PAAVAI ENGINEERING COLLEGE, NAMAKKAL – 637 018

(AUTONOMOUS)

B.E.AERONAUTICAL ENGINEERING

REGULATION 2016

CURRICULUM

(CHOICE BASED CREDIT SYSTEM)

SEMESTER III

S.No	Category	Course Code	Course Title	L	T	P	C
Theory							
1.	BS	MA16301	Transforms And Boundary Value Problems	3	2	0	4
2.	PC	AE16301	Aircraft Materials and Manufacturing	3	0	0	3
3.	PC	AE16302	Basics of Aeronautical Engineering	3	0	0	3
4.	ES	AE16303	Fluid Mechanics and Machinery	3	0	0	3
5.	ES	AE16304	Solid Mechanics	3	0	0	3
6.	ES	AE16305	Thermodynamics and Heat Transfer	3	0	0	3
Practical							
7.	ES	AE16306	Fluid Mechanics and Machinery Laboratory	0	0	4	2
8.	ES	AE16307	Strength of Materials Laboratory	0	0	4	2
9.	ES	AE16308	Thermodynamics Laboratory	0	0	4	2
			TOTAL	**18**	**2**	**12**	**25**

SEMESTER IV

S.No	Category	Course Code	Course Title	L	T	P	C
Theory							
1.	BS	MA16404	Numerical Methods	3	2	0	4
2.	PC	AE16401	Aerodynamics	3	0	0	3
3.	PC	AE16402	Aircraft Propulsion	3	0	0	3
4.	PC	AE16403	Aircraft Structures I	3	2	0	4
5.	PC	AE16404	Aircraft Systems and Instrumentations	3	0	0	3
6.	BS	CH16403	Environmental Science and Engineering	3	0	0	3
Practical							
7.	PC	AE16405	Aerodynamics Laboratory	0	0	4	2
8.	PC	AE16406	Aircraft Structures Laboratory I	0	0	4	2
9.	HS	EN16401	Business English Course Laboratory	0	0	2	1
			TOTAL	**18**	**4**	**10**	**25**

SEMESTER III

MA16301 **TRANSFORMS AND BOUNDARY VALUE PROBLEMS (COMMON TO ALL BRANCHES)** **3 2 0 4**

COURSE OBJECTIVES

- To introduce fourier series analysis which is central to many applications in engineering apart from solving boundary value problems.
- To acquaint the student with Fourier transform techniques used in many engineering systems..
- To familiarize effective application of mathematical tools for the solutions of partial differential equations that model several physical processes.
- To apply one dimensional equation of heat conduction and study about wave equation.
- To learn and apply Z transform techniques for discrete time systems.

UNIT I FOURIER SERIES 15

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series –Complex form of Fourier Series – Parseval's identity – Harmonic Analysis.

UNIT II FOURIER TRANSFORMS 15

Fourier integral theorem (without proof) – Fourier transform pair – Sine and Cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

UNIT III PARTIAL DIFFERENTIAL EQUATIONS 15

Formation of partial differential equations – Lagrange's linear equation – Solutions of standard four types of first order partial differential equations - Linear partial differential equations of second and higher order with constant, coefficients.

UNIT IV APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS 15

Solutions of one dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two-dimensional equation of heat conduction.

UNIT V Z - TRANSFORMS AND DIFFERENCE EQUATIONS 15

Z-transforms – Elementary properties – Inverse Z-transform – Convolution theorem – Formation of difference equations – Solution of difference equations using Z-transform.

TOTAL PERIODS 75

COURSE OUTCOMES

At the end of this course, students will be able to

- comprehend fourier series, their different possible forms and the frequently needed practical harmonic analysis from discrete data.
- describe the concept of a function as a double integral under certain conditions and apply in the fourier transform pair and their properties.
- solve certain boundary value problems and apply the methods and results in engineering applications.
- employ partial differential equations to solve one dimensional wave and heat equations.
- demonstrate the knowledge of differential equations gained and solve them using Z transforms.

TEXT BOOKS

1. Veerarajan T., “Transforms and Partial Differential Equations”, Tata McGraw Hill Education Pvt. Ltd., New Delhi, Second reprint, 2012.
2. Narayanan S., Manickavasagam Pillai.T.K and Ramanaiah.G “Advanced Mathematics for Engineering Students” ,Vol. II & III, S.Viswanathan Publishers Pvt Ltd. 1998

REFERENCES

1. Larry C. Andrews, Bhimsen K. Shivamoggi, “Integral Transforms for Enginears”, SPIE Optical Engineering press, Washington USA (1999).
2. Ramana.B.V., “Higher Engineering Mathematics”, Tata Mc-GrawHill Publishing Company limited, New Delhi (2010).
3. Glyn James, “Advanced Modern Engineering Mathematics”, 3rd Edition, Pearson Education (2007).
4. Erwin Kreyszig., “Advanced Engineering Mathematics” 10th Edition,Wiley Publications
5. Ray Wylie C and Barrett.L.C, “Advanced Engineering Mathematics”, Tata McGraw Hill Education Pvt Ltd, Sixth Edition, New Delhi, 2012.

WEB LINKS

1. https://www.youtube.com/watch?v=coe-UA5ONI0
2. https://www.youtube.com/watch?v=gZNm7L96pfY
3. http://172.16.100.200/NPTEL/displayweb.html?type1=111103021%2F35.pdf
4. https://www.youtube.com/watch?v=4GHY8sRKPaU
5. http://172.16.100.200/NPTEL/displayweb.html?type1=111104031%2Flectures.pdf%23page%3D101.

AE16301 AIRCRAFT MATERIALS AND MANUFACTURING TECHNOLOGY 3 0 0 3

COURSE OBJECTIVES

- To study about the various metal casting and welding process followed in industries
- To introduce the various metallic and non-metallic engineering materials used in aircraft applications and their test methods.
- To understand the effect of corrosion in the aircraft materials and its prevention methods.
- To learn the heat treatment process of ferrous and non-ferrous materials.
- To know the basic concepts of composite materials and its applications.

UNIT I CASTING 8

Casting types, procedure to make sand mould, types of core making, moulding tools, machine moulding, special moulding processes – CO2 moulding; shell moulding, investment moulding, permanent mould casting, pressure die casting, centrifugal casting, continuous casting, casting defects.

