INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)
Dundigal,Hyderabad -500043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**EXPERIMENTAL AERODYNAMICS**			
Course Code	**R15-A72120**			
Class	**IV B.Tech I Semester**			
Year	**2018-2019**			
Regulation	**R15 – JNTUH**			
Course Structure	**Lectures**	**Tutorials**	**Practical's**	**Credits**
	4	**1**	**-**	**4**
Course Coordinator	**Mr. Shiva Prasad U, Asst. Professor, Aeronautical Engineering**			
Team of Instructors	**Mr. Shiva Prasad U, Asst. Professor, Aeronautical Engineering**			

I. COURSEOVERVIEW

This course introduces the basic concepts underlying in performing experiments in aerodynamics which is the foundation for aerodynamics in the field Aeronautical Engineering. The emphasis of this course is laid on understanding the concepts of similarity, errors in experimentation, design of experimental facility, physics and instrumentation used for measurement of parameters like pressure, velocity, temperature and fundamentals of flow visualization techniques.

II. PREREQUISITE(S)

Level	Credits	Periods	Prerequisite
UG	4	4	Mechanics of Fluids
UG	4	4	Aerodynamics I
UG	4	4	Aerodynamics II

III. MARKS DISTRIBUTION

Sessional Marks	University End Exam Marks	Total Marks
There shall be 2 midterm examinations. Each midterm examination consists of subjective test and objective type tests. The subjective test is for 10 marks of 60 minutes duration. Subjective test of shall contain 4 questions; the student has to answer 2 questions, each carrying 5 marks. The objective type test is for 10 marks of 20 minutes duration. It consists of 10 Multiple choice and 10 objective type questions, the student has to answer all the questions and each carries half mark. First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion. Five marks are earmarked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two.	75	100

IV. EVALUATION SCHEME

S.No	Component	Duration	Marks
1	I Mid examination	80 minutes	20
2	I Assignment	--	05
3	II Mid examination	80 minutes	20
4	II Assignment	--	05
5	External examination	3 hours	75

V. COURSEOBJECTIVES

The objective of the teacher is to impart knowledge and abilities to the students to:

I. Describe basic fundamentals of Aerodynamics experiments, their need in comparison with numerical computation and theoretical studies.

II. Develop concepts of flow similarity and illustrate the importance of non-dimensional numbers and their use.

III. Explain the design procedure of wind tunnel and demonstrate the process in designing a practical wind tunnel.

IV. Analyze the concept of force and moment measurement using wind tunnel balances and extrapolate it to new balancedevelopment.

V. Summarize various pressure, velocity, temperature measurement techniques and flow visualization methods.

VI. COURSEOUTCOMES

After completing this course the student must demonstrate the knowledge and ability to:

1. Define requirement of aerodynamicexperiments for various speeds and to measure at varying speeds by using controller.
2. Distinguish various types of tunnels based of their purpose of build.
3. Differentiate the accuracies and precision of methods and results between numerical computations, theoretical solutions andexperimental.
4. Illustrate the process of design of low speed windtunnel.
5. Emphasize on the correctness of the design of a given low speed wind tunnel and of the numerical data obtained from various sensors andtransducers.
6. Interpret the data acquired from various sensors and images of flowvisualization.
7. Design complete wind tunnel and instrumentation required for a givenexperiment.
8. Evaluate the models for testing in wind tunnel at different speeds using various equipment's to test the variables.practical elements of experimental aerodynamics and to develop an appreciation for how aerodynamic data are acquired;
9. Provide the students with an opportunity to apply modern instrumentation and measurement techniques to the acquisition of aerodynamic data and understand the inherent limitations of each technique;
10. Become proficient in estimating experimental uncertainty in the model testing and to find the inputs for the multidisciplinary analysis.
11. Critically analyse the results of their experiments and present them in a concise and logical fashion, both in written and oral forms;

