ANNA UNIVERSITY, CHENNAI

AFFILIATED INSTITUTIONS

Regulation - 2013

B.E. AERONAUTICAL ENGINEERING

SEMESTER VIII

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	AE6801	Wind Tunnel Techniques	3	0	0	3
2.		Elective – IV	3	0	0	3
PRACTICAL						
3.	AE6811	Project Work	0	0	12	6
		TOTAL	**6**	**0**	**12**	**12**

ELECTIVE-IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	AE6013	Hypersonic Aerodynamics	3	0	0	3
2.	AE6014	Experimental Aerodynamics	3	0	0	3
3.	AE6015	Rockets and Missiles	3	0	0	3
4.	AE6016	Structural Dynamics	3	0	0	3

AE6801 WIND TUNNEL TECHNIQUES L T P C
3 0 0 3

OBJECTIVES:

- The students are exposed to various types and techniques of Aerodynamic data generation on aerospace vehicle configurations in the aerospace industry.

UNIT I PRINCIPLES OF MODEL TESTING 6

Buckingham Theorem – Non dimensional numbers – Scale effect – Geometric Kinematic and Dynamic similarities.

UNIT II TYPES AND FUNCTIONS OF WIND TUNNELS 6

Classification and types – special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions – Layouts – sizing and design parameters.

UNIT III CALIBRATION OF WIND TUNNELS 9

Test section speed – Horizontal buoyancy – Flow angularities – Flow uniformity & turbulence measurements – Associated instrumentation – Calibration of subsonic & supersonic tunnels.

UNIT IV CONVENTIONAL MEASUREMENT TECHNIQUES 12

Force measurements and measuring systems – Multi component internal and external balances – Pressure measurement system - Steady and Unsteady Pressure- single and multiple measurements - Velocity measurements – Intrusive and Non-intrusive methods – Flow visualization techniques- surface flow, oil and tuft - flow field visualization, smoke and other optical and nonintrusive techniques

UNIT V SPECIAL WIND TUNNEL TECHNIQUES 12

Intake tests – store carriage and separation tests - Unsteady force and pressure measurements – wind tunnel model design

TOTAL: 45 PERIODS

OUTCOMES

- Ability to use various techniques of Aerodynamic data generation.

TEXT BOOKS:

1. Rae, W.H. and Pope, A., "Low Speed Wind Tunnel Testing", John Wiley Publication, 1984.
2. NAL-UNI Lecture Series 12:" Experimental Aerodynamics", NAL SP 98 01 April 1998

REFERENCES:

1. Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.
2. Bradsaw "Experimental Fluid Mechanics".
3. Short term course on Flow visualization techniques, NAL , 2009
4. Lecture course on Advanced Flow diagnostic techniques 17-19 September 2008 NAL, Bangalore

AE6811 PROJECT WORK L T P C
0 0 12 6

OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same. To train the students in preparing project reports and to face reviews and viva voce examination.

The students in a group of 3 to 4 works on a topic approved by the head of the department under the guidance of a faculty member and prepares a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

OUTCOMES:

- On Completion of the project work students will be in a position to take up any challenging practical problems and find solution by formulating proper methodology.

AE6013 HYPERSONIC AERODYNAMICS L T P C
3 0 0 3

OBJECTIVES

- To introduce fundamental concepts and features peculiar to hypersonic flow to students to familiarize them with the aerodynamical aspects of hypersonic vehicles and the general hypersonic flow theory.

UNIT I FUNDAMENTALS OF HYPERSONIC AERODYNAMICS 9

Introduction to hypersonic aerodynamics – differences between hypersonic aerodynamics and supersonic aerodynamics - concept of thin shock layers and entropy layers – hypersonic flight paths – hypersonic similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows.

UNIT II SIMPLE SOLUTION METHODS FOR HYPERSONIC INVISCID FLOWS 9

Local surface inclination methods – Newtonian theory – modified Newtonian law – tangent wedge and tangent cone and shock expansion methods – approximate methods - hypersonic small disturbance theory – thin shock layer theory.

UNIT III VISCOUS HYPERSONIC FLOW THEORY 9

Boundary layer equations for hypersonic flow – hypersonic boundary layers – self similar and non self similar boundary layers – solution methods for non self similar boundary layers – aerodynamic heating and its adverse effects on airframe.