UNIT II WELDING 8

Classification of welding processes. Principles of Oxy-acetylene gas welding. A.C metal arc welding, resistance welding, submerged arc welding, tungsten inert gas welding, metal inert gas welding, plasma arc welding, thermit welding, electron beam welding, laser beam welding, defects in welding, soldering and brazing.

UNIT III MACHINING 10

General principles (with schematic diagrams only) of working and commonly performed operations in the following machines: Lathe, Shaper, Planer, Horizontal milling machine, Universal drilling machine, cylindrical grinding machine, Capstan and Turret lathe. Basics of CNC machines. General principles and applications of the following processes: Abrasive jet machining, Ultrasonic machining, Electric discharge machining, Electro chemical machining, Plasma arc machining, Electron beam machining and Laser beam machining.

UNIT IV AIRCRAFT METAL ALLOYS AND SUPERALLOYS 10

Aluminum alloys, Magnesium alloys, Titanium alloys, Plain carbon and Low carbon Steels, Corrosion and Heat resistant steels, Maraging steels, Copper alloys, Producibility and Surface treatments for each of the above – Super alloys, Nickel based super alloys, Cobalt based super alloys, and Iron based super alloys, manufacturing processes associated with super alloys, Heat treatment and surface treatment of super alloys.

UNIT V AIRCRAFT COMPOSITE MATERIALS AND NON METALLIC 9

Composite materials – GFRP, CFRP, MMC, GLARE – Classification and properties of wood, plywood and applications – Ablation process-ablative materials- super conducting materials matrix materials- their applications – Purpose of Doping – Adhesives – Aircraft paints – Rubber and Rubber materials.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, students will be able to

- demonstrate about different manufacturing process and applications in industry for component production
- analyze the properties of different aircraft materials.
- compare the properties of various alloys for aerospace application.

- conduct the heat treatment and surface treatment process for various alloys.
- identify the suitable materials for different parts of the aircraft.

TEXT BOOKS

1. Nagendra Parashar B.S. and Mittal R.K., "Elements of Manufacturing Processes", Prentice-Hall of India Private Limited, 2007
2. Hajra Choudhury, "Elements of Workshop Technology", Vol. I, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2010.

REFERENCES

1. Krishnadas Nair C G, 'Handbook of Aircraft Materials', First Edition, Interline Publishers, Bangalore, 1993.
2. Serope Kalpajian, Steven R.Schmid, "Manufacturing Processes for Engineering Materials", Fourth Edition, Pearson Education, Inc. 2007.
3. Horst Buhl (Ed.), 'Advanced Aerospace Materials', Springer-Verlag, 1992.
4. George Francis Titterton, 'Aircraft Material and Processes', Fifth Edition, Sterling Book House, Mumbai, 1998
5. Hajra Choudhury, "Elements of Workshop Technology", Vol. II, Media Promoters and Publishers Pvt., Ltd., Mumbai, 2010.

WEB LINKS

1. http://www.nptelvideos.in/2012/12/advanced-materials-and-processes.html
2. http://nptel.ac.in/courses/112107144/

AE16302 BASICS OF AERONAUTICAL ENGINEERING 3 0 0 3

COURSE OBJECTIVES

- To introduce the basic concepts of and history of aircrafts
- To infer the basic principles on which the development of aerodynamics and other principal sub disciplines of aerospace engineering are based.
- To learn about the various structures of aircraft
- To study about the aircraft power plants and its applications
- To gather knowledge in basics of space mechanics

UNIT I AIRCRAFT CONFIGURATIONS 9

History of Flight. Different types of flight vehicles, classifications. Components of an airplane and their functions. Conventional control, powered control, basic instruments for flying - typical systems for control actuation.

UNIT II BASICS OF FLIGHT MECHANICS 9

Physical properties and structure of the atmosphere, temperature, pressure and altitude relationships, newton's law of motions applied to aeronautics - evolution of lift, drag and moment. Aerofoil, mach number, maneuvers.

UNIT III AIRPLANE STRUCTURES 9

General types of construction, monocoque, semi-monocoque and geodesic constructions, typical wing and fuselage structure. Stresses and strains – Hooke's law – stress - strain diagrams – elastic constants.

UNIT IV POWER PLANTS 9

Basic ideas about piston, turboprop and jet engines - use of propeller and jets for thrust production - comparative merits, principles of operation of rocket, types of rockets and typical applications, exploration into space.

UNIT V BASICS OF SPACE MECHANICS 9

Kepler's laws – Newton's Law of Gravity – Solar System – solar eclipse-celestial sphere. Fundamentals of orbital mechanics- Space environment (atmosphere, radiation & magnetic fields)

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, students will be able to

- classify the components of Aircraft and the basic instruments
- perform basic calculation on Mechanics using Newton law for lift, drag and moment.
- select the suitable materials for Aircraft structure
- identify the types of Power plants and its applications
- carry out and analyze simple calculation about space mechanics

TEXT BOOKS

1. Anderson, J.D., "Introduction to Flight", McGraw-Hill, 2015.
2. Stephen. A. Brandt, "Introduction to Aeronautics: A design perspective" American Institute of Aeronautics & Astronautics,1997

REFERENCES

1. Wiesel, William E., Spaceflight Dynamics, Tata McGraw Hill Publishing Company Limited New Delhi.
2. Kermode, A.C., "Mechanics of Flight", Himalayan Book, 2012
3. Shevell R.S, 'Fundamentals of Flight', Pearson Education, 2012.
4. Vallado, David A., Fundamentals of Astrodynamics and Applications, Kluwer Academic Publishers, London.
5. William J. Astore , Robert B. Giffen , Wiley J. Larson .,Understanding Space: An Introduction to Astronautics, 3rd Edition (SpaceTechnology) , Jerry Jon Sellers.

WEB LINKS

1. http://aeronautics.hpage.com/
2. http://technicalsymposium.com/lecturenotes_AERO_3SEM_111305NOL.html

AE16303 FLUID MECHANICS AND MACHINERY 3 0 0 3

COURSE OBJECTIVES

- To study about the basic fluid properties and flow characteristics
- To apply the conservation laws to flow through pipes and hydraulic machines
- To know the importance of dimensional analysis.
- To study about the various types of pumps and its applications.
- understand the importance of various types of flow in turbines.

