ANNA UNIVERSITY, CHENNAI
NON- AUTONOMOUS COLLEGES AFFILIATED ANNA UNIVERSITY
M.E.AEROSPACE TECHNOLOGY
REGULATIONS 2021
CHOICEBASEDCREDITSYSTEM
I TO IV SEMESTERS CURRICULA & SYLLABI

1. PROGRAMME EDUCATIONALOBJECTIVES (PEOs):

I.	Graduates Hold positions of technical responsibility, as members or leaders of multi-disciplinary teams engaged in aerospace engineering problem solving, systems analysis, design, development, testing or research.
II.	Understanding of multicultural and global perspectives and work effectively with engineers and customers from around the world, while providing for issues such as public safety, energy efficient and product design.
III.	Have enhanced and continue to enhance their professional skills by pursuing / completing a graduate degree or other post-graduate training.

2. PROGRAMME OUTCOMES (POs):

PO#	Programme Outcomes
1	An ability to independently carry out research/investigation and development work to solve practical problems
2	An ability to write and present a substantial technical report/document
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
4	Students should know how to analyse complex engineering assets in the aerospace and aviation environment, and develop engineering, scientific and technological solutions to ensure problem-free operations.
5	An ability to develop systematic problem-solving and engineering/technological systems design methodologies operating in the industry.
6	An understanding of professional and ethical responsibility and also capable of doing doctoral studies in multidisciplinary areas.

Note: Program may add up to three additional Pos.

4. PEO/PO Mapping:

PEO	PO					
	1	**2**	**3**	**4**	**5**	**6**
I.	**2**	**-**	**3**	**3**	**2**	**-**
II.	**-**	**2**	**-**	**1**	**2**	**3**
III.	**2**	**2**	**-**	**-**	**3**	**3**
IV.						
V.						

Every programme objectives must be mapped with 1,2,3,-, scale against the correlation PO's

MAPPING–PG-AEROSPACE TECHNOLOGY

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Advanced Mathematical Methods				✓	✓	
		Space Propulsion Systems			✓	✓	✓	✓
		Aerospace Structural Analysis			✓	✓	✓	✓
		Space Vehicle Aerodynamics			✓	✓	✓	✓
		Research Methodology and IPR	✓	✓				✓
		Professional Elective-I						
		Audit course-I*						
		Launch Vehicle Aerodynamics Laboratory	✓		✓	✓	✓	
		Space Propulsion Laboratory	✓		✓	✓	✓	
	SEMESTER II	Hypersonic Aerodynamics			✓	✓		
		Orbital Mechanics			✓	✓	✓	
		Computational Modeling And Data Analysis In Aerospace Engineering	✓		✓	✓	✓	✓
		Analysis of composite structures			✓	✓		
		Professional Elective-II						
		Professional Elective-III						
		Audit course-II*						
		AerospaceStructures Laboratory	✓	✓	✓	✓		
		Computational Laboratory	✓	✓	✓	✓		
		Mini Project with Seminar	✓		✓			✓
YEAR II	SEMESTER III	Project Work I						
		Professional Elective-IV						
		Professional Elective-V						
		Open Elective						
	SEMESTER IV	Project Work II						

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I TO IV SEMESTERS CURRICULA AND SYLLABUS

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA4153	Advanced Mathematical Methods	FC	4	0	0	4	4
2.	AS4101	Space Propulsion Systems	PCC	4	0	0	4	4
3.	AS4102	Aerospace Structural Analysis	PCC	3	1	0	4	4
4.	AS4103	Space Vehicle Aerodynamics	PCC	3	0	0	3	3
5.	RM4151	Research Methodology and IPR	RMC	2	0	0	2	2
6.		Professional Elective-I	PEC	3	0	0	3	3
7.		Audit course-I*	AC	2	0	0	2	0
PRACTICAL								
8.	AS4111	Launch Vehicle Aerodynamics Laboratory	PCC	0	0	4	4	2
9.	AS4112	Space Propulsion Laboratory	PCC	0	0	4	4	2
			TOTAL	**21**	**1**	**8**	**30**	**24**

* Audit Course is optional.

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AS4251	Hypersonic Aerodynamics	PCC	3	0	0	3	3
2.	AS4201	Orbital Mechanics	PCC	3	0	0	3	3
3.	AS4202	Computational Modeling and Data Analysis in Aerospace Engineering	PCC	3	0	0	3	3
4.	AO4251	Analysis of Composite Structures	PCC	3	0	0	3	3
5.		Professional Elective - II	PEC	3	0	0	3	3
6.		Professional Elective - III	PEC	3	0	0	3	3
7.		Audit course-II*	AC	2	0	0	2	0
PRACTICAL								
8.	AS4211	Aerospace Structures Laboratory	PCC	0	0	4	4	2
9.	AS4212	Mini Project with Seminar	EEC	0	0	4	4	2
10.	AS4213	Computation Laboratory	PCC	0	0	4	4	2
			TOTAL	**20**	**0**	**12**	**32**	**24**

* Audit Course is optional.

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective -IV	PEC	3	0	0	3	3
2.		Professional Elective -V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICAL								
4.	AS4311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICAL								
1.	AS4411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE: 75

PROFESSIONAL ELECTIVE COURSES

SEMESTER I, ELECTIVE – I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AS4001	Elements of Satellite Technology	PEC	3	0	0	3	3
2.	AS4002	Cryogenic Technology	PEC	3	0	0	3	3
3.	AS4003	Introduction to Aeronautics and space Technology	PEC	3	0	0	3	3
4.	AS4004	Fundamentals of Combustion	PEC	3	0	0	3	3
5.	AS4072	Computational Heat Transfer	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE – II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AS4005	Missile Aerodynamics	PEC	3	0	0	3	3
2.	AS4006	Spacecraft Attitude Dynamics and Control	PEC	3	0	0	3	3
3.	AS4007	Chemical Rocket Technology	PEC	3	0	0	3	3
4.	AS4071	Aerospace Materials	PEC	3	0	0	3	3
5.	AS4008	Space Vehicle Design	PEC	3	0	0	3	3
6.	AS4009	Theory of Plates and Shells	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE – III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AS4010	Missile Guidance and Control	PEC	3	0	0	3	3
2.	AO4075	Theory of Boundary Layers	PEC	3	0	0	3	3
3.	AO4252	Finite Element Analysis	PEC	3	0	0	3	3
4.	AO4071	Fatigue and Fracture Mechanics	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE – IV

SL. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AO4076	Vibration Isolation and Control	PEC	3	0	0	3	3
2.	AO4073	Non-Destructive Evaluation	PEC	3	0	0	3	3
3.	AS4011	Plasma Engineering	PEC	3	0	0	3	3
4.	AS4012	Rocket and Missile Systems	PEC	3	0	0	3	3
5.	AS4013	Electric Propulsion Systems	PEC	3	0	0	3	3
6.	AO4077	Theory of Vibrations	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE – V

SL. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AS4014	Manned Space Missions	PEC	3	0	0	3	3
2.	AS4015	High Temperature Gas Dynamics	PEC	3	0	0	3	3
3.	AO4072	High Speed Jet Flows	PEC	3	0	0	3	3
4.	AO4074	Smart Materials and Structural Health Monitoring	PEC	3	0	0	3	3
5.	AS4016	Unmanned Aerial Systems	PEC	3	0	0	3	3
6.	AS4017	Reliability and Quality	PEC	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	AX4091	English for Research Paper Writing	2	0	0	0
2.	AX4092	Disaster Management	2	0	0	0
3.	AX4093	Constitution of India	2	0	0	0
4.	AX4094	நற்றமிழ் இலக்கியம்	2	0	0	0

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AS4212	Mini Project with Seminar	0	0	4	2	2
2.	AS4311	Project Work - I	0	0	12	6	3
3.	AS4411	Project Work-II	0	0	24	12	4

LIST OF OPEN ELECTIVES FOR PG PROGRAMMES

SL. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	OCE431	Integrated Water Resources Management	3	0	0	3
2.	OCE432	Water, Sanitation and Health	3	0	0	3
3.	OCE433	Principles of Sustainable Development	3	0	0	3
4.	OCE434	Environmental Impact Assessment	3	0	0	3
5.	OIC431	Blockchain Technologies	3	0	0	3
6.	OIC432	Deep Learning	3	0	0	3
7.	OBA431	Sustainable Management	3	0	0	3
8.	OBA432	Micro and Small Business Management	3	0	0	3
9.	OBA433	Intellectual Property Rights	3	0	0	3
10.	OBA434	Ethical Management	3	0	0	3
11.	ET4251	IoT for Smart Systems	3	0	0	3
12.	ET4072	Machine Learning and Deep Learning	3	0	0	3
13.	PX4012	Renewable Energy Technology	3	0	0	3
14.	PS4093	Smart Grid	3	0	0	3
15.	CP4391	Security Practices	3	0	0	3
16.	MP4251	Cloud Computing Technologies	3	0	0	3
17.	IF4072	Design Thinking	3	0	0	3
18.	MU4153	Principles of Multimedia	3	0	0	3
19.	DS4015	Big Data Analytics	3	0	0	3
20.	NC4201	Internet of Things and Cloud	3	0	0	3
21.	MX4073	Medical Robotics	3	0	0	3
22.	VE4202	Embedded Automation	3	0	0	3
23.	CX4016	Environmental Sustainability	3	0	0	3
24.	TX4092	Textile Reinforced Composites	3	0	0	3
25.	NT4002	Nanocomposite Materials	3	0	0	3
26.	BY4016	IPR, Biosafety and Entrepreneurship	3	0	0	3

MA4153 ADVANCED MATHEMATICAL METHODS

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

- To attain the knowledge of solving Partial Differential Equations using Laplace transform.
- To apply Fourier Transform to solve boundary value problems.
- To achieve maxima and minima of a functional.
- To acquire knowledge on using conformal mapping to fluid flow and heat flow problems.
- To understand the tensor analysis as a tool to solve problems arising in engineering disciplines.

UNIT I LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform : Definitions – Properties – Transform error function – Bessel's function - Dirac delta function – Unit step functions – Convolution theorem – Inverse Laplace transform : Complex inversion formula – Solutions to partial differential equations : Heat equation – Wave equation.

UNIT II FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Fourier transform : Definitions – Properties – Transform of elementary functions – Dirac delta function – Convolution theorem – Parseval's identity – Solutions to partial differential equations : Heat equation – Wave equation – Laplace and Poisson's equations.

UNIT III CALCULUS OF VARIATIONS 12

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems – Direct methods – Ritz and Kantorovich methods.

UNIT IV CONFORMAL MAPPING AND APPLICATIONS 12

Introduction to conformal mappings and bilinear transformations – Schwarz Christoffel transformation – Transformation of boundaries in parametric form – Physical applications : Fluid flow and heat flow problems.

UNIT V TENSOR ANALYSIS 12

Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation – Gradient - Divergence and curl.

TOTAL : 60 PERIODS

COURSE OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Application of Laplace and Fourier transforms to initial value, initial–boundary value and boundary value problems in Partial Differential Equations.
- Maximizing and minimizing the functional that occur in various branches of Engineering Disciplines.
- Construct conformal mappings between various domains and use of conformal mapping in studying problems in physics and engineering particularly to fluid flow and heat flow problems.
- Understand tensor algebra and its applications in applied sciences and engineering and develops ability to solve mathematical problems involving tensors.
- Competently use tensor analysis as a tool in the field of applied sciences and related fields.

REFERENCES :

1. Andrews L.C. and Shivamoggi, B., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolc, L.D., "Calculus of Variations", Dover Publications Inc., New York, 2007.
3. Mathews, J. H., and Howell, R.W., "Complex Analysis for Mathematics and Engineering", 6th Edition, Jones and Bartlett Publishers, 2012.
4. Kay, D. C., "Tensor Calculus", Schaum's Outline Series, Tata McGraw Hill Edition, 2014.
5. Naveen Kumar, "An Elementary Course on Variational Problems in Calculus ", Narosa Publishing House, 2005.
6. Saff, E.B and Snider, A.D, "Fundamentals of Complex Analysis with Applications in Engineering, Science and Mathematics", 3rd Edition, Pearson Education, New Delhi, 2014.
7. Sankara Rao, K., "Introduction to Partial Differential Equations", 3rd Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2010.
8. Spiegel, M.R., "Theory and Problems of Complex Variables and its Applications", Schaum's Outline Series, McGraw Hill Book Co., 2009.
9. Ramaniah. G. "Tensor Analysis", S. Viswanathan Pvt. Ltd., 1990.

AS4101	SPACE PROPULSION SYSTEMS	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES:

This course will enable students

1. To impart knowledge on the basic concepts of space propulsion.
2. To learn about the physics of ionized gases.
3. To get familiarize with the types of nuclear rockets and the basic concepts of nuclear propulsion systems.
4. To study about the radioisotope propulsion.
5. To realise the importance of advanced space propulsion concepts.

UNIT I INTRODUCTION TO SPACE PROPULSIONSYSTEMS 12

Historical outline, Scramjet Propulsion-Scramjet Inlets; Scramjet Performance, Chemical rocket Propulsion-Tripropellants; Metalized Propellants; Free Radical Propulsion, Electric Propulsion, Micropropulsion-Micropropulsion Requirements, MEMS and MEMS- Hybrid Propulsion Systems.

UNIT II BASIC CONCEPTS OF IONIZED GASES 12

Electromagnetic theory: electric charges and fields, currents, and magnetic fields, and applications to ionized gases. Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas – Electrical conductivity of an ionized gas - Kinetic Theory, Introduction to plasma physics- Electrode phenomena.

UNIT III NUCLEAR ROCKET PROPULSION 12

Nuclear Rocket Engine Design and Performance, Types of Nuclear Rockets, Overall Engine Design, Nuclear Rocket Performance, Component Design, Nuclear Rocket Reactors, General Design Considerations, Reactor Core Materials, Thermal Design, Mechanical Design, Nuclear Design, Shielding, Nuclear Rocket Nozzles, General Design Considerations, Heat-Transfer Analysis, Over-all Problem, Hot-Gas Boundary, Cold-Gas Boundary.