UNIT IV VISCOUS INTERACTIONS IN HYPERSONIC FLOWS 9

Introduction to the concept of viscous interaction in hypersonic flows - Strong and weak viscous interactions - hypersonic viscous interaction similarity parameter – introduction to shock wave boundary layer interactions.

UNIT V HIGH TEMPERATURE EFFECTS in HYPERSONIC FLOWS 9

Nature of high temperature flows – chemical effects in air – real and perfect gases – Gibb"s free energy and entropy - chemically reacting boundary layers – recombination and dissociation.

TOTAL: 45 PERIODS

OUTCOMES

- Knowledge in basics of hypersonic and supersonic aerodynamics
- Acquiring knowledge in theory of hypersonic flow.
- Understanding of boundary layers of hypersonic flow and viscous interaction
- Role of chemical and temperature effects in hypersonic flow.

TEXT BOOKS:

1. John D. Anderson. Jr., “Hypersonic and High Temperature Gas Dynamics”, Mc.Graw hill Series, New York, 1996.

REFERENCES:

1. John D. Anderson. Jr., “Modern Compressible flow with historical Perspective”, Mc.Graw Hill Publishing Company, New York, 1996.
2. John T. Bertin, “Hypersonic Aerothermodynamics”, published by AIAA Inc., Washington. D.C., 1994.

AE6014 EXPERIMENTAL AERODYNAMICS L T P C
3 0 0 3

OBJECTIVES:

- To provide details, operating principles and limitations of forces, pressure, velocity and temperature measurements. To describe flow visualization techniques and to highlight in depth discussion of analog methods.

UNIT I BASIC MEASUREMENTS IN FLUID MECHANICS 7

Objective of experimental studies – Fluid mechanics measurements – Properties of fluids – Measuring instruments – Performance terms associated with measurement systems – Direct measurements - Analogue methods – Flow visualization –Components of measuring systems – Importance of model studies.

UNIT II CHARACTERISTICS OF MEASUREMENTS 10

Characteristic features, operation and performance of low speed, transonic, supersonic and special tunnels - Power losses in a wind tunnel – Instrumentation of wind tunnels – Turbulence- Wind tunnel balance –principles, types and classifications -Balance calibration.

UNIT III FLOW VISUALIZATION AND ANALOGUE METHODS 9

Principles of Flow Visualization – Hele-Shaw apparatus - Interferometer – Fringe-Displacement method – Schlieren system – Shadowgraph - Hydraulic analogy – Hydraulic jumps – Electrolytic tank

UNIT IV PRESSURE, VELOCITY AND TEMPERATURE MEASUREMENTS 9

Measurement of static and total pressures in low and high speed flows- Pitot-Static tube characteristics - Pressure transducers – principle and operation – Velocity measurements - Hot-wire anemometry – LDV – PIV: Temperature measurements.

UNIT V SPECIAL FLOWS AND UNCERTAINTY ANALYSIS 10

Experiments on Taylor-Proudman theorem and Ekman layer – Measurements in boundary layers - Data acquisition and processing – Signal conditioning - Uncertainty analysis – Estimation of measurement errors – External estimate of the error – Internal estimate of the error – Uncertainty calculation - Uses of uncertainty analysis.

TOTAL: 45 PERIODS

OUTCOMES

- Knowledge on measurement techniques in aerodynamic flow.
- Acquiring basics of wind tunnel measurement systems
- Specific instruments for flow parameter measurement like pressure, velocity, temperature etc

TEXT BOOKS:

1. Rathakrishnan, E., “Instrumentation, Measurements, and Experiments in Fluids,” CRC Press – Taylor & Francis, 2007.
2. Robert B Northrop, “Introduction to Instrumentation and Measurements”, Second Edition, CRC Press, Taylor & Francis, 2006.

REFERENCES:
1. Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.Bradsaw Experimental Fluid Mechanics.
2. NAL-UNI Lecture Series 12: Experimental Aerodynamics, NAL SP 98 01 April 1998
3. Lecture course on "Advanced Flow diagnostic techniques" 17-19 September 2008 NAL, Bangalore

AE6015 ROCKETS AND MISSILES L T P C
3 0 0 3

OBJECTIVES:
- To give exposure on important topics like rocket motion, rocket aerodynamics and staging & control of rockets to students to enrich their knowledge in the area of missile flight.