UNIT I FLUID PROPERTIES AND FLOW CHARACTERISTICS 6

Units and dimensions-Properties of fluids. Flow characteristics – concept of control volume - application of continuity equation, energy equation and momentum equation.

UNIT II FLOW THROUGH CIRCULAR CONDUITS 9

Hydraulic and energy gradient - Laminar flow through circular conduits and circular annuli-Boundary layer concepts – types of boundary layer thickness – Darcy Weisbach equation –friction factor- Moody diagram- commercial pipes- minor losses – Flow through pipes in series and parallel.

UNIT III DIMENSIONAL ANALYSIS 10

Need for dimensional analysis – methods of dimensional analysis – Similitude –types of similitude - Dimensionless parameters- application of dimensionless parameters – Model analysis.

UNIT IV PUMPS 10

Impact of jets - Euler's equation - Theory of roto-dynamic machines – various efficiencies– velocity components at entry and exit of the rotor- velocity triangles - Centrifugal pumps– working principle - work done by the impeller - performance curves - Reciprocating pump- working principle – Rotary pumps –classification.

UNIT V TURBINES 10

Classification of turbines – heads and efficiencies – velocity triangles. Axial, radial and mixed flow turbines. Pelton wheel, Francis turbine and Kaplan turbines- working principles - work done by water on the runner – draft tube. Specific speed - unit quantities – performance curves for turbines – governing of turbines.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, students will be able to

- apply mathematical knowledge to predict the properties and characteristics of a fluid.
- perform the flow analysis in circular pipes
- identify about the concepts involved in dimensional analysis
- analyze the performance of pumps and its industrial applications.
- execute the performance calculations of turbines.

TEXT BOOKS

1. White F, Fluid 'Mechanics',5th Edition, Tata McGraw-Hill, , New Delhi, 2011.
2. Nodi P.N. and Seth, S.M. "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi 2009.

REFERENCES

1. Streeter, V. L. and Wylie E. B., "Fluid Mechanics", McGraw Hill Publishing Co. 2010
2. Kumar K. L., "Engineering Fluid Mechanics", Eurasia Publishing House(p) Ltd., New Delhi 2010
3. Philip J. Pritchard, 'Fox and McDonald's Introduction to Fluid Mechanics', Eighth Edition, Wiley, 2011.
4. Yunus A. Cengel and John M. Cimbala, 'Fluid Mechanics: Fundamentals and Applications', Third Edition,McGraw-Hill, 2013.
5. R. K. Bansal, 'Fluid Mechanics', Laxmi Publications (P) Ltd, 2008.

WEB LINKS

1. http://www.nptelvideos.in/2012/11/fluid-mechanics.html
2. http://nptel.ac.in/courses/112105182/#

AE16304 **SOLID MECHANICS** **3 0 0 3**

COURSE OBJECTIVES

- To study the behavior of mate rials due to axial, bending, tensional and combined loads.
- To infer the knowledge of Stresses in various beams of mechanical, civil and aeronautical engineering
- To study about the bending of beams with its various methods.
- To know the application of torsion for various material sections.
- To understand the basic concepts of bi axial Stresses with pressure for different sections.

UNIT I BASICS AND AXIAL LOADING **9**

Stress and Strain – Hooke's Law – Elastic constants and their relationship – Volumetric strain. Bar with uniform and varying section – composite bar. Thermal Stresses – stresses due to freely falling weight.

UNIT II STRESSES IN BEAMS **9**

Shear force and bending moment diagrams for simply supported and cantilever beams with concentrated load and uniformly distributed – Bending stresses in straight beams – Shear Stresses in bending of beams with various cross sections – beams of uniform strength.

UNIT III DEFLECTION OF BEAMS **9**

Double integration method – McCauley's method – Area moment method – Conjugate beam method.

UNIT IV TORSION **9**

Torsion of circular shafts - shear stresses and twist in solid and hollow circular shafts – closely coiled helical springs.

UNIT V BI AXIAL STRESSES **9**

Stresses in thin circular cylinder and spherical shell under internal pressure. Combined loading – Principal Stresses and maximum Shear Stresses - Analytical and Graphical methods.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, students will be able to

- understand principles of mathematics, basic sciences and engineering.
- analyze the stress and bending of beams in structures
- apply knowledge of science and engineering principles to solve aeronautical engineering problems.
- perform the torsion analysis process of beam sections
- acquire knowledge about the Bi Axial stress in structures

TEXT BOOKS

1. Stephen Timoshenko, James M. Gere "Mechanics of materials" Van Nostrand Reinhold Co., 1972.
2. Rajput R.K "Strength of Materials"S.Chand and Company Ltd,2012

REFERENCES

1. Stephen Timoshenko and D. H.Young, Elements of strength Materials, Vol. I and Vol. II, T. Van No Strand Co-Inc Princeton- N.J
2. Dym C L and I. H. Shames, 'Solid Mechanics', 2013.
3. Nash William, 'Strength of Materials', TMH, 2010.
4. Timoshenko.S, 'Strength of Materials', Vol. II, CBS Publishers, 2002.
5. Srinath L.S., 'Advanced Mechanics of Solids', Tata McGraw-Hill Publishing Co., New Delhi, 2003.

WEB LINKS

1. http://www.nptelvideos.in/2012/11/mechanics-of-solids.html
2. http://web.mit.edu/emech/dontindex

AE16305 THERMODYNAMICS AND HEAT TRANSFER 3 0 0 3

COURSE OBJECTIVES

- To understand the principles and basics of thermodynamics.
- To study about the various air cycles and its applications.
- To provide in-depth study of thermodynamic principles, thermodynamics of state, basic thermodynamic relations, properties of pure substances.
- To infer the concept of air-conditioning and its concepts
- To enlighten the basic concepts of heat transfer and propulsion cycles.

UNIT I BASIC THERMODYNAMICS 9

Systems – Zeroth Law, First Law – Heat and work transfer in flow and non-flow processes – Difference in heat capacities, Ratio of specific heats – Second law, Kelvin Planck statement – Clausius statement – Concept of entropy – Entropy change in non-flow processes – T-S equations for entropy change – Numerical Problems.

