problems.

III. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Illustrate** the types of wind tunnels, Scaling Laws, Similarity parameters used for the analysis of the prototype models	Understand
CO 2	**Explain** the components and the percentage energy loss in the various parts of low and high-speed wind tunnels for obtaining theaccurate results from the wind tunnel experiments	Understand
CO 3	**Select** the methods for the improvements of wind tunnel performance and corrective measures for obtaining accurate results	Apply
CO 4	**Identify** the various load balances used in the wind tunnels for analyzing the aerodynamic characteristics of designed prototypemodel.	Apply
CO 5	**Illustrate** the flow measurement devices for pressure, velocity, andtemperature for a prototype model.	Apply
CO 6	**Examine** the various flow visualization techniques used in wind tunnels for the analysis of aerodynamic and automobile engineeringproblems.	Analyze

IV. COURSE SYLLABUS:

MODULE-I: FUNDAMENTALS OF EXPERIMENTS IN AERODYNAMICS (10)

Forms of aerodynamic experiments, observations, measurement objectives. History: Wright Brother's wind tunnel, model testing, wind tunnel principles, scaling laws, scale parameters, geometric similarity, kinematic similarity& dynamic similarity. Wind tunnels: low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels, shock tubes. Special tunnels: low turbulence tunnels, high Reynolds number tunnels, environmental tunnels, automobile tunnels, distinctive features, application.

MODULE –II: WIND TUNNEL EXPERIMENTATION CONSIDERATIONS (08)
Low speed wind tunnels, principal components. Function, description, design requirements, constraints and loss coefficients. Wind tunnel performance flow quality, power losses, wind tunnel corrections, sources of inaccuracies: buoyancy, solid blockage, wake blockage, streamline curvature causes, estimation and correction.

MODULE –III: WIND TUNNEL BALANCE (10)
Load measurement: low speed wind tunnel balances, mechanical & Strain gauge types, null displacement methods & strain method, sensitivity, weigh beams, steel yard type and current balance type, balance linkages, levers and pivots.

Model support three point wire support, three point strut support, platform balance, yoke balance, strain gauge, 3component strain gauge balance, description, application.

MODULE –IV: PRESSURE, VELOCITY & TEMPERATURE MEASUREMETNS (09)
Pressure: static pressure, surface pressure orifice, static probes, pitot probe for total pressure, static pressure and flow angularity, pressure sensitive paints, steady and unsteady pressure measurement and various types of pressure probes and transducers, errors in pressure measurement. Temperature: measurement of temperature using thermocouples, resistance thermometers, temperature sensitive paints and liquid crystals. Velocity: measurement of airspeed, Mach number from pressure measurements, flow direction, boundary layer profile using pitot static probe, 5 hole probe yaw meter, total head rake, hot wire anemometry, laser doppler anemometry, particle image velocimetry, working principle description of equipment, settings, calibration, measurement, data processing, applications.

MODULE –V: FLOW VISUALIZATION TECHNIQUES (08)
Flow visualization: necessity, streamlines, streak lines, path lines, time lines, tufts, china clay, oil film, smoke, hydrogen bubble. Optical methods: density and refractive index, schlieren system, convex lenses, concave mirrors, shadowgraph, interferometry, working principle, description, setting up, operation, observation, recording, interpretation of imagery, relative merits and applications

V. TEXT BOOKS:

1. Jewel B Barlow, William H Rae Jr. & Alan Pope, “Low Speed Wind Tunnel Testing”, John Wiley & Sons, Re-Print, 1999.
2. Alan Pope, Kennith L Goin, “High Speed Wind Tunnel Testing”, John Wiley & Sons, Reprint, 1965.

VI. REFERENCE BOOKS:

1. Gorlin S M & Slezinger I I, “Wind tunnels & Their Instrumentations”, NASA publications, Translated version, 1966.
2. Jorge C Lerner & Ulfilas Boldes, “Wind Tunnels and Experimental Fluid Dynamics Research”, InTech, 1st Edition, 2011.
3. Liepmann H W and Roshko A, “Elements of Gas Dynamics”, John Wiley & Sons, 4th Edition, 2003.