UNIT IV RADIOISOTOPE PROPULSION 12

Alternative Approaches, Direct Recoil Method, Thermal Heating Method, Basic Thruster Configurations, Propulsion System and Upper Stage, Relative Mission Capabilities, Primary Propulsion, Auxiliary Propulsion, Thruster Technology, Design Criteria, Performance, Safety, Heat Source Development, Radioisotope Fuel, Capsule Technology, General Considerations, Thermal Design, Fabrication and Non-Destructive Testing Techniques, Pressure Containment, Heat Source Simulation, Oxidation and Corrosion of Encapsulating Materials, Nozzle Performance.

UNIT V ADVANCED SPACE PROPULSION CONCEPTS 12

Introduction, General Consideration for Propulsion in Space, Power Supply, Propellant Storage and Handling Facilities, Electrostatic and Electromagnetic Thrusters, Advanced Electric Propulsion Systems for Space Vehicles, Sputtering, A Thrust Generation Mechanism, Sputtering Phenomena, Possible Performance of Sputtering Thrusters, Energy Efficiency of the Sputtering Process, Analyses of an Elementary Mission with Different Electric Thrusters, General Consideration, Performance Formula for Electric Thrusters, Optimization with Electric Thrusters

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Have knowledge on the basics and classification of space propulsion.

CO2: Comprehend the physics of ionized gases, their theories and particle collisions.

CO3: Demonstrate the working, types and performance of nuclear rockets with their design considerations.

CO4: Learn the basics of radioisotope propulsion with their performance studies.

CO5: Have knowledge on advanced methods of space propulsion systems with new thrust generation mechanisms.

REFERENCES:

1. Czysz**,** Paul A., Bruno**,** Claudio, Chudoba, Bernd “Future Spacecraft Propulsion Systems and Integration”, Springer, Praxis Publishing Ltd, 2018.
2. George W. Sutton, “Engineering Magneto hydrodynamics”, Dover Publications Inc., New York, 2006.
3. George P. Sutton & Oscar Biblarz, “Rocket Propulsion Elements, John Wiley & Sons Inc., NewYork, 9th Edition, 2016.
4. Martin Tajmar, “Advanced Space Propulsion Systems” Springer Verlag GmbH, 2003.
5. Robert G. Jahn, “Physics of Electric Propulsion”, McGraw-Hill Series, New York, 1968.
6. William J. Emrich, “Principles of Nuclear Rocket Propulsion” Elsevier Science, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	-	-
CO2	2	1	1	2	-	-
CO3	2	1	2	2	2	-
CO4	2	1	2	2	2	-
CO5	2	1	2	2	2	-

AS4102 **AEROSPACE STRUCTURAL ANALYSIS** **L T P C**
3 1 0 4

COURSE OBJECTIVES:

This course will enable students

1. To learn the important technical aspects on theory of bending.
2. To find the shear flow distribution and to locate the shear centre for open and closed sections.
3. To analyse the stability problems involved in aircraft structural components under various modes of loadings.
4. To impart knowledge on how to analyze aircraft structural components under various forms of loading.
5. To gain knowledge on the spacecraft structures and materials used.

UNIT I BENDING OF BEAMS 9+3

Elementary theory of pure bending – Stresses in beams of symmetrical and unsymmetrical sections - Box beams – Generalized theory of bending – Methods of bending stress determination – Principal axes method – Neutral axis method – 'k' method – Deflection of unsymmetrical beams – Stresses in Composite Beams – Deflection of Sandwich Beams – Design Principles.

UNIT II SHEAR FLOW ANALYSIS 9+3

Concept of shear flow in thin walled open & closed sections – Determination of the shear centre in symmetrical and unsymmetrical cross-sections – Flexural shear flow in multi-flange box beams – Shear flow due to combined bending & torsion in closed sections – Torsion of thin-walled open section members – Stress analysis of aerospace components – Tapered wing spar.

UNIT III DESIGN OF COMPRESSION MEMBERS 9+3

Analysis of solid columns – Governing Equations – Critical Loads & Buckled Modes – Thin-walled Compressions Members – Stability Analysis – Design Criterion – Buckling of sheets under compression – Plate buckling coefficient – Inelastic buckling of plates – Sheet-stiffener panels – Effective width – Failure stress in plates and stiffened panels – Local Buckling – Crippling Load Estimation.

UNIT IV ANALYSIS OF AEROSPACE STRUCTURAL COMPONENTS 9+3

Loads on an aircraft – Aerodynamic loads – Manoeuvre loads – Load factor determination – The flight envelope – Shear force, bending moment and torque distribution along the span of the wing and fuselage – Structural parts of wing and fuselage and their functions – Introduction to aeroelasticity – Sources of launch vehicles loads – Launch vehicle categories – Load and acceleration time-line profile.

UNIT V REQUIREMENTS OF SPACECRAFT STRUCTURES 9+3

Introduction & General Aspects – The Satellite Primary Structure – Load Classification – Typical Requirements – Strength – Failure Theories – Buckling – Sources of Vibration – Frequency Limits – Stiffness, Damping & Mass Distribution – Satellite Vibration Analysis – Response Spectrum – Design Requirements – Materials Used for Construction – Mechanical Interfaces.

L : 45, T : 15, TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1: Apply the concept of normal stress variation on unsymmetrical sections subjected to bending moments on practical problems.

CO2: Find the shear flow variation in thin walled open sections with skin effective and ineffective in bending.

CO3: Evaluate the shear flow variation in single cell and multi-cell tubes subjected to shear and torque loads.

CO4: Analyse the behaviour of buckling of simply supported plates and also to know the effective width of sheet stringers combination.

CO5: Analyse and design structural members subject to compression.

REFERENCES:

1. Bruce.K.Donaldson, “Analysis of Aircraft Structures: An Introduction”, Cambridge University Press, 2nd edition, 2008.
2. Bruhn. EF, “Analysis and Design of Flight Vehicle Structures”, Tristate Offset Co, 1980.
3. Megson, TMG, “Aircraft Structures for Engineering Students”, Elsevier Aerospace Engineering Series, 5th Edition, 2012.
4. Peery, DJ and Azar, JJ, “Aircraft Structures”, 2nd Edition, McGraw-Hill, New York, 1993.
5. Rivello, RM, “Theory and Analysis of Flight Structures”, McGraw-Hill, N.Y., 1993.
6. Sun. CT, “Mechanics of Aircraft Structures”, Wiley publishers, 3rd edition, 2021.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	3	-	-
CO2	2	1	1	3	-	-
CO3	2	1	1	3	2	-
CO4	2	1	1	3	2	-
CO5	2	1	1	3	2	-

AS4103 SPACE VEHICLE AERODYNAMICS L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enable students to

1. Gain knowledge on the basics of low speed aerodynamics
2. Learn the physics involved in compressible flows.
3. Provide enough knowledge on boundary layers and their interactions.
4. Impart knowledge on the aerodynamic characteristics of missile components.
5. Gain an idea about aerodynamic heating phenomena.

UNIT I BASICS OF INCOMPRESSIBLE FLOW 9

Aerodynamic forces and moments - Centre of pressure - Aerodynamic centre - Continuity equation - Momentum equation - Stream function - Potential function - Elementary flows - Flow over cylinder, sphere and cones – Kutta Joukowski theorem– Kutta Joukowski Transformations and its applications.

UNIT II COMPRESSIBLE FLOWS 9

Compressibility - Speed of sound - Normal shock - Oblique shock - Expansion fan - Shock Expansion Theory - Unsteady shock waves - Fanno flow - Rayleigh flow - Wave drag- Crocco's Theorem - Method of characteristics .

UNIT III BOUNDARY LAYER THEORY 9

Laminar boundary layer - Turbulent boundary layer – Prandtle mixing length theory, Velocity distribution loss - Skin friction drag estimation - Shock wave-boundary layer interactions – Thermal Boundary Layer – Exact and Approximate solutions to thermal Boundary Layer flows.

UNIT IV AERODYNAMIC CHARACTERISTICS OF MISSILES 9

Airframe components of missiles - Forebody shapes - Prediction of component characteristics - Wing planform for missiles Delta wing - Vortex break down - Compressibility effect on delta wing - Wing-body interference effects - Transonic and Supersonic drag reduction methods - Fin drag - Body drag.

UNIT V AERODYNAMIC HEATING 9

Heat transfer process - Basic parameters in aerodynamic heating - Reference temperature method - Aerodynamic heating on conical surfaces - Variable entropy effects - Heat transfer across junctures - Non isothermal wall effects - Swept shock interactions - Application of methodology in practical missile design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will

CO1: Have through knowledge on the concepts of incompressible aerodynamics.

CO2: Be able to analyse practical problems involving Fanno and Rayleigh flow and also flow affecting phenomena.

CO3: Have knowledge on the concepts of laminar and turbulent boundary layer flows and their interaction with shock waves and thermal effects.

CO4: Able to demonstrate and analyse different configurations of missiles and their characteristics.

CO5: Be able to design efficient re-entry vehicles by solving the problem of aerodynamic heating.

REFERENCES:

1. Anderson, JD, “Fundamentals of Aerodynamics”, McGraw-Hill Book Co, 6th edition 2017.
2. Chin SS, “Missile Configuration Design”, Mc GrawHill, 1961.
3. Hermann Schlichting, “Boundary Layer Theory”, Springer, 9th edition, 2017.
4. Michael Mendenhall, “Tactical Missile Aerodynamics: Prediction Methodology, Progress in Astronautics and Aeronautics”, 1992.
5. Nielson, JackN, Stever, Gutford, “Missile Aerodynamics”, McGraw Hill, 1960.
6. Anderson, JD, “Modern Compressible Flows”, McGraw-Hill Book Co, 2010

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2	-	-
CO2	2	1	2	2	-	-
CO3	3	1	2	3	2	-
CO4	3	1	2	3	2	-
CO5	3	1	2	2	-	-

RM4151 RESEARCH METHODOLOGY AND IPR L T P C
2 0 0 2

UNIT I RESEARCH DESIGN 6

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II DATA COLLECTION AND SOURCES 6

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III DATA ANALYSIS AND REPORTING 6

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT IV INTELLECTUAL PROPERTY RIGHTS 6

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT V PATENTS **6**

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL : 30 PERIODS

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

AS4111 LAUNCH VEHICLE AERODYNAMICS LABORATORY **L T P C**
0 0 4 2

COURSE OBJECTIVES:

This laboratory course will enables students

1. To get exposure with a practical knowledge on various aerodynamic principles related to inviscid incompressible fluids.
2. To have a practical exposure on Aerodynamic measurement techniques.
3. To do testing of sub systems and components of aircraft at low speed.
4. To measure force and moments on missile models.
5. To calibrate subsonic and supersonic wind tunnels.

LIST OF EXPERIMENTS:

1. Calibration of subsonic wind tunnel
2. Pressure distribution on a swept wing model
3. Pressure distribution on nose cone model at subsonic speeds
4. Pressure distribution on a sphere model
5. Force and moment measurements on D model using wind tunnel balance
6. Base drag measurements on missile model
7. Pressure distribution on backward step model
8. Thermal boundary layer measurements over a flat plate
9. Calibration of supersonic wind tunnel
10. Wall pressure measurements over a circular cone in a Supersonic flow
11. Wall pressure measurements on a semi wedge in a supersonic flow
12. Flow visualization of a bow shock in front of a bluff body
13. Flow visualization of shock boundary layer interaction
14. Wall pressure measurements in single expansion ramp nozzle

TOTAL: 60 PERIODS

Any 10 Experiments will be conducted.

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To operate and calibrate subsonic and supersonic wind tunnel

CO2: To comprehend the pressure distribution over the streamlined and bluff bodies.

CO3: To measure force and moments on aircraft models

CO4: To measure boundary layer thickness for various models

CO5: To carry out flow visualization at subsonic speeds.

LABORATORY EQUIPMENTS REQUIREMENTS

1. Subsonic wind tunnel
2. Supersonic wind tunnel
3. Wind tunnel balance
4. Schlieren system
5. Pressure Transducers/ pressure scanner
6. Models for testing cone, wedge, bluff body, swept wind, missile, D model and SERN.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

AS4112 **SPACE PROPULSION LABORATORY** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

This course will enable students to

1. Visualize the shock pattern in supersonic flows
2. Provides an idea of wall pressure distribution on subsonic and supersonic inlets and nozzles.
3. Perform testing on compressor blades and basic knowledge on cold flow studies.
4. Develop ability to analyze and interpret the experimental data using software.
5. Perform experiments on cavity models.

LIST OF EXPERIMENTS:

1. Flow visualization of a secondary injection in a supersonic flow
2. Flow visualization of shock system in front of a supersonic inlet
3. Wall pressure measurements in a supersonic nozzle
4. Wall pressure measurements in a supersonic diffuser
5. Total pressure measurements in the radial direction of a supersonic circular jet
6. Total pressure measurements along the jet axis of a circular supersonic jet
7. Cold flow studies of a wake region behind flame holders
8. Wall pressure measurements of a noncircular combustor
9. Wall pressure measurements of a subsonic diffuser
10. Cascade testing of compressor blades.
11. Pressure distribution on cavity model with injections.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, student will be able

CO1: To perform wall pressure distribution on subsonic and supersonic nozzles

CO2: To acquire knowledge on fundamental concepts of low speed and high speed jets and experimental techniques pertains to measurements.

CO3: To gain adequate knowledge on pressure distribution on cavity models

CO4: To have exposure on wake survey methods.

CO5: To carry out flow visualization at supersonic speeds.

LABORATORY EQUIPMENTS REQUIREMENTS

1. Supersonic nozzle and supersonic diffuser
2. Total pressure probes
3. Symmetrical Cambered aerofoil
4. Models of flame holders and non circular combustor
5. Traversing mechanism (at least 2-D)
6. Pressure Transducers/ pressure scanner
7. Cascade model for compressor blades
8. Multitube manometers

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	-	-	-
CO2	3	2	-	-	-	-
CO3	3	2	-	-	-	-
CO4	3	2	-	-	-	-
CO5	3	2	-	-	-	-

AS4251 **HYPERSONIC AERODYNAMICS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To realise the importance of studying the peculiar hypersonic speed flow characteristics pertaining to flight vehicles.
2. To provide knowledge on various surface inclination methods for hypersonic inviscid flows.
3. To arrive at the approximate solution methods for hypersonic flows.
4. To impart knowledge on hypersonic viscous interactions.
5. To impart knowledge on the effect on aerodynamic heating on hypersonic vehicles.