12. Gain experience using embedded microprocessors for experimental applications.
13. Steady and unsteady pressure measurements and various types ofpressure probes and transducers, errors in pressure measurements.
14. Measurement of temperature using thermocouples, resistancethermometers, temperature sensitive paints and liquid crystals.
15. Understand the optimal methods and apply it to various systems of visualization for subsonic and supersonic speeds.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED

Program outcomes		Level	Proficiency assessed by
PO1	**General knowledge:** An ability to apply the knowledge of mathematics, science and Engineering for solving multifaceted issues of Aeronautical Engineering	S	Assignments
PO2	**Problem Analysis:** An ability to communicate effectively and to prepare formal technical plans leading to solutions and detailed reports for Aeronauticalsystems	S	Exercise
PO3	**Design/Development of solutions:** To develop Broad theoretical knowledge in Aeronautical Engineering and learn the methods of applying them to identify, formulate and solve practical problems involving Aerodynamics	H	Assignments
PO4	**Conduct investigations of complex problems**: An ability to apply the techniques of using appropriate technologies to investigate, analyze, design, simulate and/or fabricate/commission complete systems involving complex aerodynamics flow situations.	H	Exercise
PO5	**Modern tool usage:** An ability to model real life problems using different hardware and software platforms, both offline and real-time with the help of various tools along with upgraded versions.	-	--
PO6	**The engineer and society**: An Ability to design and fabricate modules, control systems and relevant processes to meet desired performance needs, within realistic constraints for social needs	-	--
PO7	**Environment and sustainability:** An ability To estimate the feasibility, applicability, optimality and future scope of power networks and apparatus for design of eco-friendly with sustainability	-	--
PO8	**Ethics:** To Possess an appreciation of professional, societal, environmental and ethical issues and proper use of renewableresources	-	--
PO9	**Individual and team work:** An Ability to design schemes involving signal sensing and processing leading to decision making for real time Aeronautical systems and processes at individual and team levels.	-	--
PO10	**Communication:** an Ability to work in a team and comprehend his/her scope of work, deliverables, issues and be able to communicate both in verbal ,written for effective technical presentation	-	--
PO11	**Life-long learning**: An ability to align with and upgrade to higher learning and research activities along with engaging in life-longlearning.	H	Discussions
PO12	**Project management and finance**: To be familiar with project management problems and basic financial principles for a multi-disciplinary work	-	--

S- Supportive H – HighlyRelated

VIII. HOW PROGRAM SPECIFIC OUTCOMES AREASSESSED

Program Specific Outcomes		Level	Proficiency assessed by
PSO 1	**Professional skills:** Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products	H	Lectures, Assignments
PSO 2	**Problem solving skills:** imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles	S	Tutorials
PSO 3	**Practical implementation and testing skills:** Providing different types of in house and training and industry practice to fabricate and test and develop the products with more innovative technologies	S	Seminars and Projects
PSO 4	**Successful career and entrepreneurship:** To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats	-	--

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IX. SYLLABUS

UNIT – I

Forms of Aerodynamic experiments- observation, measurement-objectives, History- WRIGHT Brothers'wind tunnel, Model Testing- wind tunnel principles-scaling laws, scale parameters, similarity-geometric., kinematic & Dynamic. Wind tunnels- low speed- types, description. High Speed tunnels-transonic, supersonic, hypersonic, shock tubes, special tunnels- low turbulence, high Re, environmental tunnels, automobile tunnels- distinctive features,application.

UNIT – II

Low Speed Wind Tunnels-Detailed Design: 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 inaccuracies- buoyancy, solid blockage, wake blockage, streamline curvature- causes, estimation and correction.

UNIT – III

High Speed Tunnels and Low speed Balances: High Speed Tunnels basic features of transonic wind tunnel, supersonic wind tunnel- blow down and suction- basic features, shock tubes & hypersonic gun tunnel. 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 & Pivots, model support- three point wire support, three point strut support, platform balance, yoke balance, strain gauge, 3-component strain gauge balance, description, application.