UNIT II AIR CYCLES 9

Air standard cycle approximations – Otto, Diesel Cycles – P-v and T-s diagrams –Description – Efficiency, Mean Effective Pressure – Comparison of Otto, Diesel cycles for same compression ratio and heat input – Dual cycles – P-v and T-s diagrams – Brayton cycle for open and closed systems – Efficiency of gas turbine cycle – Numerical problems.

UNIT III THERMODYNAMICS OF ONE DIMENSIONAL FLUID FLOW 9

Application of continuity, momentum and energy equations- Rankine cycle - Isentropic flow of ideal gases through nozzles - Simple jet propulsion system - Thrust rocket motor – Specific impulse.

UNIT IV AIR CONDITIONING 9

Principles of refrigeration, Air conditioning – Vapour compression – Vapour absorption types –Air cycle machine – Humidity control – Coefficient of performance – Properties of refrigerants

UNIT V BASICS OF HEAT TRANSFER 9

Types of heat transfer-free convection-forced convection- specific impulse – ideal and non- ideal cycle analysis - conduction in parallel, radial and composite wall.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, students will be able to

- apply thermodynamic laws to solve the complex engineering problems.
- explain the principles of continuity, momentum and energy equation to solve the problems in simple jet propulsion systems.
- determine the efficiency and net work of the otto, diesel, and brayton cycles, and to make connections between these cycles and aircraft propulsion systems.
- calculate the design parameters for various air conditioning components.
- apply the basic concepts of heat transfer to solve the various engineering problems

TEXT BOOKS

1. Nag P K, 'Engineering Thermodynamics', Fifth Edition, Tata McGraw-Hill, 2013.
2. Rathakrishnan, E, 'Fundamentals of Engineering Thermodynamics', Prentice Hall, 2005.

REFERENCES

1. Gordon J. Van Wylen and Richard E. Sonntag, 'Fundamentals of Classical Thermodynamics', Sixth Edition, Wiley Publication, 2003.
2. Yunus A. Çengel and Michael A. Boles, 'Thermodynamics an Engineering Approach', Seventh Edition, Tata McGraw-Hill, 2010.
3. Oates, G.C., 'Aero Thermodynamics of Aircraft Engine Components', AIAA Education Series, New York, 1985.
4. Holman.J.P., "Thermodynamics", 3rd Edition, McGraw-Hill, 1995.
5. Prasanna Kumar: Thermodynamics "Engineering Thermodynamics" Pearson Education, 2013

WEB LINKS

1. http://nptel.ac.in/courses/Webcourse-contents/IIT-KANPUR/Basic_Thermodynamics/ui/TOC.htm
2. http://nptel.ac.in/courses/112105123/1

AE16306 FLUID MECHANICS AND MACHINERY LABORATORY 0 0 4 2

COURSE OBJECTIVES

- To study and experiment the flow measurement and the performance of the various fluid machinery

LIST OF EXPERIMENTS

1. Calibration of venturimeter
2. Pressure measurement with pitot static tube
3. Determination of pipe flow losses
4. Verification of Bernoulli's theorem
5. Flow visualization by Heleshaw apparatus
6. Performance test on centrifugal pumps
7. Performance test on reciprocating pumps
8. Performance test on piston wheel turbine
9. Performance test on Francis turbine
10. Determination of Viscosity of a Fluid

TOTAL PERIODS 60

COURSE OUTCOMES

At the end of this course, students will be able to

- gain the knowledge measurement equipments for flow measurement
- perform the flow visualization of various apparatus
- analyze the performance thrust on different fluid machinery pumps

AE16307 STRENGTH OF MATERIALS LABORATORY 0 0 4 2

COURSE OBJECTIVES

- To impart the knowledge in testing the materials for hardness, fatigue, impact, tension and torsion.

LIST OF EXPERIMENTS

1. Determine the BHN using Brinell Hardness Test
2. Determine the RHN using Rockwell Hardness test
3. Determine the Tension of various Materials using Tension test
4. Determine the Torsion of Various Materials using Torsion test
5. Determine the Impact Strength value by using Izod Impact test
6. Determine the Impact Strength value by using Charpy Impact test
7. Perform the Reverse plate bending Fatigue test
8. Perform the Rotating Beam Fatigue test
9. Testing of springs
10. Perform the Block Compression Test for various Materials

TOTAL PERIODS 60

COURSE OUTCOMES

At the end of this course, students will be able to

- perform different destructive testing
- gain knowledge of torsion, Fatigue and Tension
- characterize materials by its strength values

AE16308 **THERMODYNAMICS LABORATORY** **0 0 4 2**

COURSE OBJECTIVES

- To enhance and experiment the basic knowledge in applied thermodynamics and engines

LIST OF EXPERIMENTS

1. Performance test on a 4-stroke engine
2. Valve timing of a 4 – stroke engine and port timing of a 2 stroke engine
3. Determination of effectiveness of a parallel flow heat exchanger
4. Determination of effectiveness of a counter flow heat exchanger
5. Determination of heating value of a fuel
6. COP test on a vapour compression refrigeration test rig
7. COP test on a vapour compression air-conditioning test rig
8. Determination of specific heat of solid
9. Determination of Thermal Conductivity of solid.
10. Determination of Thermal Resistance of a Composite wall.

TOTAL PERIODS 60

COURSE OUTCOMES

At the end of this course, students will be able to

- perform test on diesel/petrol engine
- explain the characteristics of the diesel/petrol engine
- compute the properties of the fuels.

SEMESTER IV

MA16404 **NUMERICAL METHODS (COMMON TO MECH, MCT,CIVIL, EEE & AERO)** **3 2 0 4**

COURSE OBJECTIVES

- To analyse different methods to find solution for a large system of linear equations
- To find the intermediate values for a series of given data
- To develop efficient algorithms for solving problems in science, engineering and technology
- To solve the non linear differential equations that cannot be solved by regular conventional method.
- To apply finite element method to increase the accuracy of second order differential equations

UNIT I SOLUTION OF EQUATIONS AND EIGEN VALUE PROBLEMS 15

Solution of equation –Iteration method : Newton Raphson method – Solution of linear system by Gaussianelimination and Gauss - Jordon method – Iterative method – Gauss-Seidel method – Inverse of a matrix by Gauss Jordon method – Eigenvalue of a matrix by power method.