UNIT I INTRODUCTION TO HYPERSONIC AERODYNAMICS 9

Peculiarities of Hypersonic flows - Thin shock layers – entropy layers – low density and high density flows – hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows – velocity vs altitude map for hypersonic vehicles.

UNIT II SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS 8

Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge tangent cone and shock expansion methods – Calculation of surface flow properties – practical application of surface inclination methods – hypersonic independence principle.

UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS 10

Assumptions in approximate methods hypersonic small disturbance equation and theory – Maslen''s theory– blast wave theory – hypersonic equivalence principle- entropy effects - rotational method of characteristics - hypersonic shock wave shapes and correlations.

UNIT IV VISCOUS HYPERSONIC FLOW THEORY 10

Peculiarities of hypersonic boundary layers - boundary layer equations r – hypersonic boundary layer theory and non similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating – heat flux and skin friction estimation.

UNIT V VISCOUS INTERACTIONS AND TRANSITION 8

Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Parameters affecting hypersonic boundary layer transition - Estimation of hypersonic boundary layer transition- Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will

CO1: Be able to arrive at the solution for problems involving inviscid and viscous hypersonic flows.

CO2: Have thorough knowledge on high temperature effects in hypersonic aerodynamics.

CO3: Be able to arrive at various solution methods to overcome aerodynamic heating problem on hypersonic vehicles.

CO4: To gain ideas on the design issues associated with hypersonic vehicles.

CO5: Able to realize the importance and use of the relevant equations for viscous hypersonic flows.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓	
CO5	✓	✓	✓	✓		

REFERENCES:

1. Anderson, JD, "Hypersonic and High Temperature Gas Dynamics", AIAA Education Series, 2nd edition, 2006.
2. Anderson, JD, "Modern compressible flow: with Historical Perspective", McGraw Hill Education, 3rd edition, 2017.
3. William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAA Education Series, 1994.
4. John T. Bertin, Hypersonic Aerothermodynamics, AIAA Education Series, 1993.

AS4201 **ORBITAL MECHANICS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To have a basic knowledge on the peculiarities of space environment and to realize the importance of manned space missions.
2. To get introduced with the characteristics of various orbits and the importance of orbital elements.
3. To get familiarize with the basic aspects of satellite injection and the types of satellite perturbations.
4. To compute trajectory for interplanetary travel and flight of ballistic missiles based on the fundamental concepts of orbital mechanics.
5. To provide basic knowledge on the ballistic missile trajectories.

UNIT I SPACE ENVIRONMENT9

Peculiarities of space environment and its description– effect of space environment on materials of spacecraft structure and astronauts- manned space missions – effect on satellite life time.

UNIT II CHARACTERISTICS OF VARIOUS ORBITS9

Properties of elliptic, Parabolic and hyperbolic properties in terms of orbital elements – relations between position and time – Barker's theorem – Whittaker's theory – Sphere of influence.

UNIT III SATELLITE INJECTION AND SATELLITE PERTURBATIONS9

General aspects of satellite injection – satellite orbit transfer – various cases – orbit deviations due to injection errors – special and general perturbations – Cowell's method and Enake's method – method of variations of orbital elements – general perturbations approach.

UNIT IV INTERPLANETARY TRAJECTORIES9

Two-dimensional interplanetary trajectories – fast interplanetary trajectories – three dimensional interplanetary trajectories – launch of interplanetary spacecraft – trajectory estimation about the target planet – concept of sphere of influence – Lambert's theorem.

UNIT V BALLISTIC MISSILE TRAJECTORIES9

Introduction to ballistic missile trajectories – boost phase – the ballistic phase – trajectory geometry – optimal flights – time of flight – re-entry phase – the position of impact point – influence coefficients.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able

CO1: To acquire knowledge on the peculiarities of space environment and its effect on spacecraft materials.

CO2: To estimate the time and position of an object in various orbits.

CO3: To acquire knowledge on the basic concepts of satellite injection and satellite perturbations.

CO4: To calculate orbital parameters and to perform conceptual trajectory designs for geocentric or interplanetary missions.

CO5: To estimate the time of flight and the position of impact point of ballistic missiles.

REFERENCES:

1. Cornelisse, JW, Schoyer, HFR &Wakker, KF, “Rocket Propulsion and Space Dynamics”, Pitman Publishing, 1979.
2. Howard D.Curtis, “Orbital Mechanics for Engineering Students”, 3rd Edition, Butterworth-Heinemann, 2013.
3. Parker, ER, “Materials for Missiles and Spacecraft”, Mc.Graw Hill Book Co. Inc., 1982.
4. Suresh. BN & Sivan. K, “Integrated Design for Space Transportation System”, Springer India, 2015.
5. Sutton, G.P. “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th Edition, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓	✓		
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓	✓		

AS4202 COMPUTATIONAL MODELING AND DATA ANALYSIS IN AEROSPACE ENGINEERING **L T P C 3 0 0 3**

COURSE OBJECTIVES:

This course will make the students

1. To get familiarize with the procedure to obtain numerical solution to fluid dynamic problems.
2. To gain knowledge on the important aspects of grid generation for practical problems.
3. To get exposure on time dependant and panel methods.
4. To understand the use of computation to understand real world phenomena.
5. To learn the data analysis techniques and its applications to space science.

UNIT I NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS 9

Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, mathematical properties of fluid dynamic equations and classification of partial differential equations - Finding solution of a simple gas dynamic problem, Local similar solutions of boundary layer equations, Numerical integration and shooting technique. Numerical solution for CD nozzle isentropic flows and local similar solutions of boundary layer equations-Panel methods.

UNIT II GRID GENERATION 9

Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation – importance of grid control functions – boundary point control – orthogonality of grid lines at boundaries. Elliptic grid generation using Laplace’s equations for geometries like aerofoil and CD nozzle.Unstructured grids, Cartesian grids, hybrid grids, grid around typical 2D and 3D geometries – Overlapping grids – Grids around multi bodies.

UNIT III TIME DEPENDENT METHODS 9

Stability of solution, Explicit methods, Time split methods, Approximate factorization scheme, Unsteady transonic flow around airfoils. Some time dependent solutions of gas dynamic problems. Numerical solution of unsteady 2-D heat conduction problems using SLOR methods.

UNIT IV INTRODUCTION TO DATA ANALYSIS 9

An introduction to probability theory-the modeling and analysis of probabilistic systems and elements of statistical inference - Probabilistic models - conditional probability. Discrete and continuous random variables

UNIT V DATA ANALYSIS IN AEROSPACE APLICATIONS 9

Expectation and conditional expectation, and random variables - Limit Theorems - Bayesian estimation and hypothesis testing - Elements of classical statistical inference - Bernoulli and Poisson processes - Markov chains.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able

CO1: To arrive at the numerical solutions to boundary layer equations.
CO2: To perform numerical grid generation and have knowledge about the mapping techniques.
CO3: To familiarise himself/herself with high performance computing for CFD applications.
CO4: To implement the explicit time dependent methods and their factorization schemes.
CO5: To do the stability analysis and linearization of the implicit methods.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

REFERENCES:

1. Bose. TK, “Numerical Fluid Dynamics”,Narosa Publishing House, 2001.
2. Chung. TJ, “Computational Fluid Dynamics”, Cambridge University Press, 2010.
3. Hirsch,AA, “Introduction to Computational Fluid Dynamics”, McGraw-Hill, 1989.
4. John D. Anderson, “Computational Fluid Dynamics”, McGraw Hill Education, 2017.
5. Anil Maheshwari, Data Analytics, McGraw Hill Education; First edition, 2017
6. Erwin Kreysig, Advanced Engineering Mathematics Wiley 2015.

AO4251 ANALYSIS OF COMPOSITE STRUCTURES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

This course will make students

1. To impart knowledge on the macro mechanics of composite materials.
2. To determine stresses and strains in composites and also imparts an idea about the manufacturing methods of composite materials.
3. To get an idea on failure theories of composites.
4. To provide the basic knowledge on the properties of fibre and matrix materials used in commercial composites as well as some common manufacturing techniques.
5. To gain knowledge on the basic concepts of acoustic emission technique.

UNIT I FIBERS, MATRICES, AND FABRICATION METHODS 9

Production & Properties of Glass, Carbon and Aramid Fibers – Thermosetting and Thermoplastic Polymers – Polymer Properties of Importance to the Composite, Summary of Fabrication Processes – Scope of Composite Materials for Various Aerospace Application.

UNIT II MICROMECHANICS OF A UNIDIRECTIONAL COMPOSITE 9

Volume and Weight Fractions in a Composite Specimen – Longitudinal Behaviour of Unidirectional Composites – Load Sharing – Failure Mechanism and Strength – Factors Influencing Longitudinal Strength and Stiffness – Transverse Stiffness· and Strength – Prediction of Elastic Properties Using Micromechanics –Typical Unidirectional Fiber Composite Properties – Minimum and Critical Fiber Volume Fractions.

UNIT III MACROMECHANICS APPROACH 9

Stress Analysis of an Orthotropic Lamina-Hooke's Law-Stiffness and Compliance Matrices - Specially Orthotropic Material-Transversely Isotropic Material & Specially Orthotropic Material under Plane Stress-Determination of E_x, E_y, G_{xy}-Stress & Strain Transformations-Transformation of Stiffness and Compliance Matrices-Strengths of an Orthotropic Lamina Using Different Failure Theories.

UNIT IV ANALYSIS OF LAMINATED COMPOSITES 10

Laminate Strains - Variation of Stresses in a Laminate - Resultant Forces and Moments - Synthesis of Stiffness Matrix - Laminate Description System - Construction and Properties of Special Laminates - Symmetric Laminates – Balanced Laminate - Cross-Ply, and Angle-Ply Laminates - Quasi-isotropic Laminates - Determination of Laminae Stresses and Strains – Determination of Hygrothermal Stresses - Analysis of Laminates after Initial Failure.

UNIT V ANALYSIS OF LAMINATED PLATES AND BEAMS 8

Governing Equations For Laminated Composite Plates -- Governing Equations for Laminated Beams -Application of Theory – Bending, Buckling and Vibration of Laminated Beams and Plates repair-Analysis of sandwich construction-AE technique.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To calculate the elastic and strength properties of unidirectional laminates using micromechanics theory.

CO2: To analyze a composite laminate using the different failure theories.

CO3: To select the most appropriate manufacturing process for fabricating composite components.

CO4: To demonstrate understanding of the different materials (fibres, resins, cores) used in composites.

CO5: To gain knowledge on non-destructive inspection (NDI) and structural health monitoring of composites.

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
	1	**2**	**3**	**4**	**5**	**6**
CO1	2		2		3	1
CO2	2		2		3	1
CO3			2		2	1
CO4			2		2	1
CO5			2		1	1
	0.8	0	2	0	2.2	1

REFERENCES:

1. Agarwal, BD and Broutman, LJ, “Analysis and Performance of Fibre Composites”, John Wiley & Sons, 3rd edition, 2006.
2. Allen Baker, “Composite Materials for Aircraft Structures”, AIAA Series, 2nd Edition, 2004.
3. Autar K Kaw, “Mechanics of Composite Materials”, CRC Press, 2nd edition, 2005.
4. Calcote, LR, “The Analysis of laminated Composite Structures”, Von – Nostrand Reinhold Company, New York, 1998.
5. Isaac M. Daniel &Orilshai ,“Mechanics of Composite Materials”, OUP USA publishers, 2nd edition, 2005.
6. Lubing, “Handbook on Advanced Plastics and Fibre Glass”, Von Nostran Reinhold Co., New York, 1989.

AS4211 **AEROSPACE STRUCTURES LABORATORY** **L T P C**

0 0 4 2

COURSE OBJECTIVES:

This laboratory course will make students

1. To impart practical knowledge on calibration of photoelastic materials.
2. To determinethe elastic constant for composite lamina,
3. To find the symmetrical and unsymmetrical bending of beams.
4. To determine the shear centre locations for closed and open sections.
5. To find the buckling of columns with different end conditions.

LIST OF EXPERIMENTS:

1. Symmetrical & Unsymmetrical Bending of Beams
2. Buckling of Columns with Different End Conditions
3. Shear Centre Location of Thin-Walled Beams
4. Influence Coefficients & Flexibility Matrix Determination
5. Stresses Due to Combined Loading
6. Calibration of Photo Elastic Materials / Experiments in Photoelasticity
7. Experimental Modal Analysis / Free Vibration Tests
8. Resonance Testing of Structural Parts
9. Fabrication of Composite Laminates
10. Mechanical Testing & Characterization of Composite Material
11. Non-Destructive Characterization of Materials
12. Non-Destructive Evaluation of Flaws using Acoustic Emission / Ultrasonics
13. Modelling and Static Analysis of an Aircraft Component using FE software
14. Fatigue Testing and Inspection of Failure Surface

NOTE: Any TEN experiments will be conducted out of 14.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, a student will be able

CO1: To conduct tests on beams and columns.

CO2: To design an experimental evaluation technique for a given application.

CO3: To carry out non-destructive testing.

CO4: To fabricate a composite laminate and characterize it.

To carry out structural analysis using finite element software.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓										
CO2	✓	✓										
CO3	✓	✓										
CO4	✓	✓										
CO5	✓	✓										

LABORATORY EQUIPMENTS REQUIREMENTS

1. Constant strength beam setup
2. Column setup
3. Unsymmetrical Bending setup
4. Experimental setup for location of shear centre (open & close section)
5. Cantilever beam setup
6. Experimental setup for bending and torsional loads
7. Diffuser transmission type polariscope with accessories
8. Experimental setup for vibration of beams
9. Universal Testing Machine
10. Wagner beam setup

AS4212	MINI PROJECT WITH SEMINAR	L T P C 0 0 4 2

Seminar is to be given by the student after the completion of a mini project chosen by the student. Topics for the mini projects can be from the aeronautical engineering and allied fields. The mini project can be based on either numerical or analytical solution or design or fully experimental; or a combination of these tasks.

