



# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad, Telangana

## INSTRUMENTATION MEASUREMENTS AND EXPERIMENTS IN FLUIDS

**I Semester: AE**

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P		CIA	SEE	Total
BAEE09	Elective	3	-	-	3	40	60	100
<b>Contact Classes: 45</b>		<b>Tutorial Classes: Nil</b>		<b>Practical Classes: Nil</b>		<b>Total Classes: 45</b>		

**Prerequisite: Aerodynamics**

### I. COURSE OVERVIEW:

The instrumentation and experiments in fluids 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 technique 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 course related issues to measuring techniques, wind tunnel design, method and practical applications used. This course will help the students to develop the tool by using multidisciplinary techniques.

### II. COURSE OBJECTIVES:

**The students will try to learn:**

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

### III. COURSE OUTCOMES:

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

- CO 1 Explain the need of wind tunnel and its measuring techniques for analysis of model using geometric similarity, kinematic similarity and dynamic similarity.
- CO 2 Identify the principal components of low-speed wind tunnel and their functions for determining loss coefficients and constraints.
- CO 3 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.
- CO 4 Identify the principles of probes and transducers used in pressure, velocity & temperature measurements techniques.
- CO 5 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.
- CO 6 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.

### IV. COURSE CONTENT:

**MODULE-I: AERODYNAMIC EXPERIMENTS- HISTORY, MODEL TESTING AND WIND TUNNELS**

### **-TYPES, APPLICATION (09)**

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 (09)**

Low speed wind tunnel, principal components, working section, diffuser, corners, turning vanes, fan, straighteners, honeycombs, 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 in accuracies, buoyancy, solid blockage, wake blockage, streamline curvature- causes, estimation, and correction; Total correction on airspeed, dynamic pressure, zero lift drag.

### **MODULE-III: HIGH SPEED TUNNEL (09)**

Transonic wind tunnel - Transonic Test Section - Supersonic wind tunnels - Losses in Supersonic Tunnels - Supersonic Wind Tunnel Diffusers- Effects of Second Throat - Runtime calculation -Calculating Air Flow

Rates -Calibration of Supersonic Wind Tunnels - Hypersonic wind tunnel and Calibration -Lud wieg Tube - Shock tube and shock tunnels - Gun tunnel - Plasma arc tunnels - Measurement of shock speed.

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

Pressure measurement - Barometers, Pressure transducers, Pitot, Static and Pitot-static tubes, Velocity measurement - Laser doppler anemometer, Hot-wire anemometer, Fluid-jet anemometer, Particle image velocimetry, Temperature measurement - Thermometers, Thermocouples

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, shadow graphy, Schlieren, interferometry.

### **MODULE-V: DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS (09)**

Data acquisition and processing - Signal conditioning - Statistical analysis of experimental data -Regression analysis - Estimation of measurement errors - Uncertainty calculation - Uses of uncertainty analysis.

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

1. Rathakrishnan, E, "Instrumentation, Measurements, and Experiments in Fluids", CRC Press -Taylor & Francis, 2020.
2. Barlow,J.B., Rae,W.H., Pope, A, "Low Speed Wind Tunnel Testing, Wiley, 1999.
3. Pope, A. and Goin, K.L, "High Speed Wind Tunnel Testing, Wiley, 1965.
4. Yang, W.J, "Hand book 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, "Hand book of Experimental Fluid Mechanics, Springer, 2007.

### **VII. ELECTRONICS RESOURCES:**

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/>
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#### **VIII. MATERIALS ONLINE**

1. Course template
  2. Assignments
  3. Tutorial question bank
  4. Model question paper – I
  5. Model question paper – II
  6. Lecture notes
  7. Power point presentations
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