UNIT II INTERPOLATION AND APPROXIMATION 15

Lagrangian Polynomials – Divided differences – Newton's Divided Difference, Hermite Interpolation Polynomial and Interpolating with a cubic spline – Newton's forward and backward difference formulas.

UNIT III NUMERICAL DIFFERENTIATION AND INTEGRATION 15

Differentiation using interpolation formulae –Numerical integration by trapezoidal and Simpson's 1/3– Romberg's method – Two and Three point Gaussian quadrature formulas – Double integrals using trapezoidal and Simpsons' rule.

UNIT IV INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS 15

Single step methods: Taylor series method – Modified Euler method for first order equation – Fourth order Runge – Kutta method for solving first and second order equations – Multistep methods: Milne's and Adam's predictor and corrector methods.

UNIT V BOUNDARY VALUE PROBLEMS IN ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 15

Finite difference solution of second order ordinary differential equation – Finite difference solution of one dimensional heat equation by explicit and implicit methods – One dimensional wave equation and two dimensional Laplace and Poisson equations.

TOTAL PERIODS 75

COURSE OUTCOMES

At the end of this course, students will be able to

- comprehend the basics of linear equations.
- apply the interpolation methods for constructing approximate polynomials
- demonstrate the knowledge of numerical differential equations in computational and simulation process
- utilize the concept of initial value problems in the field of science and engineering
- describe the computational procedure of the amount of heat emitted or transferred from an object

TEXT BOOKS

1. Erwin Kreyszig., "Advanced Engineering Mathematics" 10th edition, Wiley Publications, 2010.
2. T. Veerarajan. and T .Ramachandran, "Numerical Methods with programming in C", 2nd ed., Tata McGraw-Hill, 2006.
3. Sankar Rao K " Numerical Methods For Scientisits And Engineers –3rd Edition Princtice Hall of India Private, New Delhi, 2007.

REFERENCES

1. P. Kandasamy, K. Thilagavathy and K. Gunavathy, "Numerical Methods", S.Chand Co. Ltd., New Delhi, 2003
2. Gerald C.F. and Wheatley, P.O., "Applied Numerical Analysis" 6th Edition, Pearson Education Asia, New Delhi, 2002.
3. M.K.Jain , S.R.K. Iyangar , R.K.Jain , "Numerical Methods For Scientific & Engineering Computation" New Age International (P) Ltd , New Delhi , 2005.
4. M.B.K. Moorthy and P.Geetha, "Numerical Methods" , Tata McGraw Hill Publications company, New Delhi, 2011.

WEB LINKS

1. https://www.youtube.com/watch?v=QTQ8bO1F-Dg
2. https://www.youtube.com/watch?v=AT7Olelic8U
3. https://www.youtube.com/watch?v=TH06N7Q7FJw
4. https://www.youtube.com/watch?v=DnBJLpdVHCY
5. https://www.youtube.com/watch?v=5TccPEz2nB8

AE16401 AERODYNAMICS 3 0 0 3

COURSE OBJECTIVES

- To introduce the concepts of mass, momentum and energy conservation relating to aerodynamics.
- To make the student to understand the concept of vorticity, irrotationality, theory of airfoils and wing sections.
- To study the conformal transformation process.
- To introduce the basics of airfoil wing theory and its applications.
- To learn the boundary layer theory and its problems

UNIT I INTRODUCTION TO AERODYNAMICS 9

Aerodynamic forces and moments – Pressure distribution on an airfoil – Types of drag – Continuity, momentum and energy equations – Incompressible-inviscid flow – Irrotational flow – Circulation and Vorticity – Euler's equation – Bernoulli's Equation – Pitot tube: Measurement of airspeed, Pressure Coefficient.

UNIT II TWO DIMENSIONAL FLOWS 9

Elementary flows – Uniform, Source, Sink, Doublet and vortex flow, Combination of a uniform flow with a source and sink, Non lifting flow over a circular cylinder, Lifting flow over a cylinder, Kutta Joukowski theorem and Generation of lift, D'Alembert Paradox, Magnus effect-Numerical Problemes

UNIT III CONFORMAL TRANSFORMATION 8

Joukowski transformation and its application to fluid flow problems, Joukowski, and Karman-Trefftz Profiles-Numerical Problems.

UNIT IV AIRFOIL AND WING THEORY 10

Airfoil Nomenclature – Airfoil characteristics, NACA airfoils and Modern airfoils – Kutta condition – Thin airfoil theory and its applications – Aerodynamic Center – Horse shoe vortex, Vortex filament – Biot and Savart law – Downwash and induced drag – Helmholtz theorems, Lifting line theory and its limitations.

UNIT V INTRODUCTION TO BOUNDARY LAYER THEORY 9

Boundary layer and boundary layer thickness, displacement thickness, momentum thickness, energy thickness, shape parameter, boundary layer equations for a steady, two dimensional incompressible flow, boundary layer growth over a flat plate, critical Reynolds number, Blasius solution, basics of turbulent flow

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, students will be able to

- apply airfoil theory to predict airfoil performance and behavior of airflow over bodies
- analyze and optimize the aircraft wing performance.
- perform the dimensional analysis in two dimensions
- analyze the problems of incompressible flow for airfoils

TEXT BOOKS

1. Anderson, J.D., 'Fundamentals of Aerodynamics', Fifth Edition, McGraw-Hill Book Co., New York, 2012.
2. Houghton E L, P. W. Carpenter, Steven H. Collicott, and Daniel T. Valentine, 'Aerodynamics for Engineering Students', Sixth Edition, Butterworth-Heinemann, 2012.

REFERENCES

1. Clancy, L.J., 'Aerodynamics', Pitman, 1986.
2. Kuethe A M and C-Y Chow, 'Foundations of Aerodynamics: Bases of Aerodynamic Design', Fifth Edition, Wiley, 1997.
3. John J. Bertin and Russell M. Cummings, 'Aerodynamics for Engineers', Sixth Edition, Pearson, 2013.