TOTAL : 60 PERIODS

AS4213	COMPUTATION LABORATORY (Consists of FEM & CFD experiments)	L T P C 0 0 4 2

COURSE OBJECTIVES:

1. This course is intended to make students familiar with different types of structural analysis using finite element software
2. This course helps students to correctly interpret the results of simulation.
3. To equip with the knowledge base essential for application of computational fluid dynamics to engineering flow problems.
4. To provide the essential numerical background for solving the partial differential equations governing the fluid flow.
5. To develop students' skills of using a commercial software package

EXPERIMENTS IN FEM

LIST OF EXPERIMENTS:

1. Static analysis of a uniform bar subject to different loads -1-D element
2. Thermal stresses in a uniform and tapered member - 1-D element
3. Static analysis of trusses / frames under different loads
4. Stress analysis & deformation of a beam using 1-D element & 2-D – incorporation of discrete, distributed, and user-defined loads
5. Static analysis of a beam with additional spring support
6. Stress concentration in an infinite plate with a small hole
7. Bending of a plate with different support conditions
8. Stability analysis of a plate under in-plane loads
9. Buckling of solid and thin-walled columns under different end conditions
10. Free vibration analysis of a bar / beam
11. Forced response of a bar / beam under harmonic excitation
12. Heat transfer analysis using 1-D & 2-D elements - conduction and convection
13. Modelling and analysis of a laminated plate
14. Impact analysis of a laminated plate

EXPERIMENTS IN CFD

LIST OF EXPERIMENTS:

1. Numerical simulation of 1-D diffusion and conduction in fluid flows
2. Numerical simulation of 1-D convection-diffusion problems
3. Numerical simulation of 2-D unsteady state heat conduction problem
4. Numerical simulation of 2-D diffusion and 1-D convection combined problems
5. Structured grid generation over airfoil section
6. 3-D numerical simulation of flow through CD nozzles
7. 3-D numerical simulation of flow development of a subsonic and supersonic jets
8. Numerical simulation of boundary layer development
9. Numerical simulation of subsonic combustion in a ramjet combustor
10. Numerical simulation of transonic flow over airfoils

(note) Experiments 6-10 can be done by using CFD Software tools

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be

CO1: Able to get solution of aerodynamic flows.

CO2: Able to perform stability analysis of structural components.

CO3: To define and setup flow problem properly within CFD context, performing solid modelling using CAD package and producing grids via meshing tool.

CO4: Able to comprehend both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution.

CO5: Able to use CFD software to model relevant engineering flow problems.

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
	1	**2**	**3**	**4**	**5**	**6**
CO1	3		2			1
CO2	3		2			1
CO3	3	2	3			1
CO4	3	2	3			1
CO5	3		2			1
	3	0.8	2.4	0	0	1

LABORATORY EQUIPMENTS REQUIREMENTS

1. Desktop computers
2. MS visual C++
3. CFD software

AS4311 **PROJECT WORK I** **L T P C**
0 0 12 6

OBJECTIVE:

To develop the ability to solve a specific problem partially right from its identification and literature review till the successful solution of the same.

The individual student must identify a project Advisor in the third semester. The student, in consultation with their Advisor, will form a Thesis Committee that includes head of the department and domain expert. 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.

TOTAL: 180 PERIODS

AS4411 **PROJECT WORK II** **L T P C**
0 0 24 12

OBJECTIVE:
To complete the process of solving a specific problem right from project phase-I to complete the entire solution.

To independently carry out research/investigation and development work to solve practical problems

To write and present a substantial technical report/document.

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.

TOTAL: 360 PERIODS

AS4001 **ELEMENTS OF SATELLITE TECHNOLOGY** **L T P C**
3 0 0 3

COURSE OBJECTIVES:
This course will make students
1. To learn the satellite mission and configurations,
2. To have an basic idea on power system of satellites
3. To learn the attitude and orbit control systems of satellites.
4. To gain knowledge on basic of propulsion systems, structures, and thermal controls involved in satellites.
5. To learn the basic aspects of telemetry systems.

UNIT I SATELLITE MISSIONAND CONFIGURATION 9
Mission Overview – Requirements for different missions – Space Environment, Spacecraft configuration-Spacecraft Bus–Payload–Requirements and constraints– Initial configuration decisions and Trade-offs–Spacecraft configuration process– Broad design of Spacecraft Bus– Subsystem layout–Types of Satellites–Constellations– Applications.

UNIT II POWER SYSTEM 8
Power sources–Energy storage–Solar panels–Deployable solar panels–Spacecraft Power management –Power distribution–Deep Space Probes.

UNIT III ATTITUDE AND ORBIT CONTROLSYSTEM (AOCS) 9
Coordinate system –AOCS requirements–Environment effects – Attitude stabilization – Attitude sensors –Actuators–Design of control algorithms.

UNIT IV PROPULSION SYSTEMS, STRUCTURES AND THERMAL CONTROL 10
Systems Trade-off–Mono-propellant systems –Thermal consideration–System integration design factors – Pre-flight test requirements–System reliability Configuration design of Spacecraft structure– Structural elements–Material selection–Environmental Loads-Vibrations– Structural fabrication– Orbital environments -Average temperature in Space– Transient temperature evaluation– Thermal control techniques– Temperature calculation for a spacecraft– Thermal design and analysis program structure –Thermal design verification– Active thermal control techniques.

UNIT V TELEMETRY SYSTEMS **9**

Base Band Telemetry system – Modulation – TT & CRF system–Telecommand system–Ground Control Systems

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will

CO1: 1 Be able to describe the main components of a satellite and its importance.
CO2: 2 Compare the merits and demerits of various power systems used.
CO3: 3 Be able to learn the dynamics of the satellite.
CO4: 4 Be able to study the design of propulsion systems, structures needed for satellites.
CO5: 5 Acquire knowledge on satellite orbit control and telemetry systems.

REFERENCES:

1. James R.Wertz,"Spacecraft Attitude Determination and Control", Kluwer Academic Publisher, Re edition 2012.
2. James R Wertz & Wiley J. Larsen, "Space Mission Analysis and Design", (Space Technology Library, Vol. 8, Microcosm Publisher, 1999.
3. Marcel J.Sidi, "Spacecraft Dynamics and Control-A Practical Engineering Approach", Cambridge University press, 2000.
4. Lecture notes on"Satellite Architecture", ISRO Satellite Centre Bangalore–560017.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-			
CO2	1	-	-	2	2	2
CO3	1	-	-	2	2	
CO4	-	-	-		2	2
CO5	-	-	-			

AS4002 CRYOGENIC TECHNOLOGY **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To learn various thermodynamic cycles for cryogenic plants.
2. To analyse the problems associated with a cryopropellants.
3. To calculate the efficiencies of cryogenic systems.
4. To gain knowledge on the various cycles of cryogenic plants.
5. To compare the performance of cryogenic engines with non-cryogenic engines.

UNIT I FUNDAMENTALS OF CRYOGENICS **10**

Theory behind the production of low temperature - expansion engine - heat exchangers - Cascade process - Joule Thomson and magnetic effects - cryogenic liquids as cryogenic propellants for cryogenic rocket engines - properties of various cryogenic propellants - handling problems associated with cryogenic propellants.

UNIT II CRYOGENIC SYSTEMS EFFICIENCY **8**

Types of losses and efficiency of cycles - amount of cooling - the features of liquefaction process - cooling coefficient of performance - Thermodynamic efficiency - The energy balancing method.

UNIT III THERMODYNAMIC CYCLES FOR CRYOGENIC PLANTS 8

Classification of cryogenic cycles - The structure of cycles Throttle expansion cycles - Expander cycles - Mixed throttle expansion and expander cycles - Thermodynamic analysis - Numerical problems.

UNIT IV PROBLEMS ASSOCIATED WITH CRYOPROPELLANTS 10

Storage problems of cryogenic propellants - zero gravity problems associated with cryopropellants - phenomenon of tank collapse - geysering effect - material strength considerations.

UNIT V CRYOGENIC ROCKET ENGINES 9

Peculiar design difficulties associated with the design of feed system, injector and thrust chamber of cryogenic rocket engines - Relative performance of cryogenic engines when compared to non-cryo engines.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able

- **CO1:** To acquire knowledge on the fundamental requirements that are peculiar to cryogenic rocket engines.
- **CO2:** To determine the thermodynamic efficiency of cryogenic systems.
- **CO3:** To carry out thermodynamic analysis for cryogenic plants.
- **CO4:** To demonstrate the peculiar problems associated with cryopropellants.
- **CO5:** To acquire knowledge oncryogenic propulsion systems

REFERENCES:

1. Barron.RF, “Cryogenic systems”, Oxford University, 1985.
2. Dieter K. Huzel& David H. Huang, “Modern Engineering for Design of Liquid-Propellant Rocket Engines", AIAA Series, 1992.
3. Haseldom.G, “Cryogenic Fundamentals”, Academic press, 2001.
4. Sarner.S.F, “Propellant Chemistry”, Reinhold Publishing Corporation New York, 1966.
5. Sutton, G.P. “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th edition, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	-	-	-
CO2	1	-	2	-	-	-
CO3	1	-	2	-	-	-
CO4	1	-	2	-	-	-
CO5	1	-	2	-	-	-

AS4003 INTRODUCTION TO AERONAUTICS AND SPACE TECHNOLOGY L T P C
3 0 0 3

COURSE OBJECTIVES:

- Students acquire knowledge about the present space technology.
- Students can focus on various orbits, re-entry paths, and also understand the future scenario.
- To provide an exposure with attitude requirements and design limitations.

UNIT - I FUNDAMENTALS OF ROCKET PROPULSION 12

Space Mission-Types based on Space Environment, vehicle selection. Rocket propulsion-Types, Rocket equation, chemical rocket propulsion, solid propellant rocket motor, liquid propellant rocket engine, Two-dimensional trajectories of rockets and missiles-Multi-stage rockets-Vehicle sizing-Two stage Multi-stage Rockets-Trade-off Ratios-Single Stage to Orbit-Sounding Rocket-Aerospace Plane-Gravity Turn Trajectories-Impact point calculation-injection conditions-Flight dispersions.

UNIT - II ATMOSPHERIC REENTRY 8

Introduction-Steep Ballistic Re-entry-Ballistic Orbital Re-entry-Skip Re-entry- "Double-Dip" Re-entry - Aero-braking - Lifting Body Re-entry.

UNIT - III FUNDAMENTALS OF ORBIT MECHANICS, ORBIT MANEUVERS 9

Two-body motion-Circular, elliptic, hyperbolic, and parabolic orbits-Basic Orbital Elements-Ground trace In-Plane Orbit changes-Hohmann Transfer Bi-elliptical Transfer-Plane Changes - Combined Maneuvers - Propulsion for Maneuvers.

UNIT - IV SATELLITE ATTITUDE DYNAMICS 8

Torque free axi-symmetric rigid body-Attitude Control for Spinning Spacecraft - Attitude Control for Non-spinning Spacecraft - The Yo-Yo Mechanism - Gravity - Gradient Satellite-Dual Spin Spacecraft- Attitude Determination.

UNIT – V SPACE MISSION OPERATIONS 8

Supporting Ground Systems Architecture and Team interfaces - Mission phases and Core operations - Team Responsibilities - Mission Diversity - Standard Operations Practices.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Understanding of rocket propulsion, types equation, their stages as well as trajectories
CO2: Ability to understand about Atmospheric Re-entry
CO3: Analysis of orbit Mechanics and their manoeuvres
CO4: Knowledge of Attitude determination of spacecraft/satellites
CO5: Analysis the space mission operations

REFERENCES:

1. "Spaceflight Dynamics", W.E. Wiesel, McGraw Hill, 3rd edition 2012
2. "Rocket Propulsion and Space flight dynamics", Cornelisse, Schoyer HFR and Wakker KF, Pitman, 1984
3. Vincent L. Pisacane, "Fundamentals of Space Systems", Oxford University Press, 2005.
4. Elements of Space Technology for aerospace Engineers", Meyer Rudolph X, Academic Press, 199

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	-	-	-
CO2	2	-	2	-	-	-
CO3	2	-	2	-	-	-
CO4	2	-	2	-	-	-
CO5	2	-	2	-	-	-

AS4004 FUNDAMENTALS OF COMBUSTION L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To impart knowledge to students on basic fuel and oxidizer characteristics.
2. To impart the concept of various governing equation and role of chemical kinetic in combustion process.
3. To make the students to understand various kinds flame and factors affecting flame.
4. The concept of diffusion flames.
5. Application of calculation in the field of Aerospace engineering.

UNIT I THERMODYNAMICS OF COMBUSTION 9

Combustion, types of fuels and oxidizers, calorific value measurements, flash point, fire point, smoke point, specific gravity, auto ignition temperature, Proximate analysis, ultimate analysis, Ideal gas law, gas mixture, sensible enthalpy, stoichiometry, equivalence ratio, heat of reaction, heat of combustion, heat of formation, adiabatic flame temperature, determination of equilibrium composition.

UNIT II TRANSPORT PHENOMENA AND CHEMICAL KINETIC OF COMBUSTION 9

Mass Transfer Rate Laws, Species Conservation, Some Applications of Mass Transfer, Global Versus Elementary Reactions, Rates of Reaction for Multistep Mechanisms, Net Production Rates, Compact Notation, Relation Between Rate Coefficients and Equilibrium Constants, Steady-State Approximation, The Mechanism for unimolecular Reactions, Chain and Chain-Branching Reactions, Chemical Time Scales, Partial Equilibrium, Reduced Mechanisms.

UNIT III PREMIXED FLAMES 10

Physical Description, detonation and deflagration, Hugoniot curve, Determination of CJ points, Governing Equations, Boundary Conditions, Structure of CH4–Air Flame, Factors Influencing Flame Velocity and Thickness, Flame Speed Correlations, Quenching, Flammability, and Ignition, Quenching by a Cold Wall Flammability Limits Ignition, Flame Stabilization.

UNIT IV LAMINAR DIFFUSION FLAMES 9

Non-reacting Constant-Density Laminar Jet, Physical Description, Conservation Laws, Boundary Conditions, Solution, Jet Flame Physical Description, Simplified Theoretical Descriptions, Flame Lengths for Circular-Port and Slot Burners, Roper's Correlations ,Flow rate and Geometry Effects, Factors Affecting Stoichiometry, Soot Formation and Destruction Counter flow.