UNIT – IV

Pressure, Velocity and Temperature Measurement: Pressure, Velocity, Temperature measurements: Pressure: static Pressure- surface pressure orifice, static probes, pitot probe for total pressure, Mach number from pressure measurements, wedge & cone measurements- 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, flow direction, boundary layer profile using pitot static probe, 5 hole probe yaw meter, total head rake, Hot wire anemometry, Laser Doppler Anemometry/velocimetry. Particle Image

Velocimetry- working principle description of equipment, settings, calibration, measurement, dataprocessing, Applications.

UNIT – V

Flow Visualization and Optical Methods: Need, Streamlines, streak lines, Path lines, Time lines. Types- tufts, china clay, oil film, smoke, hydrogen bubble, optical methods: density & refractive index, schileren system- convex lenses, knife edges, concave mirrors, Shadowgraph - working principle, description, setting up, operation, observation, recording, interpretation of imagery, relative merits & applications

Textbooks:

1. Low Speed Wind Tunnel Testing, Barlow JB, Rae WH, Pope A, Wiley1999.
2. HighSpeedWindTunnelTesting,PopeAandGoinKL,Wiley1965.
3. Experimental Fluid Mechanics, Bradshaw P., Pergamon Press,1970.

Reference books:

1. Handbook of Flow Visualization, Yang WJ, Taylor & Francis,2001.
2. Fluid Mechanics Measurements, Goldstein RJ, Taylor & Francis,1996.
3. Handbook of Experimental Fluid Mechanics, Tropea C, YarinAL, Foss JF., Springer,2007

X. COURSE PLAN

The course plan is meant as a guideline. There may probably be changes.

Lecture No.	Course Learning Outcomes	Topics to be covered	Reference
1	Introduction to Aerodynamic experiments	Explain the basics of Aerodynamic experiments	T1:1.1
2-3	observation, measurement- objectives	Discuss the relation between observation, measurement- objectives	T1:1.1
4-8	History- WRIGHT Brothers' wind tunnel	Discuss History- WRIGHT Brothers' wind tunnel	T1:2.1
9-10	Model Testing- wind tunnel principles- scaling laws, scale parameters	Explain Model Testing- wind tunnel principles- scaling laws, scale parameters	T1:1.2-1.4
11	Similarity- geometric, kinematic & Dynamic.	Explain Similarity- geometric, kinematic & Dynamic.	T1:2.5
12	Wind tunnels- low speed- types, description	Explain Wind tunnels- low speed- types, description	T1:2.5-2.6
13	High Speed tunnels- transonic, supersonic, hypersonic, shock tubes, special tunnels- low turbulence, high Re	Apply High Speed tunnels- transonic, supersonic, hypersonic, shock tubes, special tunnels- low turbulence, high Re	T1:2.6
14	environmental tunnels, automobile tunnels- distinctive features, application	Explain environmental tunnels, automobile tunnels- distinctive features, application	T1:2.5-2.6
15	Principal components- working section, diffuser, corners turning vanes, fan, straighteners, honeycombs, screens	Knowing Principal components- working section, diffuser, corners turning vanes, fan, straighteners, honeycombs, screens	T1:3.1
16-19	contraction cone, fan, motor- function, description, design requirements, constraints, construction, performance- loss coefficients	Knowing contraction cone, fan, motor- function, description, design requirements, constraints, construction, performance- loss coefficients	T1:3.2-3.8
20	Wind tunnel performance- flow quality, power losses	Knowing Wind tunnel performance- flow quality, power losses	T1:3.1-3.8
21-22	Wind Tunnel Corrections Sources of inaccuracies- buoyancy, solid blockage, wake blockage, streamline curvature- causes, estimation and correction	Knowing Wind Tunnel Corrections Sources of inaccuracies- buoyancy, solid blockage, wake blockage, streamline curvature- causes, estimation and correction	T1:9.1-9.8
23	HIGH SPEED TUNNELS basic features of transonic wind tunnel,	Knowing HIGH SPEED TUNNELS basic features of transonic wind tunnel, supersonic	T2:1.1-1.8