WEB LINKS

1. http://nptel.ac.in/courses/101105059/
2. http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-100-aerodynamics-fall-2005/lecture-notes/

AE16402 AIRCRAFT PROPULSION 3 0 0 3

COURSE OBJECTIVES

- To introduce basic concepts and salient features of engine components of jet propelled engines which are operated in atmosphere to students.
- To familiarize with jet propulsion components and its methods.
- To understand the performance and types of combustion chambers and nozzles.
- To study about the details of compressor of jet propulsion and hypersonic propulsion
- To infer about the working of turbines and its applications

UNIT I FUNDAMENTALS OF AIR BREATHING ENGINES 9

Classification of gas turbines – open cycle and closed cycle turbines, efficiencies - illustration of working of gas turbine engine – the thrust equation – factors affecting thrust – effect of pressure, velocity and temperature changes of air entering compressor – methods of thrust augmentation – characteristics of turboprop, turbofan and turbojet – performance characteristics.

UNIT II INLETS FOR JET ENGINES 9

Internal flow and Stall in subsonic inlets – relation between minimum area ratio and eternal deceleration ratio – diffuser performance – supersonic inlets – starting problem on supersonic inlets – shock swallowing by area. variation – Numerical problems

UNIT III COMBUSTION CHAMBERS AND NOZZLES 10

Classification of combustion chambers – combustion chamber performance – effect of operating variables on performance – flame stabilization real flow in nozzles and nozzle efficiency – losses in nozzles – equilibrium flow and frozen flow in nozzles- two phase flow in nozzles – ejector and variable area nozzles - interaction of nozzle flow with adjacent surfaces – thrust reversal- Numerical Problems

UNIT IV COMPRESSORS FOR JET ENGINES 8

Principle of operation of centrifugal compressor and axial flow compressor– Work done and pressure rise – velocity diagrams – degree of reaction – free vortex and constant reaction designs of axial flow compressor – performance characteristics of centrifugal and axial flow compressors

UNIT V TURBINES FOR JET ENGINES 9

Impulse and reaction blading of gas turbines – velocity triangles and power output – elementary theory – vortex theory – choice of blade profile, pitch and chord – estimation of stage performance – limiting factors in gas turbine design- overall turbine performance – methods of blade cooling – matching of turbine and compressor – numerical problems.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, students will be able to

- identify the engine components of jet propelled engines analyze thermodynamics of an aircraft jet engine
- estimate the best possible engine performance
- assess the internal mechanisms of gas turbine engine components
- evaluate the operating characteristics of compressors and Turbines

TEXT BOOKS

1. Hill, P.G. & Peterson, C.R. “Mechanics & Thermodynamics of Propulsion” Addison – Wesley Longman INC, 2009.
2. James Award, "Aerospace Propulsion System", wiley,2010

REFERENCES

1. Cohen, H. Rogers, G.F.C. and Saravana muttoo, H.I.H. “Gas Turbine Theory”, Longman, 2006.
2. Oates, G.C., “Aero thermodynamics of Aircraft Engine Components”, AIAA Education Series, NewYork,1985
3. Rolls Royce, "Jet Engine”, 5th Edition, Rolls Royce Technical Publications, 2015.
4. Mathur, M.L. and Sharma, R.P., “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers & Distributors, Delhi, 2010.
5. Ganesan.V, ‘Gas Turbines’, Third Edition, Tata McGraw-Hill, 2010.

WEB LINKS

1. http://nptel.ac.in/courses/101101001/
2. http://www.nptelvideos.in/2012/11/jet-aircraft-propulsion.html

AE16403 AIRCRAFT STRUCTURES I 3 2 0 4

COURSE OBJECTIVES

- To provide the students an understanding on the aircraft basic structures
- To infer about the indeterminate and determinate aircraft structural components.
- To learn about various energy methods and its applications
- To study about the column and loading functions
- To offer the design process using different failure theories

UNIT I INTRODUCTION TO AIRCRAFT STRUCTURES 15

Aircraft construction methods – Components of Semi-monocoque structure – Component loads – Stress types - Stress-strain relation – Strain-displacement relations – Equations of equilibrium – Strain tensor – Lame's constant - cubical dilation

UNIT II STATICALLY DETERMINATE AND INDETERMINATE STRUCTURE 15

Truss analysis – Method of joints – Method of sections – Clapeyron's three moment equation – Moment distribution method.

UNIT III ENERGY METHODS 15

Strain energy due to axial, bending and torsional loads – Castigliano's theorem – Maxwell's reciprocal theorem, unit load method – Application to beams, trusses, frames, rings, etc.

UNIT IV COLUMNS 15

Columns with various end conditions – Euler's Column curve – Rankine's formula – Column with initial curvature - Eccentric loading – South well plot – Beam column.

UNIT V FAILURE THEORY 15

Maximum Stress theory – Maximum Strain Theory – Maximum Shear Stress Theory – Distortion Theory - Maximum Strain energy theory – Application to aircraft Structural problems.

TOTAL PERIODS 75

COURSE OUTCOMES

At the end of this course, students will be able to

- understand different aircraft structures.
- calculate the response of statically indeterminate structures under various loading conditions.
- apply the reaction forces of structures using strain energy concept.
- create a structure to carry the given load.
- examine the structural failures using failure theories

TEXT BOOKS

1. Donaldson B.K, "Analysis of Aircraft Structures – An Introduction", 2nd Edition, Cambridge University Press.
2. Megson T.H.G, "Aircraft Structures for Engineering Students" 4th Edition, Elsevier AerospaceEngineering Series, 2007.

REFERENCES

1. Prof S K Maiti, "Advanced Strength of Materials", NPTEL, Web course, Department of Mechanical Engineering, Indian Institute of Technology, Bombay
2. John Cutler, Jeremy liber, "Understanding Aircraft Structures", 4th Edition, Wiley Balckwell publishing.
3. Lakshmi Narasaiah.G,"Aircraft Structures", BSP Books Pvt.Ltd-Hyderabad.
4. Peery D.J,"Aircraft Structures", 2nd Edition, McGraw Hill.