UNIT V DROPLET EVAPORATION AND BURNING 8

Simple Model of Droplet Evaporation, Gas-Phase Analysis, Droplet, Simple Model of Droplet Burning, Burning Rate Constant and Droplet, Lifetimes, Extension to Convective Environments, Additional Factors, One-Dimensional Vaporization-Controlled Combustion.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be

CO1: Exposed to different kinds of fuel and oxidizer characteristics.
CO2: Able to realize basic chemical kinetics and mechanisms behind exothermic reactions.
CO3: Exposed to the significance of premixed flames.
CO4: To acquire knowledge on characteristics of diffusion flames, soot formations etc.
CO5: To familiarize in the field of droplet and evaporation theory.

REFERENCES:

1. Kenneth K.Kuo, "Principles of combustion", John Wiley & sons Inc, 2nd edition, 2012.
2. Mishra, DP, "Fundamentals of Combustion",PHI publishers, 2008.
3. Mukunda,HS, "Understanding combustion", Orient Blackswan, 2nd edition, 2009.
4. Stephen Turns , "An Introduction to Combustion: Concepts and Applications", McGrawHill, 4th edition, 2020.
5. VasudevanRaghavan, "Combustion Technology: essentials of flames and burners", Ane Books Pvt.Ltd, 1st edition, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	-	-	-
CO2	2	-	2	1	-	-
CO3	2	-	2	1	-	-
CO4	2	-	2	1	-	-
CO5	2	-	2	1	-	-

AS4072 COMPUTATIONAL HEAT TRANSFER L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To get insights into the basic aspects of various discretization methods.
2. To provide basic ideas on the types of PDE's and its boundary conditions to arrive at its solution.
3. To impart knowledge on solving conductive, transient conductive and convective problems using computational methods.
4. To solve radiative heat transfer problems using computational methods.
5. To provide a platform for students in developing numerical codes for solving heat transfer problems.

UNIT I INTRODUCTION 9

Finite Difference Method-Introduction-Taylor's series expansion-Discretization Methods Forward, backward and central differencing scheme for first order and second order Derivatives – Types of partial differential equations-Types of errors-Solution to algebraic equation-Direct Method and Indirect Method-Types of boundary condition-FDM – FEM – FVM.

UNIT II CONDUCTIVE HEAT TRANSFER 9

General 3D-heat conduction equation in Cartesian, cylindrical and spherical coordinates. Computation (FDM) of One –dimensional steady state heat conduction –with Heat generation-without Heat generation- 2D-heat conduction problem with different boundary conditions-Numerical treatment for extended surfaces- Numerical treatment for 3D- Heat conduction-Numerical treatment to 1D-steady heat conduction using FEM.

UNIT III TRANSIENT HEAT CONDUCTION 9

Introduction to Implicit, explicit Schemes and crank-Nicolson Schemes Computation(FDM) of One– dimensional un-steady heat conduction –with heat Generation-without Heat generation – 2D-transient heat conduction problem with different boundary conditions using Implicit, explicit Schemes-Importance of Courant number- Analysis for I-D,2-D transient heat Conduction problems.

UNIT IV CONVECTIVE HEAT TRANSFER 9

Convection- Numerical treatment (FDM) of steady and unsteady 1-D and 2-d heat convection-diffusion steady-unsteady problems- Computation of thermal and Velocity boundary layer flows. Upwind scheme-Stream function-vorticity approach-Creeping flow.

UNIT V RADIATIVE HEAT TRANSFER 9

Radiation fundamentals-Shape factor calculation-Radiosity method- Absorption Method – Montacalro method-Introduction to Finite Volume Method- Numerical treatment of radiation enclosures using finite Volume method. Developing a numerical code for 1D, 2D heat transfer problems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will

CO1: Have an Idea about discretization methodologies for solving heat transfer problems.

CO2: Be able to solve 2-D conduction and convection problems.

CO3: Have an ability to develop solutions for transient heat conduction in simple geometries.

CO4: Be capable of arriving at numerical solutions for conduction and radiation heat transfer problems.

CO5: Have knowledge on developing numerical codes for practical engineering heat transfer problems.

REFERENCES:

1. Chung,TJ, "Computational Fluid Dynamics", Cambridge University Press, 2002.
2. Holman,JP, "Heat Transfer", McGraw-Hill Book Co, Inc., McGraw-Hill College; 10th edition, 2017.
3. John D. Anderson, "Computational Fluid Dynamics", McGraw Hill Education, 2017.
4. John H. Lienhard, "A Heat Transfer", Text Book, Dover Publications, 5th edition, 2020.
5. Richard H. Pletcher, John C. Tannehill & Dale Anderson**, "**Computational Fluid Mechanics and Heat Transfer", 4th edition, CRC Press**,** 2021
6. Sachdeva,SC, "Fundamentals of Engineering Heat & Mass Transfer", New age publisher, 4th edition Internationals, 2017.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	2	3	4	5	6
CO1	3	-	2	3	3	-
CO2	3	-	2	3	3	-
CO3	3	-	2	3	3	-
CO4	3	-	2	3	3	-
CO5	3	-	2	3	3	-

AS4005 MISSILE AERODYNAMICS L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To impart knowledge on the basic aspects on the classification of missiles and its aerodynamics characteristics.
2. To provide idea about the missile configurations and preliminary drag estimation.
3. To analyse the aerodynamic characteristics of slender and blunt bodies.
4. To get insight into the basic aspects of launching phase of missiles.
5. To demonstrate the stability aspects of missile configuration and various control methods of missiles.

UNIT I BASICS ASPECTS OF MISSILE AERODYNAMICS 9

Classification of missiles-Aerodynamics characteristics and requirements of air to air missiles, air to surface missiles and surface to air missiles-Missile trajectories-fundamental aspects of hypersonic aerodynamics.

UNIT II MISSILE CONFIGURATIONS AND DRAG ESTIMATION 9

Various configurations-components-forces on the vehicle during atmospheric flight-nose cone design and drag estimation – Various types of drag and their origin – methods of minimize the drag types.

UNIT III AERODYNAMICS OF SLENDER AND BLUNT BODIES 9

Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles- determination of aero elastic effects.

UNIT IV AERODYNAMIC ASPECTS OF LAUNCHING PHASE 9

Booster separation-cross wind effects-specific considerations in missile launching-missile integration and separation-methods of evaluation and determination- Wind tunnel tests – Comparison with CFD Analysis.

UNIT V STABILITY AND CONTROL OF MISSILES 9

Forces and moments acting on missiles-Lateral, rolling and longitudinal moments-missile dispersion-stability aspects of missile configuration-Aerodynamic control methods-Jet control methods-Stability derivatives.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able

- **CO1:** To apply the concepts of high speed aerodynamics on missiles.
- **CO2:** To acquire knowledge on aerodynamics characteristics of missiles of various types.
- **CO3:** To estimate drag for various missile configurations and methods to reduce it.
- **CO4:** To estimate the forces and moments acting on missiles.
- **CO5:** To apply slender body aerodynamics knowledge during launching phase and stability and control aspects of missiles.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓	✓		
CO4	✓	✓	✓	✓	✓	
CO5	✓	✓	✓	✓		

REFERENCES:

1. Anderson, JD, “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series, 2nd edition, 2006.
2. Anderson JD, “Modern compressible flow: with Historical Perspective”, McGraw Hill Education, 3rd edition, 2017.
3. Chin SS, “Missile Configuration Design”, McGrawHill, NewYork, 1961.
4. Jack Nielson, “Missile Aerodynamics”,AIAA; 1st edition, 1988.

AS4006 SPACECRAFT ATTITUDE DYNAMICS AND CONTROL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

This course will enable students

1. To get introducedwiththe basics of attitude sensors and its types.
2. To gain knowledge on the basic principles of operation of thrusters.
3. To learn rigid body dynamics and various disturbing forces in space.
4. To gain in-depth knowledge on attitude stabilization schemes & orbit maneuvers.
5. To be familiar with the concepts of operating principles and design of guidance laws.

UNIT I ATTITUDE SENSORS8

Relative Attitude sensors – Gyroscopes, Motion reference Units, Absolute Attitude sensors – Horizon sensor, Orbital Gyrocompass, Earth sensors, sun sensors (Digital and analog), star sensor- Magnetometer

UNIT II CONTROL ACTUATORS9

Fundamental principles of operation of Thrusters- Momentum Wheel-Control Moment Gyros- Reaction wheel- Magnetic Torques- Reaction Jets- Ion Propulsion- Electric propulsion- solar sails

UNIT III ATTITUDE DYNAMICS, ATTITUDE AND ORBITAL DISTURBANCES9

Rigid Body Dynamics - Flexible body Dynamics - Slosh Dynamics- disturbing forces due to Drag, Solar radiation Pressure and forces - Disturbances due to Celestial bodies

UNIT IV ATTITUDE STABILIZATION SCHEMES & ORBIT MANEUVERS10

Spin, Dual spin - Gravity gradient - Zero momentum system - Momentum Biased system - Reaction control system - Single and Multiple Impulse orbit Adjustment - Hohmann Transfer- Station Keeping and fuel Budgeting

UNIT V MISSILE AND LAUNCH VEHICLE GUIDANCE9

Operating principles and design of guidance laws - homing guidance laws- short range - Medium range and BVR missiles - Launch Vehicle- Introduction - Mission requirements- Implicit guidance schemes - Explicit guidance - Q guidance schemes

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able to

CO1: Get basic idea on the working principles of attitude sensors and its applications.

CO2: Familiarize with control actuators used for satellite applications.

CO3: Comprehend the application of rocket vehicle guidance laws.

CO4: Demonstrate satellite orbit stabilization schemes and methods of satellite orbit transfer.

CO5: Familiarize with orbit manoeuvres of satellites and rocket vehicle guidance.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓										
CO2	✓	✓	✓	✓	✓							
CO3	✓	✓	✓	✓								
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓									

REFERENCES:

1. Blake Lock, J.H Automatic control of Aircraft and missiles, John Wiley Sons, New York, 1990.
2. James R Wertz, Spacecraft Attitude Determination and control, Reidel Publications.2001.
3. Kaplan M, Modern Spacecraft Dynamics and control, Wiley Press, 1979.
4. Marcel J. Sidi, Spacecraft Dynamics and control, A Practical Engineering Approach, Cambridge University Press.2000.
5. Meyer Rudolph X, Elements of Space Technology for Aerospace Engineers, Academic Press, 1999.
6. Vladimir A Chobotov, Spacecraft Attitude Dynamics and Control (Orbit)", Krieger Publishing Company Publishers, 1991.

AS4007 **CHEMICAL ROCKET TECHNOLOGY** **L T P C**
3 0 0 3

COURSEOBJECTIVES:

This course will make students

1. To classify the rockets and can develop the thrust equation.
2. To impart knowledge to the students on solid, liquid and hybrid rocket propulsion.
3. To provide knowledge on the types of igniters and injectors used in solid and liquid rocket systems.
4. To conduct various rocket testing and to analyse various modes of combustion instabilities.
5. To describe and understand types of rocket testing, safety and environmental concerns.

UNIT I ROCKET PERFORMANCE 9

Classification of Rockets - Propellants classification -Thrust equation, specific impulses, total impulse, characteristic velocity – Thrust coefficient – Efficiency: Real and ideal nozzle characteristic, Adiabatic flame temperature and its calculation, Criterion for Choice of propellants.

UNIT II SOLID ROCKET MOTORS 9

Viscous subsystems of solid rocket motor and their function – Igniters - Type of igniters – Internal ballistics properties– Burning rate - Factor affecting burning rate - Equilibrium Chamber pressure– Propellant grain geometry design, Erosive burning – Pressure vs Time curve- thrust vs time curve – Special problems of solid rocket nozzle – Combustion mechanism of solid propellants – Solid rocket motor design.

UNIT III LIQUID ROCKET ENGINES 10

Classification of liquid rocket engine –– Injectors and its types - various of types of feeding system - performance and choice of feed system cycle – Propellants tank and propellant slosh - Gas requirement for propellant draining - Thrust chamber – Thrust chamber cooling – Cryogenic propellants – Problems peculiar to cryogenic engine –– Turbo pumps – Ignition system - Combustion of liquid rocket – Thrust chamber design.

UNIT IV HYBRID PROPULSION SYSTEM 8

Standard and reverse hybrid rocket – Application – Limitation - Advance fuel – Combustion mechanism of hybrid rocket – Regression rate measurement – Methods for improving regression rate.

UNIT V ROCKET TESTING AND COMBUSTION INSTABILITIES 9

Burning rate measurement techniques - Rocket testing – Static testing of rockets – Instrumentation and safety procedures – Ignition delay testing – Combustion instability - L* instability – different modes of combustion instability – Bulk and wave mode of combustion instability in solid and liquid rockets – Pogo instability.

TOTAL :45 PERIODS

COURSE OUTCOMES

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

CO1: To identify the rocket propulsion system and its applications.
CO2: Analyze the performance of thrust chambers.
CO3: Describe and classify solid propellant rocket motors and its components.
CO4: Analyse propellants properties and associated physical and chemical processes.
CO5: Describe and classify liquid propellant rocket motors, its components and various associated systems.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓		✓	
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

REFERENCES:

1. Martin J. Chiaverini& Kenneth K. Kuo, "Fundamentals of Hybrid Rocket Combustion and Propulsion", Progress in Astronautics and Aeronautics (book218), 1st edition, 2007.
2. Ramamurthi,K, "Rocket Propulsion", Laxmi Publications Private Limited, 1st edition, 2016.
3. Sutton,GP "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2016.

AS4071 AEROSPACE MATERIALS L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To get insights into the basic aspects of material science.
2. To provide basic idea on the mechanical behaviour of materials.
3. To impart knowledge on the macro mechanics of composite materials,
4. To gain knowledge on the analysis and manufacturing methods of composite materials.
5. To learn about the sandwich construction.