UNIT I CLASSIFICATION OF ROCKETS AND MISSILES 9

Various methods of classification of missiles and rockets – Basic aerodynamic characteristics of surface to surface, surface to air, air to surface and air to air missiles – Examples of various Indian space launch vehicles and missiles – Current status of Indian rocket programme with respect to international scenario

UNIT II AERODYNAMICS OF ROCKETS AND MISSILES 10

Airframe components of rockets and missiles – forces acting on a missile while passing through atmosphere – classification of missiles – slender body aerodynamics – method of describing forces and moments – lift force and lateral moment –lateral aerodynamic damping moment – longitudinal moment – drag estimation – upwash and downwash in missile bodies – rocket dispersion.

UNIT III ROCKET MOTION IN FREE SPACE AND GRAVITATIONAL FIELD 10

One dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields – description of vertical, inclined and gravity turn trajectories – determination of range and altitude – simple approximations to determine burn out velocity and altitude – estimation of culmination time and altitude.

UNIT IV STAGING OF ROCKETS AND MISSILES 8

Design philosophy behind multistaging of launch vehicles and ballistic missiles – optimization of multistage vehicles – stage separation techniques in atmosphere and in space – stage separation dynamics and lateral separation characteristics –

UNIT V CONTROL OF ROCKETS AND MISSILES 8

Introduction to aerodynamic and jet control methods – various types of aerodynamic control methods for tactical and short range missiles- aerodynamic characteristics - various types of thrust vector control methods including secondary injection thrust vector control for launch vehicles and ballistic missiles – .

TOTAL: 45 PERIODS

OUTCOMES
- Knowledge in types of rockets and missiles with respect to Indian & international scenario
- Gaining informations on aerodynamics of rocket and missiles
- Knowledge on stages and remote control of rockets missiles

TEXT BOOKS:

1. Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd, London, 1982
2. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5th Edition, 1993.

REFERENCES:

1. Parker, E.R., "Materials for Missiles and Spacecraft", McGraw Hill Book Co. Inc. 1982.
2. Mathur, M.L., and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers and Distributors, Delhi, 1988.

AE6016 STRUCTURAL DYNAMICS L T P C
3 0 0 3

OBJECTIVES:

- To study the effect of periodic and a periodic forces on mechanical systems with matrix approach and also to get the natural characteristics of large sized problems using approximate methods.

UNIT I FORCE DEFLECTION PROPERTIES OF STRUCTURES 9

Constraints and Generalized coordinates – Virtual work and generalized forces – Force – Deflection influence functions – stiffness and flexibility methods.

UNIT II PRINCIPLES OF DYNAMICS 9

Free and forced vibrations of systems with finite degrees of freedom – Response to periodic excitation – Impulse Response Function – Convolution Integral

UNIT III NATURAL MODES OF VIBRATION 9

Equations of motion for Multi degree of freedom Systems - Solution of Eigen value problems – Normal coordinates and orthogonality Conditions. Modal Analysis.

UNIT IV ENERGY METHODS 9

Rayleigh‟s principle – Rayleigh – Ritz method – Coupled natural modes – Effect of rotary inertia and shear on lateral vibrations of beams – Natural vibrations of plates.

UNIT V APPROXIMATE METHODS 9

Approximate methods of evaluating the Eigen frequencies and eigen vectors by reduced, subspace, Lanczos, Power, Matrix condensation and QR methods.

TOTAL: 45 PERIODS

OUTCOMES

- Knowing various options of mathematical modeling of structures
- Method of evaluating the response of structures under various dynamically loaded conditions
- Knowledge in natural modes of vibration of structures
- Gaining knowledge in numerical and approxite methods of evaluating natural modes of vibration.

TEXT BOOKS:

1. Tse. F.S., Morse. I.E. and Hinkle. H.T., "Mechanical Vibrations: Theory and Applications" , Prentice Hall of India Pvt. Ltd, New Delhi, 2004.
2. Hurty. W.C. and M.F. Rubinstein, "Dynamics of Structures", Prentice Hall of India Pvt. Ltd., New Delhi 1987.

REFERENCES:

1. Vierck. R.K., “Vibration Analysis”, 2nd Edition, Thomas Y. Crowell & Co Harper & Row Publishers, New York, U.S.A. 1989.
2. Timoshenko. S.P., and D.H. Young, “Vibration Problems in Engineering”, John Willey & Sons Inc., 1984.
3. Ramamurthi. V., “Mechanical Vibration Practice and Noise Control” Narosa Publishing House Pvt. Ltd, 2008