

## EXPERIMENTAL AERODYNAMICS

I Semester: AE								
Course Code	Category	Hours /Week			Credits	Maximum Marks		
BAEC09	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
<b>Contact Classes:45</b>		<b>Tutorial Classes: Nil</b>		<b>Practical Classes: Nil</b>		<b>Total Classes:45</b>		

### I. COURSE OVERVIEW:

The experimental aerodynamics is the first course for graduate and undergraduate students in Aerospace Engineering. The testing methodology employed in low and high-speed aerodynamics is a new techniques through which the students will learn various types of wind tunnels, tools and techniques. The experimental aerodynamics will be helpful to industrial aerodynamics study in various engineering branches like, environmental engineering, civil engineering, Automobile engineering etc., 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. This subject will help the students to develop the tool by using multidisciplinary techniques. 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.

### II. COURSE OBJECTIVES:

#### The students will try to learn:

- I. The different components of wind tunnel and their function.
- II. The pressure distribution on airfoil, sphere, cylinder other aerodynamic surfaces and bluff body.
- III. The experiment to measure forces on a model force balance.
- IV. Experiment to determine boundary layer.
- V. Different flow of visualization techniques.

### III. COURSE OUTCOMES:

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

CO 1	<b>Explain the need of wind tunnel and its measuring techniques for analysis of model using geometric similarity, kinematic similarity and dynamic similarity.</b>	<b>Understand</b>
CO 2	<b>Identify the principal components of low-speed wind tunnel and their functions for determining loss coefficients and constraints.</b>	<b>Apply</b>
CO 3	<b>Demonstrate low speed wind tunnel balances, mechanical and Strain gauge types, null displacement methods and strain method and etc for load measurement using wind tunnel balance.</b>	<b>Apply</b>
CO 4	<b>Identify the principles of probes and transducers used in pressure, velocity &amp; temperature measurements techniques.</b>	<b>Apply</b>
CO 5	<b>Identify the necessity of streamlines, streak lines, path lines, time lines, tufts, china clay, oil film, and smoke and hydrogen bubble for flow visualization of wind in wind tunnel.</b>	<b>Apply</b>
CO 6	<b>Identify the applications of wind tunnels for the analysis of load, pressure, velocity and temperature measurements using flow visualization for the analysis of aerodynamic problems in automobile and aerospace industries.</b>	<b>Apply</b>

### IV. COURSE SYLLABUS:

#### MODULE-I: AERODYNAMIC EXPERIMENTS- HISTORY, MODEL TESTING AND WIND TUNNELS -TYPES, APPLICATION (08)

Forms of aerodynamic experiments: Observation, measurement, objectives, history, means; Model testing-wind tunnel, principles, scaling laws, scale parameters, significance; Wind tunnels, low speed types, description; High

speed tunnels, transonic, supersonic, hypersonic, shock tubes, special tunnels, low turbulence, high environmental, automobile, function, distinctive features, application; Major wind tunnel facilities - description, details.

#### **MODULE-II: LOW SPEED WIND TUNNELS - CONSTRUCTION, COMPONENTS, PERFORMANCE & WIND TUNNEL CORRECTIONS (10)**

Low speed wind tunnel, principal components, working section, diffuser, corners, turning vanes, fan, straighteners, honey combs, screens, contraction cone, fan, motor- function, description, design requirements, constraints, construction, performance-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; Total correction on airspeed, dynamic pressure, zero lift drag.

#### **MODULE-III: LOAD MEASUREMENTS-WIND TUNNEL BALANCES AND FLOW MEASUREMENTS - INSTRUMENTATION (10)**

Load measurements, wind tunnel balances, types, description, application; Steady and unsteady pressure measurement and various types of pressure probes and transducers, errors in pressure measurements. Measurement of temperature using thermocouples, resistance thermometers, temperature sensitive paints and liquid crystals; Measurement of airspeed, flow direction, boundary layer profile using Pitot static tubes, 5 hole probes, total head rake-function, working principle, types, details of design and construction, use.

#### **MODULE-IV: FLOW VISUALISATION TECHNIQUES (09)**

Flow visualization, need, types, tufts, china clay, oil film, smoke, working principle, description, setting up, operation, observation, recording, interpretation of imagery, relative merits, applications; High speed flows, optical methods, shadowgraphy, Schlieren, interferometry.

#### **MODULE-V: MEASUREMENT OF VELOCITY- HOTWIRE ANEMOMETRY, LASER DOPPLER ANEMOMETRY, PARTICLE IMAGE VELOCIMETRY- OVERVIEW (08)**

Hot wire anemometry, laser Doppler anemometry, particle image velocimetry, working principles, description of equipment, experimental setup, settings, calibration, measurement, data processing, applications.

#### **V. TEXT BOOKS:**

1. Barlow, J.B., Rae, W.H., Pope, A., "Low Speed Wind Tunnel Testing, Wiley, 1999.
2. Pope, A. and Goin, K.L., "High Speed Wind Tunnel Testing, Wiley, 1965.
3. Yang, W.J., "Handbook of Flow Visualization, Taylor and Francis, 2<sup>nd</sup> Edition, 2001.

#### **VI. REFERENCE BOOKS:**

1. Bradshaw, P., "Experimental Fluid Mechanics", Pergamon Press, 1970.
2. Goldstein, R.J., (Ed.), "Fluid Mechanics Measurements", Taylor & Francis, Washington 1996.
3. Tropea, C., Yarin, A.L., Foss, J.F., "Handbook of Experimental Fluid Mechanics, Springer, 2007.

#### **VII. WEB REFERENCES:**

1. [www.mace.manchester.ac.uk/our-research/research-themes/.../aerodynamics/](http://www.mace.manchester.ac.uk/our-research/research-themes/.../aerodynamics/)
2. [ocw.metu.edu.tr/pluginfile.php/1876/mod\\_resource/.../0/.../AE547\\_1\\_Outline1.pdf](http://ocw.metu.edu.tr/pluginfile.php/1876/mod_resource/.../0/.../AE547_1_Outline1.pdf)
3. <https://www.coursehero.com/file/13548586/AE547-1-Outline1pdf/>

#### **VIII. E-TEXT BOOKS:**

1. <https://books.google.co.in/books?isbn=0471694029>
2. <https://books.google.co.in/books?id=VxchAAAAMAAJ>
3. <http://as.wiley.com/WileyCDA/WileyTitle/productCd-0471557749.html>
4. <http://www.gbv.de/dms/ilmenau/toc/318379147.PDF>