UNIT I MATERIAL SCIENCE 9

Crystallography of metals & metallic alloys – Imperfections – Dislocations in Different Crystal Systems – Effect on plasticity – Strengthening Mechanisms Due to Interaction of Dislocations with Interfaces – Other Strengthening Methods – Dislocation Generation Mechanisms

UNIT II MECHANICAL BEHAVIOUR 9

Stress-strain curve and mechanical behaviour of materials – linear elasticity and plasticity – failure of ductile and brittle materials – use of failure theories – maximum normal stress and maximum shear stress failure theories – importance of the octahedral stress failure theory – failure theories based on strain energy – cyclic loading and fatigue of materials – the S-N curve

UNIT III METALLIC ALLOYS 9

Metals and alloys used for different aerospace applications – Properties of conventional and advanced aerospace alloys – Effect of alloying elements – Summary of conventional and state-of-the-art manufacturing processes – Types of heat treatment and their effect – other processing parameters – Materials for aerospace application – Design requirements & standards

UNIT IV HIGH TEMPERATURE MATERIALS 9

Carbon-Carbon Composites and Ceramic Materials For High Temperature Aerospace Application – Manufacturing Technologies & Controlling Parameters – Mechanical and Thermal Properties of These Material Systems – Thermal Protection Material System for a Re-Entry Vehicle – Use of Superalloys – Metal Matrix Composites &Cermets – Properties and Applications – Mechanical and Thermal Fatigue

UNIT V SMART MATERIALS 9

Introduction to smart materials-shape memory effects-shape memory alloys-shape memory polymers-electro-rheological fluids-energy harvesting materials-self healing polymers.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will

CO1: Be able to investigate the physical and mechanical behaviour of different materials.
CO2: Have exposure on dislocation theories and their importance.
CO3: Have general knowledge of the properties of different aerospace materials
CO4: Be able to apply failure theories appropriately.
CO5: Be able to select good materials for a specific aerospace application.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	
CO5	✓		✓			✓

REFERENCES

1. Adrian Mouritz, “Introduction to Aerospace Materials”, Woodhead Publishing, 1st edition, 2012.
2. Jones. R M, “Mechanics of Composite Materials”, 2nd Edition, CRC Press, Taylor & Francis Group, 1998.
3. Prasad, N. Eswara, Wanhill, RJH, “Aerospace Materials and Material Technologies Volume 1: Aerospace Materials”, Springer Singapore, 2017.
4. Sam Zhang & Dongliang Zhao, “Aerospace Materials Handbook”, CRC Press, Taylor & Francis Group, 2012.
5. Brain culshaw, smart structures and materials, Artech house, 2000.

AS4008 SPACE VEHICLE DESIGN L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To provide knowledge on the basic aspects of space vehicle operation environment.
2. To give an idea about the structural loads acting on space vehicles
3. To introduce the space vehicle design aspects, its complex issues requiring expertise from many different areas of Aerospace Engineering.
4. To impart knowledge on various parameters that influences the design of space vehicles including their mission, orbital mechanics and the space environment.
5. To get insight into the basic aspects of re-entry motion.

UNIT I SPACE VEHICLE BASICS 9

Earth environment - Launch environment – Atmospheric environment – Rocket performance and staging – Selection criteria of space vehicles - Expendable launch vehicles- Advanced mission concepts.

UNIT II STRUCTURAL DESIGN 9

Design drivers – Mission goals – Payload and instrument requirements – factors in structural concept selection - Deployable Structures – Vehicle mass – Vehicle centre of mass – Moment of inertia – Sources of structural loads – Analysis of structural loads – Load alleviation – Stress levels and safety factors – Structural materials.

UNIT III CONFIGURATION ASPECTS 9

Propulsion system aspects – Vehicle configuration – Number of stages/boosters – Vehicle layout – Recovery system selection – Launch sites – Guidance strategy - Ascent guidance – Flyback guidance systems – Attitude controller.

UNIT IV POWER SYSTEM DESIGN 9

Power system functions – Power system design drivers – Power system elements – Solar array design – Fuel cells – Power conditioning and control – Future concepts in space propulsion.

UNIT V RE-ENTRY MOTION 9

Re-entry Motion **-** Trade-offs for Re-entry Design **-** Significant Forces on a Re-entry vehicle - Ballistic Coefficient - Re-entry Motion Analysis - Trajectory and Deceleration - Trajectory and Heating - Trajectory and the Re-entry Corridor - Vehicle Shape design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the completion of this course, students will be

CO1: Familiar with the selection criteria of space launch vehicles.
CO2: Able to design space vehicles considering the various structural loads.
CO3: In a position to wisely select suitable configuration of space launch vehicle for given requirements.
CO4: Able to perform the design of power system for space vehicles.
CO5: Able to analyze re-entry motion of vehicles.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓	✓		✓							
CO2	✓	✓	✓	✓		✓						
CO3	✓	✓	✓	✓	✓	✓						
CO4	✓	✓				✓						
CO5	✓	✓		✓	✓	✓						

REFERENCES:

1. Alan C. Tribble, “The Space Environment: Implications for Spacecraft Design”, 2nd edition, Princeton University Press, 2003.
2. Michael D. Griffin, James R. French, “Space Vehicle Design”, AIAA Education Series, Second edition, 1991.
3. Mukund R. Patel, “Spacecraft Power Systems”, CRC Press, 2005.
4. Pasquale M Sforza, “Manned Spacecraft Design Principles”, Butterworth - Heinemann, 2015.
5. Peter Fortescue, John Stark and Graham Swinerd, “Spacecraft Systems Engineering”,Wiley, 3rd Edition, 2003.

AS4009 **THEORY OF PLATES AND SHELLS** **L T P C**
3 0 0 3

COURSE OBJECTIVE

To get fundamental understanding of the classical theory of elastic plates and shells, address limitations and differences, nomenclature, analytical and numerical solution techniques.

To enable students to apply the theory of plates to problems, involving various geometries and boundary conditions, to diverse problems in aerospace engineering.

UNIT I THEORY OF PLATE BENDING 9

Plate-Bending Theory - Classical Solution Methods-Rectangular Plates, Circular Plates - Plates on Elastic Foundations

UNIT II ENERGY METHODS 9

Analysis of Membranes-Bending & Stretching- Ritz Method- Galerkin's method- Finite Difference method- Large Deflection - Stability: Fundamentals, Applications

UNIT III VIBRATIONS AND STABILITY OF PLATES 9

Stability and Free Vibration Analysis of Rectangular Plates with various end conditions.- nonlinear geometric effects- Free Vibration and Stability Analysis.

UNIT IV SHELLS 9

Basic Concepts of Shell Type of Structures – Membrane and Bending Theories for Circular Cylindrical Shells - the general theory of elastic shells and axisymmetric shells - Introduction to the nonlinear analysis of shells.

UNIT V BUCKLING OF SHELLS 9

buckling, crushing and bending strength of cylindrical shells - Energy absorption and crashworthiness of prismatic tubes - Applications: Pipes, Tanks, Pressure Vessels

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: To get knowledge on the behavior of plates with different geometry under various types of loads
CO2: To analyses the plates by approximation methods and its applications
CO3: Have exposure on failure of plates under vibrations.
CO4: To get knowledge on the behavior of shells under various types of loads.
CO1: Able to get attentiveness on shells for aerospace applications.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓			
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓		✓	

REFERENCES:

1. Timoshenko, Stephen P., and S. Woinowsky-Krieger. *Theory of Plates and Shells*. 2nd ed. New York, NY: McGraw-Hill Companies, 1959.
2. A. C. Ugural, "Stresses in Beams, Plates, and Shells," 3 rd edition," CRC Press, 2009.
3. Reddy, J. N., "Theory and Analysis of Elastic Plates and Shells," CRC, 2nd edition, December 2006.
4. S. Timoshenko, and S. Woinowsky-Krieger "Theory of Plates and Shells," McGraw-Hill, 1959.

AS4010	MISSILE GUIDANCE AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

This course will make students

1. To provide basic introduction to missiles systems
2. To impart knowledge to students on basic missile configurations and preliminary drag estimation.
3. To introduce slender body aerodynamics, aerodynamic aspects during launching phase and stability and control aspects of missile.
4. To provide knowledge on strategic missiles.
5. To get insight into the basic aspects of weapon delivery systems.

UNIT I MISSILE SYSTEMS INTRODUCTION 8

History of guided missile for defence applications- Classification of missiles– The Generalized Missile Equations of Motion- Coordinate Systems- Lagrange's Equations for Rotating Coordinate Systems-Rigid-Body Equations of Motion-missile system elements, missile ground systems.

UNIT II MISSILE AIRFRAMES, AUTOPILOTS AND CONTROL 9

Missile aerodynamics- Force Equations, Moment Equations, Phases of missile flight. Missile control configurations. Missile Mathematical Model. Autopilots — Definitions, Types of Autopilots, Example Applications. Open-loop autopilots. Inertial instruments and feedback. Autopilot response, stability, and agility- Pitch Autopilot Design, Pitch-Yaw-Roll Autopilot Design.

UNIT III MISSILE GUIDANCE LAWS 10

Tactical Guidance Intercept Techniques, Derivation of the Fundamental Guidance Equations, explicit, Proportional Navigation, Augmented Proportional Navigation, beam riding, bank to turn missile guidance, Three-Dimensional Proportional Navigation, comparison of guidance system performance, Application of Optimal Control of Linear Feedback Systems.

UNIT IV STRATEGIC MISSILES 10

Introduction, The Two-Body Problem, Lambert's Theorem, First-Order Motion of a Ballistic Missile-Correlated Velocity and Velocity- to-Be-Gained Concepts, Derivation of the Force Equation for Ballistic Missiles, Atmospheric Reentry, Ballistic Missile Intercept, Missile Tracking Equations of Motion, Introduction to Cruise Missiles , The Terrain-Contour Matching (TERCOM) Concept.

UNIT V WEAPON DELIVERY SYSTEMS 8

Weapon Delivery Requirements, Factors Influencing Weapon Delivery Accuracy, Unguided Weapons, The Bombing Problem, Guided Weapons, Integrated Flight Control in Weapon Delivery, Missile Launch Envelope, Mathematical Considerations Pertaining to the Accuracy of Weapon Delivery Computations

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Have through knowledge with the advanced concepts of missile guidance and control to the engineers.

CO2: Provide the necessary mathematical knowledge that is needed in understanding the physical processes.

CO3: Derive fundamental guidance equations and to compare guidance system performance.

CO4: Explain the importance of strategic missiles and tracking equation of motions.

CO5: Provide concepts on weapon delivery systems and also the factors influences weapon delivery system.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

REFERENCES:

1. Blakelock, JH,"Automatic Control of Aircraft and Missiles", 2nd edition, John Wiley & Sons, 1991.
2. Fleeman, Eugene L, "Tactical Missile Design", 2nd edition, AIAA Education series, 2006.
3. Garnell, P, "Guided Weapon Control Systems", 2nd Edition, Pergamon Press, 1980.
4. Joseph Ben Asher and Isaac Yaesh, "Advances in Missile Guidance Theory" AIAA Education series, 1998.
5. Paul Zarchan, "Tactical and Strategic Missile Guidance", AIAA Education series,6th edition, 2013.
6. Siouris, GM,"Missile Guidance and control systems", Springer, 2004.

AO4075 THEORY OF BOUNDARY LAYERS L T P C

3 0 0 3

COURSE OBJECTIVES:

1. This course imparts knowledge to students on growth of boundary layer and its effect on the aerodynamic design of airframe of flight vehicles.
2. This course will introduce them the solution methods for boundary layer problems.
3. This course enables the students to understand the importance of viscosity and boundary layer in fluidflow.
4. This course also introduces the theory behind laminar and turbulent boundary layers.
5. This course will make students to learn the concepts of boundary layer transition and separation.

UNIT I THEORY OF VISCOUS FLOW 8

Fundamental equations of viscous flow, Conservation of mass, Conservation of Momentum-Navier-Stokes equations, Energy equation, Mathematical character of basic equations, Dimensional parameters in viscous flow, Non-dimensionalising the basic equations and boundary conditions, vorticity considerations, creeping flow, boundary layer flow.

UNIT II INCOMPRESSIBLE VISCOUS FLOWS AND BOUNDARY LAYER 10

Solutions of viscous flow equations, Couette flows, Hagen-Poisuelle flow, Flow between rotating concentric cylinders, Combined Couette-Poiseuille Flow between parallel plates, Creeping motion, Stokes solution for an immersed sphere, Development of boundary layer, Displacement thickness, momentum and energy thickness.

UNIT III LAMINAR BOUNDARY LAYER THEORY 10

Laminar boundary layer equations, Flat plate Integral analysis of Karman – Integral analysis of energy equation – Laminar boundary layer equations – boundary layer over a curved body-Flow separation- similarity solutions, Blasius solution for flat-plate flow, Falkner–Skan wedge flows, Boundary layer temperature profiles for constant plate temperature –Reynold's analogy, Integral equation of Boundary layer – Pohlhausen method – Thermal boundary layer calculations.

UNIT IV THEORY OF TURBULENT BOUNDARY LAYER 9

Turbulence-physical and mathematical description, Two-dimensional turbulent boundary layer equations — Velocity profiles – The law of the wall – The law of the wake – Turbulent flow in pipes and channels – Turbulent boundary layer on a flat plate – Boundary layers with pressure gradient, Eddy Viscosity, mixing length , Turbulence modelling.

UNIT V BOUNDARY LAYER TRANSITION AND SEPARATION 8

Boundary layer control in laminar flow-Methods of Boundary layer control: Motion of the solid wall- Acceleration of the boundary layer-Suction- Injection of different gas-Prevention of transition-Cooling of the wall-Boundary layer suction-Injection of a different gas.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

1. To apply proper governing equations for various types of viscous flows in engineering applications.
2. To obtain solutions for various viscous flow problems in engineering.
3. To estimate skin friction over solid surfaces, over which laminar boundary layer persists.
4. To arrive at the solutions for turbulent boundary layer and the resulting drag.
5. To gain insights on the techniques for boundary layer control.

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
	1	**2**	**3**	**4**	**5**	**6**
CO1			2	2	3	1
CO2			2	3	3	1
CO3			2	3	3	1
CO4			2	2	3	1
CO5			2	1	3	1

REFERENCES:

1. White, F. M., Viscous Fluid Flow, McGraw-Hill & Co., Inc., New York, 2008.
2. Schlicting, H., Boundary Layer Theory, McGraw-Hill, New York, 1979.
3. Reynolds, A, J., Turbulent Flows Engineering, John Wiley and Sons, 1980.