WEB LINKS

1. http://www.nptelvideos.in/2012/11/structural-analysis-ii.html
2. http://www.nptel.ac.in/courses/112107146/34

AE16404 AIRCRAFT SYSTEMS AND INSTRUMENTATIONS 3 0 0 3

COURSE OBJECTIVES

- To impart the knowledge of hydraulic and pneumatic systems components.
- To study the engines and its various control systems
- To gain knowledge of advance control systems and its applications
- To learn about the types of instruments and its operation including navigational instruments
- To understand about the cockpit layout of a aircraft

UNIT I CONVENTIONAL AIRCRAFT SYSTEMS 9

Conventional flight control system – Hydraulic and Pneumatic systems – Electrical Power generation and distribution system – Environmental control system – De-icing and anti-icing systems – Landing gear system – Aircraft fuel systems.

UNIT II CONVENTIONAL ENGINE CONTROL SYSTEMS 9

Fuel systems of Piston engine and Jet engine – Main engine components and functions of jet engines – Engine lubrication systems – Accessory gear box and accessories driven – Engine starting system – Main and After burner fuel control systems – Thrust reversing and Thrust vector control.

UNIT III ADVANCED TECHNOLOGY SYSTEMS 9

Autopilot system – Advanced flight control systems – Flight Management System – Communication and Navigation systems – Radar and weapon control systems – Full Authority Digital Engine Control (FADEC) system.

UNIT IV AIRCRAFT INSTRUMENTS 9

Flight instruments, Navigation and Communication instruments, Gyroscope, Accelerometers, Airspeed indicator, Mach meter, Electronic horizontal situation indicator, Horizontal situation indicator, Multi Function Display, Attitude director indicator, Primary Flight Display, Engine instruments and display – Operation and principles, Flight Data Recorder (FDR), Cockpit Voice Recorder (CVR).

UNIT V COCKPIT LAYOUT 9

Ergonomic layout – Controls and Indications – Display systems – Self test and Built-In Test Equipment (BITE) – Cockpit air-conditioning and pressurization – Challenges posed by cockpit to the designer – Failure warning system.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, students will be able to

- compare the features of various flight control systems.
- describe the principle and working of different aircraft systems.
- analyze the performance of various aircraft engine systems.
- acquire and interpret data from various aircraft instruments.
- identify the various cockpit controls.

TEXT BOOKS

1. Pallett E H J, ‘Aircraft Instruments – Principles and Applications’, Second Edition, Longman House, 1981.
2. Pallett E H J and S. Coyle, ‘Automatic Flight Control’, Fourth Edition, Blackwell Science Ltd, 1993.
3. Irwin Treager, ‘Aircraft Gas Turbine Engine Technology’, Third Edition, McGraw- Hill, 2013.

REFERENCES

1. James Powell, ‘Aircraft Radio Systems’, Shroff Publishers, 2006.
2. Ian Moir and Allan Seabridge, ‘Aircraft Systems – Mechanical, electrical and avionics subsystems integration’,Second Edition, Professional Engineering Publishing Limited, 2001.
3. Ian Moir, Allan Seabridge and Malcolm Jukes, ‘Civil Avionics Systems’, Second Edition, Wiley, 2013.
4. “General Hand Book of Airframe and Powerplant Mechanics”, U.S.Dept. of Transportation, Federal Aviation Administration, English Book Store, New Delhi, 1995.
5. Mike Tooly and David Wyatt, ‘Aircraft Communications and Navigation Systems: Principles, Maintenance and Operation’,Butterworth-Heinemann’s Series, 2007.

WEB LINKS

1. http://www.faa.gov/regulations_policies
2. http://www.niuniv.com

CH16403 ENVIRONMENTAL SCIENCE AND ENGINEERING 3 0 0 3
(COMMON TO AERO,CIVIL & MECH)

COURSE OBJECTIVES

- To understand the constituents of the environment and the precious resources in the environment.
- To study all types of ecosystems and biodiversity.
- To familiarize the role of human being in maintaining a clean and green environment.
- To analyze social issues related to environment.
- To learn about the role of population explosion, family welfare programme and value education.

UNIT I INTRODUCTION TO ENVIRONMENTAL STUDIES AND NATURAL RESOURCES 9

Environment: Definition- scope - importance – need for public awareness. Forest resources: Use –over exploitation- deforestation - case studies- mining - effects on forests and tribal people. Water resources: Use – over utilization of surface and ground water- floods – drought - conflicts over water. Mineral resources: Use – exploitation - environmental effects of extracting and using mineral resources - case studies. Food resources: World food problems - changes caused by agriculture and overgrazing - effects of modern agriculture-fertilizer-pesticide problems - water logging - salinity -case studies. Energy resources: Growing energy needs - renewable and non-renewable energy sources. Role of an individual in conservation of natural resources.

UNIT II ECOSYSTEMS AND BIODIVERSITY 9

Concept of an ecosystem: Structure and function of an ecosystem – producers - consumers -decomposers – energy flow in the ecosystem – ecological succession – food chains - food webs and ecological pyramids. Types of ecosystem: Introduction - characteristic features - forest ecosystem - grassland ecosystem - desert ecosystem - aquatic ecosystems (lakes, rivers, oceans, estuaries). Biodiversity: Introduction– definition (genetic - species –ecosystem) diversity. Value of biodiversity: Consumptive use productive use – social values – ethical values - aesthetic values. Biodiversity level: Global - national - local levels- India as a mega diversity nation- hotspots of biodiversity. Threats to biodiversity: Habitat loss poaching of wildlife – man wildlife conflicts – endangered and endemic species of India. Conservation of biodiversity: In-situ and ex-situ conservation of biodiversity.

UNIT III POLLUTION 9

Pollution: Definition –air pollution - water pollution - soil pollution - marine pollution - noise pollution - thermal pollution – nuclearhazards. Solid waste management: Causes - effects - control measures of urban and industrial wastes. Role of an individual in prevention of pollution -Disaster management: Floods – earthquake - cyclone - landslides. Electronic waste-Sources-Causes and its effects.

UNIT IV SOCIAL ISSUES AND ENVIRONMENT 9

Sustainable development: Unsustainable to sustainable development – urban problems related to energy. Water conservation - rain water harvesting - watershed management. Resettlement and rehabilitation of people. Environmental ethics: Issues - possible solutions – climate change - global warming and its effects on flora and fauna - acid rain - ozone layer depletion - nuclear accidents - nuclear holocaust. Environment protection act: Air (Prevention and Control of Pollution) act – water (Prevention and control of Pollution) act – wildlife protection act – forest conservation act – issues involved in enforcement of environmental legislation.