	supersonic wind tunnel	wind tunnel	
24	blow down and suction- basic features, shock tubes & hypersonic gun tunnel	Knowing blow down and suction- basic features, shock tubes & hypersonic gun tunnel	T2:1.1-1.8
25	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	Knowing 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	T1:4.1-4.8
26	balance linkages- levers **& Pivots, model support- three** point wire support, three point strut support, platform balance, yoke balance, strain gauge, 3- component strain gauge balance, description, application.	Knowing balance linkages- levers & Pivots, model support- three point wire support, three point strut support, platform balance, yoke balance, strain gauge, 3-component strain gauge balance, description, application.	T1: 4.1-4.8
27	PRESSURE: static Pressure- surface pressure orifice, static probes, pitot probe for total pressure, Mach number from pressure measurements	Knowing PRESSURE: static Pressure- surface pressure orifice, static probes, pitot probe for total pressure, Mach number from pressure measurements	T1: 6.1-6.8
28	wedge& cone measurements- static pressure and flow angularity. pressure sensitive paints	Exercise wedge & cone measurements- static pressure and flow angularity. pressure sensitive paints	T1:6.10
29-30	Steady and unsteady pressure measurement and various types of pressure probes and transducers. Errors in pressure measurement	Knowing Steady and unsteady pressure measurement and various types of pressure probes and transducers. Errors in pressure measurement	T1: 6.1-6.8
31-32	TEMPERATURE: measurement of temperature using thermocouples, resistance thermometers,	Knowing TEMPERATURE: measurement of temperature using thermocouples, resistance thermometers,	T1:6.8
33-34	temperature sensitive paints, and liquid crystals	Knowing temperature sensitive paints, and liquid crystals	T1:11.1
35-36	VELOCITY: measurement of airspeed, flow direction, boundary layer profile using pitot static probe	Knowing VELOCITY: measurement of airspeed, flow direction, boundary layer profile using pitot static probe	T1:11.2
37-38	5 hole probe yaw meter, total head rake	Knowing 5 hole probe yaw meter, total head rake	T1:11.7
39-40	Hot wire anemometry	Knowing Hot wire anemometry	T1:11.5
41-43	Laser Doppler Anemometry/velocimetry	Knowing Laser Doppler Anemometry/velocimetry	T1:15.1-15.5
44-46	Particle Image Velocimetry	Knowing Particle Image Velocimetry	T1:12.1
47-48	Streamlines, streak lines, Path lines, Time lines	Knowing Streamlines, streak lines, Path lines, Time lines	T1:11.9
49-50	Types- tufts, china clay	Exercise Types- tufts, china clay	T1:11.11, 15.18
51-53	oil film, smoke, hydrogen bubble,	Knowing oil film, smoke, hydrogen bubble	T1:3.4,3.7 ,3.10
54-56	OPTICAL METHODS: density & refractive index	Knowing OPTICAL METHODS: density & refractive index	T1:3.2-3.3
57-58	schileren system- convex lenses, knife edges, concave mirrors,	Knowing schileren system- convex lenses, knife edges, concave mirrors	T1:3.5-3.6
59-61	Shadowgraph	Knowing Shadowgraph	T1:3.9
62-64	Problems	Exercise	T1:3.11

XI. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
I	H				S								S			
II					S						H				S	
III	H		S											H		
IV		S									H				S	
V													H			

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XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Course Outcomes	Program Outcomes												Program Specific Outcomes			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
1				S												
2		S														
3	S												S	H	S	
4	H															
5			H													
6	H												S		S	
7																
8																
9		S			S											
10	S												S			
11	H				S											
12			H													
13	H												S		S	
14														H		
15				S												

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Prepared by: Mr. Shiva Prasad U, Assistant Professor,

HOD, AE