AO4252 FINITE ELEMENT ANALYSIS L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will enable the students

1. To learn the concepts of finite element methods and the various solution schemes available.
2. To impart knowledge to solve plane stress and plane strain problems.
3. To solve heat transfer and fluid mechanics problems using Finite element methods.
4. To formulate mass and stiffness element matrices for vibration problems.
5. To be familiar in obtaining solutions to fluid flow problems.

UNIT I INTRODUCTION 9

Review of various approximate methods – Rayleigh-Ritz, Galerkin and Finite Difference Methods – Problem Formulation – Application to Structural Elements & Practical Problems – Derivation of Stiffness and Flexibility Matrices – Spring Systems – Role of Energy Principles – Basic Concepts of Finite Element Method – Interpolation, Nodes, Degrees of Freedom – Solution Schemes.

UNIT II DISCRETE ELEMENTS 9

Finite Element Structural Analysis Involving 1-D Bar and Beam Elements – Tapered Bar – Temperature Effects – Static Loading – Formulation of the Load Vector for 1-D Elements – Methods of Stiffness Matrix Formulation – Interpolation & Shape Functions – Boundary Conditions – Determination of Displacements & Reactions – Constitutive Relations – Determination of Nodal Loads & Stresses.

UNIT III CONTINUUM ELEMENTS 9

Plane Stress & Plane strain Loading – CST Element – LST Element – Element Characteristics – Problem Formulation & Solution Using Finite Elements – Axisymmetric Bodies & Axisymmetric Loading – Consistent and Lumped Load Vectors – Use of Local, Area and Volume Co-ordinates – Isoparametric Formulation – Shape Functions – Role of Numerical Integration – Load Consideration – Complete FE Solution.

UNIT IV VIBRATION & BUCKLING 9

Formulation of the Mass and Stiffness Element Matrices for Vibration Problems – Bar and Beam Elements – Derivation of the Governing Equation – Natural Frequencies and Modes – Damping Considerations –Harmonic Response – Response Calculation Using Numerical Integration – Buckling of Columns – Problem Formulation – Solution – Determination of Buckling Loads and Modes.

UNIT V HEAT TRANSFER & FLUID MECHANICS PROBLEMS 9

One Dimensional Heat Transfer Analysis – Formulation of the Governing Equations in Finite Element Form – Equivalent Load Vector – Solution & Temperature Distribution – Finite Element Formulation & Solution for Sample Problems Involving Fluid Mechanics .

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will have

CO1: An ability to frame governing equations involving different type of finite elements.

CO2: Knowledge on the general finite element methodology for a variety of practical problems.

CO3: An ability to solve simple 1-D and 2-D problems using the finite element method.

CO4: Knowledge on how to apply numerical integration techniques effectively in finite elements solutions.

CO5: An ability to frame and solve heat transfer and fluid mechanics problems using the FE method.

REFERENCES:

1. Bathe, KJ &Wilson,EL, Numerical Methods in Finite Elements Analysis, Prentice Hall of India Ltd., 1983.
2. Dhanaraj, R &K.PrabhakaranNair,K, Finite Element Method, Oxford university press, India, 2015.
3. Krishnamurthy,CS, Finite Elements Analysis, Tata McGraw – Hill, 1987.
4. Rao,SS Finite Element Method in Engineering, Butterworth, Heinemann Publishing, 3rd Edition, 1998.
5. Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt, Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 4th Edition, 2002.
6. Segerlind,LJ, Applied Finite Element Analysis, , John Wiley and Sons Inc., New York, 2nd Edition,1984.

7. Tirupathi R. Chandrupatla& Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2002.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	2	3	4	5	6
CO1	1		3		2	1
CO2	1		2		2	1
CO3	2		3		3	1
CO4	1		3		3	1
CO5	2		3		3	1
	1.4	0	2.8	0	2.6	1

AO4071 FATIGUE AND FRACTURE MECHANICS L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To learn the fundamentals aspects of fatigue & fracture mechanics.
2. To gain knowledge on the statistical aspects of fatigue behaviour of materials.
3. To get insights into the physical aspects of fatigue.
4. To evaluate the strength of the cracked bodies.
5. To provide knowledge on fatigue design and testing of aerospace structures.

UNIT I BASIC CONCEPTS & OVERVIEW 9

Historical Perspective – Case Studies – Review of Material Behaviour – Linear & Non-Linear Response – Temperature and Strain Rate Effect – Strain Hardening – Different Mechanisms of Failure – Typical Defects & Elements of Dislocation Theories – Atomic View of Fracture – Fractographic Examination of Failure Surfaces of Different Materials – Overview of Design Approach – Safe Life Design.

UNIT II FATIGUE OF STRUCTURES 9

S.N. curves – Endurance limit – Effect of mean stress – Goodman, Gerber and Soderberg relations and diagrams – Notches and stress concentrations – Stress concentration factors – Notched S-N curves – Low cycle and high cycle fatigue – Coffin-Manson's relation – Transition life – Cyclic Strain hardening and softening – Load History Analysis – Cycle counting techniques – Cumulative damage theory

UNIT III PHYSICAL ASPECTS OF FATIGUE 9

Fracture mechanism in metals - Phase in fatigue life – Crack source – Cleavage initiation – Crack growth – Ductile-brittle transition – Final fracture – Dislocations – Fatigue fracture surface of inter and intra-granular fracture – Environmental effects – Terminology and classification – Corrosion principles – Stress corrosion cracking – Hydrogen embrittlement – Influencing parameters on crack behaviour

UNIT IV LINEAR ELASTIC FRACTURE MECHANICS 9

Stress analysis and strength of a cracked body – Stress concentration – potential energy and surface energy – Energy release rate – Griffith's theory – Irwin extension of Griffith's theory to ductile materials – Plastic zone shape – Effect of thickness on fracture toughness – Stress intensity factors for typical geometries – Instability of the R-curve – K-controlled fracture – Plane strain fracture toughness – Mixed mode – Interaction of cracks – Limitations of the linear elastic fracture theory

UNIT V FRACTURE TOUGHNESS TESTING 9

General considerations for metallic specimens – Specimen configuration – Stress intensity factors – Pre-cracking – Grooving – ASTM E-399 and similar standards – K-R curve – J-testing on metals – Determination of crack parameters – CTOD testing – Testing of metals in the ductile-brittle transition region – Quantitative toughness tests – Charpy & Izod tests –- Mathematical modelling concepts

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis.
CO2: To correctly apply linear elastic fracture to predict material failure.
CO3: To predict lifetimes for fatigue and environmentally assisted cracking.
CO4: To demonstrate fatigue design and testing of structures.
CO5: To realise the importance of composite materials in Aerospace structures.

REFERENCES:

1. Barrois, W &Ripley,L, “Fatigue of Aircraft Structures”, Pergamon Press, Oxford, 1983.
2. Brock,D, “Elementary Engineering Fracture Mechanics”, Noordhoff International Publishing Co., London, 1994.
3. Knott,JF, “Fundamentals of Fracture Mechanics”, Butterworth & Co. Ltd., London, 1983.
4. Sih,CG, “Mechanics of Fracture, Vol.1”, Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
	1	**2**	**3**	**4**	**5**	**6**
CO1	1	1	1	1	1	1
CO2	2	2	1	2	2	1
CO3	3	2	1	3	3	1
CO4	2	2	1	2	2	1
CO5	2	2	1	2	2	1
	2	1.8	1	2	2	1

AO4076 VIBRATION ISOLATION AND CONTROL L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To get insight into the basic aspects of vibration theory.
2. To get in-depth knowledge on different types of isolators and its effectiveness.
3. To provide the basic knowledge on dynamic vibration absorber.
4. To realize the importance of materials selection for appropriate applications.
5. To get knowledge on the principles of active vibration control.

UNIT I BASIC VIBRATION THEORY 9

Free Vibration Theory – Determination of Natural Frequency of a Single Degree Of Freedom – System– Response of a Damped Single Degree of Freedom System – Role of Damping – Forced Vibrations of Discrete Systems – Continuous Systems – Vibrations of Beams and Shafts – Idealization of a Real System Into a Discrete Model – Resonance – An Overview of the Different Methods of Vibration Control

UNIT II VIBRATION ISOLATION 9

Transmissibility – Numerical Examples – Necessity of Vibration Isolation – Vibration Reduction at Source – System Redesign – Different Types of Isolators & Their Effectiveness – Pneumatic Suspension – Excitation Reduction at Source and Factors Affecting Vibration Level – Source Classification – Control of Flow Induced & Self-Excited Systems

UNIT III DYNAMIC VIBRATION ABSORBER 9

Dynamic Vibration Neutralizers – Self-tuned Pendulum Neutralizer - Optimum Design of Damped Absorbers – Absorber with ideal spring and viscous dashpot – Gyroscopic vibration absorbers – Impact Absorbers – Absorbers attached to continuous systems – Field Balancing of Rotors – Resonance: Detuning and Decoupling – Remedial Measures

UNIT IV SELECTION OF MATERIALS 9

Dynamic Properties of Viscoelastic Material – Selection of Materials – Damping-Stress Relationship – Selection Criteria for Linear Hysteretic Material – Design for enhanced material damping – Linear Viscoelastic Model – Constrained Layer Damping – Relaxation – Frequency and Temperature Dependence of the Complex Modulus – Overview and Role of Smart Materials

UNIT V PRINCIPLES OF ACTIVE VIBRATION CONTROL 9

Conceptual Understanding – Shape Memory Actuators for Vibration Control – Shape Memory Materials – Tuned Vibration Absorbers using SMA – Basics of Electro-and Magneto-Rheological Fluids – Active Vibration Isolation using ERF and MRF – Methods of Active Vibration Control Using Piezoelectric Materials – Derivation of Governing Equations – Response of the Structure

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able

CO1: To realise the importance of vibration theory & its practical applications
CO2: To work out response calculations
CO3: To analyse and compare the different methods of vibration control
CO4: To exposure on vibration control using smart materials
CO5: To design a vibration control unit.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	2	3	4	5	6
CO1	2	2	2	2	2	1
CO2	2	2	2	2	2	1
CO3	3	3	3	3	3	1
CO4	1	1	1	1	1	1
CO5	3	3	3	3	3	3
	2.2	2.2	2.2	2.2	2.2	1.4

REFERENCES:

1. Malcolm J. Crocker, “Handbook of Noise and Vibration Control”, Wiley; 1st edition, 2007.
2. Mallik, AK, “Principles of Vibration Control”,Affiliated East-West Press, India, 1990.
3. Mead,DJ, “Passive Vibration Control”, Wiley, 1st edition, 1999.
4. Preumont,A“Vibration Control of Active Structures”, Springer Netherlands, 3rd edition, 2011.

AO4073 **NON-DESTRUCTIVE EVALUATION** **L T P C**
3 0 0 3

COURSE OBJECTIVES:
This course will make students

1. To impart knowledge on the fundamentals of nondestructive testing methods and techniques, aircraft inspection methodology using NDT methods
2. To get insights into the basic aspects of electron microscopy.
3. To learn modern NDT techniques like acoustic emission, ultrasonic and thermographic testing methods.
4. To inspect the aircraft structures using NDT techniques.
5. To get basic knowledge on the structural health monitoring of aerospace structures.

UNIT I INTRODUCTION **9**
Need for non-destructive evaluation (NDT) – Applications – Structural inspection – Structural deterioration due to corrosion and fatigue – Crack growth – Fabrication defects – Overloading – Detailed visual inspection – Aircraft wing and fuselage inspection using various NDT techniques – Overview and relative comparison of NDT methods – Jet engine inspection – Critical locations

UNIT II ELECTRON MICROSCOPY **9**
Fundamentals of optics – Optical microscope and its instrumental details – Variants in the optical microscopes and image formation – Polarization light effect – Sample preparation and applications of optical microscopes – Introduction to Scanning electron microscopy (SEM) – Instrumental details and image formation of SEM – Introduction to transmission electron microscopy (TEM) – Imaging techniques and spectroscopy – Sample preparation for SEM and TEM

UNIT III ACOUSTIC EMISSION AND ULTRASONICS **9**
Sources of acoustic emission – Physical principals involving acoustic emission and ultrasonics – Configuration of ultrasonic sensors – Phased array ultrasonics – Instrument parts and features for acoustic emission and ultrasonics – Defect characterization – Inspection of cracks and other flaws in metals and composites – Interpretation of data – Image processing – Concepts and application

UNIT IV AIRCRAFT INSPECTION **9**
Inspection Levels – General Visual Inspection – During pre, or post flight – Detailed Visual Inspection (DET) – Periodic inspection – Special Detailed Inspection (SDET) – Uses of NDT Methods – Jet Engine Inspection – Engine overhaul – Fluorescent penetrate inspection – Airframe Loading – Fuselage Inspection – Critical Locations – Comparison of different methods of NDT – Visual – Radiography – Eddy Current Testing – Liquid Penetrant Testing – Remote Testing - Landing Gear Inspection

UNIT V STRUCTURAL HEALTH MONITORING **9**
An Overview of Structural Health Monitoring – Structural Health Monitoring and Role of Smart Materials – Structural Health Monitoring versus Non-Destructive Evaluation – A Broad Overview of Smart Materials Applications – Notable Applications of SHM in Aerospace Engineering – Structural health monitoring of composites – Repair investigation using SHM – Current limits and future trends.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able
CO1: To realize the importance of various NDT techniques.
CO2: To identify suitable NDT technique for a particular application.
CO3: To demonstrate the physical principles involved in acoustic emission and ultrasonics.
CO4: Tohave knowledge on the physical principles involved in the various other techniques of NDT.
CO5: To realise the state-of-the-art in NDT testing and structural health monitoring.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	2	3	4	5	6
CO1	1	1	1	2	1	1
CO2	1	1	1	2	1	1
CO3	2	1	2	2	2	1
CO4	1	1	1	2	1	1
CO5	1	1	1	2	1	1
	1.2	1	1.2	2	1.2	1

REFERENCES:

1. Cullity, BD & Stock, SR, “Elements of X-ray diffraction”, Prentice Hall, Inc. USA, 2001.
2. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, “Structural Health Monitoring”, Wiley-ISTE, 2006.
3. Douglas E Adams, “Health Monitoring of Structural Materials and Components-Methods with Applications”, John Wiley and Sons, 2007.
4. Douglas B. Murphy, “Fundamentals of light microscopy and electronic imaging”, Wiley-Liss, Inc. USA, 2001.
5. Richard Brundle. C, Charles A. Evans, Jr., Shaun Wilson, “Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films”, Butterworth-Heinemann, Boston, USA, 1992.
6. Williams, DB & Barry Carter,C, “Transmission electron microscopy, vol. 4”, Springer, USA, 1996.
7. Non-destructive Testing Handbook – ASNT Series – Volume 1 – 6.