UNIT V HUMAN POPULATION AND ENVIRONMENT 9

Human population: Population growth - variation among nations – population explosion – family welfare programme and family planning – environment and human health – Human rights – value education – HIV / AIDS, Swine flu – women and child welfare. Role of information technology in environment and human health.

TOTAL PERIODS 45

COURSE OUTCOMES

At the end of this course, the student will be able to

- comprehend the basic concepts of environment studies and natural resources.
- discuss about ecosystem and biodiversity.
- describe the causes, effects and control measures of various types of pollution.
- explain social issues and various environmental acts.
- debate on the relationship between the human population and environment.

TEXT BOOKS

1. T.G.Jr. Miller, Environmental Science, 10thEdn, Wadsworth Publishing Co., (2004).
2. Raman Sivakumar, Introduction to Environmental Science and Engineering, 2ndEdn, Tata McGraw Hill Education Private Limited, New Delhi, (2010).
3. Benny Joseph, "Environmental Science and Engineering", Tata McGraw Hill, (2010).

REFERENCES

1. BharuchaErach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad India, 2010.
2. S. Divan, Environmental Law and Policy in India, Oxford University Press, New Delhi, 2002.
3. K.D. Wager, Environmental Management, W.B. Saunders Co., Philadelphia, USA, 1998.
4. W.P. Cunningham, Environmental Encyclopedia, JaicoPublising House, Mumbai, 2004.
5. Clair Nathan Sawyer, Perry L. McCarty, Gene F. Parkin, "Chemistry for Environmental Engineering", McGraw Hills

WEB LINKS

1. www.chegg.com
2. www.vidhyarathiplus.com

AE16405 **AERODYNAMICS LABORATORY** **0 0 4 2**

COURSE OBJECTIVES

- To familiarize the students in basic aerodynamics and use of wind tunnels.

LIST OF EXPERIMENTS

1. Flow visualization in water flow channel
2. Flow visualization in smoke tunnel
3. Plot of RPM VS test section velocity in a subsonic wind tunnel.
4. Pressure distribution over circular cylinder.
5. Pressure distribution over airfoil and estimation of C_L and C_D.
6. Force measurement using wind tunnel balance.
7. Determination of lift and drag for the given airfoil section
8. Pressure distribution over a smooth and rough circular cylinder.
9. Pressure distribution over a symmetric and cambered aerofoil.
10. Flow visualization studies in subsonic flows
11. Surface and Flow Pattern Visualization

TOTAL PERIODS 60

COURSE OUTCOMES

At the end of this course, students will be able to

- operate the wind tunnel for various models
- gain knowledge of lift , drag and pressure relation
- analyze the pressure distribution around various models

AE16406 AIRCRAFT STRUCTURES LABORATORY I 0 0 4 2

COURSE OBJECTIVES

- To experiment the load deflection characteristics of structural materials under different types of loads.

LIST OF EXPERIMENTS

1. Determination of Young's modulus of a material.
2. Determination of deflection of a simply supported beam.
3. Determination of deflection of a cantilever beam.
4. Determination of forces in statically indeterminate force system.
5. Verification of Principle of superposition
6. Verification of Maxwell's Reciprocal theorem
7. Column – Testing using various materials
8. South – well's plot.
9. Testing of Riveted Joints.
10. Determination of membrane stresses in a thin cylinder under internal pressure.

TOTAL PERIODS 60

COURSE OUTCOMES

At the end of this course, students will be able to

- know the strength of rivet and thin cylinder
- find the properties of different materials
- gain knowledge of stress variation in the deflected materials

EN16401 BUSINESS ENGLISH COURSE LABORATORY 0 0 2 1

COURSE OBJECTIVES

- To develop the reading skills of the students and to familiarize them in skimming and scanning.
- To instill the communication concepts and enhance the student's conversational skills through various practice sessions.
- To familiarize them with a variety of business correspondence.
- To develop the receptive skills such as listening and reading and to make the students well versed in the productive skills (writing and speaking).
- To assist them in improving their vocabulary and comprehension of grammar

UNIT I READING AND VOCABULARY 8

Understanding short, notices, messages - detailed comprehension of factual material- skimming and scanning skills- interpreting visual information- reading for gist and specific information - reading for grammatical accuracy and understanding of text structure - reading and information transfer.

UNIT II WRITING 7

Fixing appointments - asking for permission - giving instructions - apologizing and offering compensation - making or altering reservations - dealing with requests – giving information about a product

UNIT III LISTENING 8

Listening to short telephonic conversation - Listening to short conversation or monologue - Listening to specific information -Listening to recorded interview, discussion.

UNIT IV SPEAKING 7

Conversation between the interlocutor and the candidate -genral interaction in social contexts - A mini presentation by each candidate on a business theme - organising a larger unit of discourse - giving information and expressing opinions –to way conversation between candidates followed by further prompting from the interlocutor- Expressing opinions- agreeing and disagreeing.

TOTAL PERIODS 30

List of Experiments

1. Reading
2. Writing
3. Listening
4. Speaking

COURSE OUTCOMES

At the end of this course, students will be able to

- enrich the business vocabulary through reading.
- develop their pronunciation skills.
- Speak effectively in English in various occasions
- prepare flawless reports and proposals.
- understand and communicate as a professional

TEXT BOOKS

1. Cambridge BEC Preliminary, Self Study Edition, Cambridge University Press, New York, 2012.
2. Whitby, Norman. Business Benchmark, Pre-intermediate to intermediate, Business Preliminary, Shree Maitrey Printech Pvt. Ltd., Noida, 2014.

REFERENCES

1. Raman, Meenakshi & Sangeetha Sharma. Technical Communication: Principles and Practice Oxford University Press, New Delhi. 2011.
2. Rizvi, Ashraf. M. Effective Technical Communication. Tata McGraw-Hill, New Delhi. 2005.
3. Rutherford, Andrea. J Basic Communication Skills for Technology. Pearson, New Delhi.

WEB SOURCE

1. http://www.cambridge.org/us/cambridgeenglish/catalog/cambridge-english-exams-ielts/business-benchmark