AS4011 PLASMA ENGINEERING L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To impart knowledge to students on basic plasma and its application in aerospace engineering.
2. To learn about the motion of charged particles.
3. To get inference about the collision of charged particles and energy Equilibrium.
4. To learn about the MHD plasma and its stability.
5. To get information about electromagnetic waves, kinetic of plasma and some of the damping mechanism.

UNIT I INTRODUCTION TO PLASMA 8

Plasma, An Ionized Gas, Plasmas are Quasi-Neutral, Plasma Shielding, Elementary Derivation of the Boltzmann Distribution, Plasma Density in Electrostatic Potential, Debye Shielding, Plasma-Solid Boundaries (Elementary), Thickness of the Sheath, the 'Plasma Parameter', Occurrence of Plasmas, Different Descriptions of Plasma, Equations of Plasma Physics.

UNIT II MOTION OF CHARGED PARTICLES IN FIELDS 9

Uniform B field, E = 0, Uniform B and Non-zero E, Drift Due to Gravity or Other Forces, Non-uniform B Field, Curvature Drift, Interlude: Toroidal Confinement of Single Particles, The Mirror Effect of Parallel Field Gradients: E = 0, ∇B ||B, Time Varying B Field (E Inductive), Time Varying E-field (E, B Uniform), Direct Derivation of [(dE)/dt] Effect: 'Polarization Drift', Non Uniform E (Finite Larmor Radius)

UNIT III COLLISIONS IN PLASMAS 9

Binary Collisions between Charged Particles, Scattering Angle, Differential Cross-Section for Scattering by Angle, Relaxation Processes, ,Energy Loss, Cut-offs Estimate, Momentum Loss, Thermal Distribution Collisions, Thermal Collision Frequencies, Applications of Collision Analysis, Energy Equilibration

UNIT IV FLUID DESCRIPTION OF PLASMA 9

Particle Conservation (In 2-d Space),Fluid Motion, Lagrangian& Eulerian Viewpoints, Two-fluid Equilibrium: Diamagnetic Current, Reduction of Fluid Approach to the Single Fluid Equations, Single Fluid Equations: M.H.D, Heuristic Derivation/Explanation, Maxwell's Equations for MHD Us, MHD Equilibria, General Properties of MHD Equilibria, Low β equilibria: Force-Free Plasmas, Toroidal Equilibrium, MHD Stability, General Principles Governing Instabilities.

UNIT V ELECTROMAGNETIC WAVES IN PLASMAS 10

Linear Waves in Anisotropic Medium, Isotropic Medium, High Frequency Plasma Conductivity, Cold Plasma Waves, Thermal Effects on Plasma Waves, Electrostatic Approximation Waves, Simple Example of MHD Dynamics: Alfven Waves, Non-uniform Plasmas and Wave Propagation, Two Stream Instability, Kinetic Theory of Plasma Waves, Vlasov Equation, Linearized Wave Solution of Vlasov Equation, Landau's Original Approach, Solution of Dispersion Relation, Direct Calculation of Collisionless Particle Heating, Damping Mechanisms, Ion Acoustic Waves and Landau Damping, Alternative Expressions of Dielectric Tensor Elements, Electromagnetic Waves in UnmagnetizedVlasov Plasma Experimental Verification of Landau Damping

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able

CO1: To acquire knowledge on the use of plasma and its application in field of Aerospace vehicles.

CO2: To realize the basic motion of charged particles and flow physics.

CO3: To get exposure on the significance of particle collision.

CO4: To acquire knowledge about the motion of MHD and its stability in the flow field.

CO5: To get through knowledge in the field of plasma wave kinetics.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓	✓		✓	✓						
CO2	✓	✓	✓	✓								
CO3	✓	✓	✓	✓	✓	✓						
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓	✓		✓						

REFERENCES:

1. Dan M. Goebel, Ira Katz, “Fundamentals of Electric Propulsion: Ion and Hall Thrusters”, Wiley publication, 1st edition,2008.
2. George P. Sutton& Oscar Biblarz, “Rocket Propulsion Elements”, Wiley publication, 9th Edition, 2016.
3. Prof. Hutchinson, “Introduction to Plasma Physics I”, lecture notes, MIT open courseware.
4. Luis Conde, “An Introduction to Plasma Physics and its Space Applications, Volume 1”,Morgan & Claypool Publishers as part of IOP Publishing- 2018.

AS4012 **ROCKET AND MISSILE SYSTEMS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To get insight into the basic aspects of rockets and missile subsystems.
2. To impart knowledge on igniters system, injection system, thermal protection system.
3. To get knowledge on stage separation system and vehicle optimization.
4. To provide knowledge on thrust vector control methods.
5. To get in-depth knowledge on thermal protection system and high temperature materials for aerospace applications.

UNIT I ROCKET AND MISSILE SUBSYTEM 9

Various subsystem of thrust chamber – igniters for solid propellants and liquid propellants – Pyrogen igniter - Pyrodyne igniter- Pelleted Pyrotechnic- Insulation system – Liner system – Injector system- Damping system for propellant slosh - Propellant hammer– Thermal insulating for cryogenic propellants – Cooling system.

UNIT II STAGE SEPARATION SYSTEM 9

Need of multi staging – Clustering – Staging method - stage separation techniques in atmosphere - Stage separation techniques in vacuum - Vehicle Optimization.

UNIT III THRUST VECTOR CONTROL 9

Thrust vector control – TVC mechanism in single nozzle – Gimbal – movable nozzle – jet vanes- jet tabs- jetavator – secondary injection of liquid and hot gas injection – small auxiliary thrust chamber – TVC with multiple thrust chamber – TVC testing

UNIT IV THERMAL PROTECTION SYSTEM 9

Principle of high temperature design – thermal environment – aerodynamic heating –solar heating – principles of thermal protection – thermal protection systems – systems based on heat dissipation – systems based on heat absorption- capabilities of thermal protection systems.

UNIT V HIGH TEMPERATURE MATERIAL FOR AEROSPACE APPLICATIONS 9

Component system analysis – re-entry component analysis – composite material systems- Ceramics reinforced with refractory metal fibres – high temperature material fabrication – Fracture of pressure vessels – temperature control of spacecrafts – ablation materials.

TOTAL:45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be

CO2: Able to learn the principles of operation and design of various rocket systems.
CO3: Able to explore the design of multi-stage launch vehicles.
CO4: Able to acquire knowledge on the application and working of thrust vector control in rocket and missiles.
CO5: Aware of thermal protecting requirements and preventive measurements for aerodynamics heating.
CO6: Able to get attentiveness on high temperature material components analysis for aerospace applications.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		
CO2	✓	✓	✓		✓	
CO3	✓	✓	✓	✓	✓	
CO4	✓	✓	✓		✓	
CO5	✓	✓	✓	✓	✓	

REFERENCES:

1. Cornelisse, JW, Schoyer, HFR &Wakker, F, “Rocket Propulsion and Space Dynamics”, Pitman Publishing, 1979.
2. Earl R. Parker, “Materials for Missiles and Spacecraft”, McGraw –Hill Book company, Inc.1982.
3. Howard D.Curtis, “Orbital Mechanics for Engineering Students”, 3rd Edition, Butterworth-Heinemann, 2013.
4. Sutton, G.P, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th Edition, 2016.

AS4013 ELECTRIC PROPULSION SYSTEMS L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To get familiarize with the basic the operating principles of the various electrical thrusters.
2. To learn the concept of plasma kinetic theory
3. To gain idea on the elements of gas kinetics.
4. To impart knowledge on the classes of MPD thrusters.
5. To study the importance of electric propulsion for space applications.

UNIT I PHYSICS OF IONIZED GASE 8

Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas Electrical conductivity of an ionized gas - Kinetic Theory – Application of ionized gas flows.

UNIT II INTRODUCTION TO THE BASIC PHYSICS OF ELECTRIC PROPULSION SYSTEMS 9

Historical outline - Definition of Electric Propulsion - High impulse Space Missions - Exhaust velocity and specific impulse - Power supply penalty – Electric charges and Electrostatic fields - Currents and Magnetic interactions - Time dependent fields and Electromagnetic wave propagation.

UNIT III ELECTRO-THERMAL PROPULSION 9

One dimensional model - Enthalpy of high temperature gases - Frozen flow efficiency – Resistojets - Electrical discharges - Arcjets - Operation and Analysis - Materials - advantages and Disadvantages

UNIT IV ELECTROSTATIC PROPULSION 9

One dimensional space-charge flows - Basic relationships - The acceleration- deceleration concept - Ion engines - Design and Performance - Hall effect – Hall thrusters - Field emission electric propulsion (FEEP) - Colloid thrusters

UNIT V ELECTROMAGNETIC PROPULSION 10

The Lorentz force - Magnetogasdynamic channel flow - Ideal steady flow acceleration -Thermal and viscous losses - Geometry considerations - Self induced fields - Sources of the conducting gas - The magnetoplasmadynamic arc - Magneto- plasmadynamic (MPD) thrusters - Pulsed plasma acceleration - Pulsed plasma thrusters (PPT) - Quasi steady acceleration - Pulsed inductive acceleration - Travelling wave acceleration

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be

CO1: Able to classify and describe the electric thrusters for space applications.
CO2: Able to perform the preliminary sizing of a test facility for electric propulsion.
CO3: Able to perform calculations of first approximation on plasmas of electric propulsion.
CO4: Able to set theory models for the study of electric propulsion systems.
CO5: Able to acquire knowledge on the basics of rarefied gas dynamics and plasma physics.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓	✓	✓								
CO2	✓	✓	✓									
CO3	✓	✓	✓	✓		✓						
CO4	✓	✓	✓	✓		✓						
CO5	✓	✓	✓	✓		✓						

REFERENCES:

1. George W. Sutton, “Engineering Magnetohydrodynamics”, Dover Publications Inc., New York, 2006.
2. Robert G. Jahn, “Physics of Electric Propulsion”, Dover Publications, 2012.
3. Sutton,GP “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th Edition, 2016.

AO4077 **THEORY OF VIBRATIONS** **L T P C**

3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To get insight into the basic aspects of vibration theory.
2. This course presents the principles of dynamics and energy methods pertaining to structures.
3. This course provides a platform for better understanding of the approximate methods for aerospace structures.
4. To get insight into the dynamic responses of the large systems.
5. To get insight into the basic aspects of aero-elasticity.

UNIT I SINGLE DEGREE OF FREEDOM SYSTEMS 9

Simple harmonic motion, definition of terminologies, Newton’s Laws, D’Alembert’s principle, Energy methods. Free and forced vibrations with and without damping, base excitation, and vibration measuring instruments.

UNIT II MULTI-DEGREES OF FREEDOM SYSTEMS 9

Two degrees of freedom systems, Static and dynamic couplings, eigen values, eigen vectors and orthogonality conditions of eigen vectors, Vibration absorber, Principal coordinates, Principal modes. Hamilton’s Principle, Lagrange’s equation and its applications.

UNIT III VIBRATION OF ELASTIC BODIES 9

Transverse vibrations of strings, Longitudinal, Lateral and Torsional vibrations. Approximate methods for calculating natural frequencies.

UNIT IV EIGEN VALUE PROBLEMS & DYNAMIC RESPONSE OF LARGE SYSTEMS **9**

Eigen value extraction methods – Subspace hydration method, Lanczos method – Eigen value reduction method – Dynamic response of large systems – Implicit and explicit methods.

UNIT V ELEMENTS OF AEROELASTICITY **9**

Aeroelastic problems – Collar's triangle of forces – Wing divergence – Aileron control reversal – Flutter.

TOTAL: 45 PERIODS

REFERENCES

1. Timoshenko, S. "Vibration Problems in Engineering", John Wiley & Sons, Inc., 2018.
2. Meirovitch, L. "Elements of Vibration Analysis", New Delhi, McGraw-Hill Education, 2014.
3. Thomson W.T, Marie Dillon Dahleh, "Theory of Vibrations with Applications", Harlow, Essex Pearson 2014
4. F.S. Tse., I.F. Morse and R.T. Hinkle, "Mechanical Vibrations", Prentice-Hall of India, 1985.
5. Rao.J.S. and Gupta.K. "Theory and Practice of Mechanical Vibrations", New Delhi, New Age International, 1999.
6. Fung, Y.C., "An Introduction to the Theory of Aeroelasticity", Dover Publications.,Mineola, N.Y., 2008.

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	2	3	3	-
CO2	3	-	2	3	3	-
CO3	3	-	2	3	3	-
CO4	3	-	2	3	3	-
CO5	3	-	2	3	3	-

AS4014 MANNED SPACE MISSIONS **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To get insights into the basic aspects of manned and unmanned missions.
2. To provide with the basic knowledge on the structure of atmosphere and the space environment.
3. To learn the complexities involved in sending human being into space missions.
4. To learn how the unmanned missions with respect to mission logistics and planning are different from manned missions.

UNIT I INTRODUCTION **8**

The physics of space - Current missions: space station, Moon mission and Mars missions - Engineering challenges on Manned vs. unmanned missions - Scientific and technological gains from space programs - Salient features of Apollo and Space station missions – space shuttle mission

UNIT II SPACE VS EARTH ENVIRONMENT **10**

Atmosphere: Structure and Composition - - Atmosphere: Air Pressure, Temperature, and Density - Atmosphere: Meteoroid, Orbital Debris & Radiation Protection - Human Factors of Crewed Spaceflight, . Safety of Crewed Spaceflight - Magnetosphere - Radiation Environment: Galactic Cosmic Radiation (GCR) , Solar Particle Events (SPE) - Radiation and the Human Body – Impact of microgravity and g forces on humans – space adaptation syndrome

UNIT III LIFE SUPPORT SYSTEMS AND COUNTERMEASURES 8

Life Support Systems and Space Survival Overview - - Environment Controlled Life Support Systems (ECLSS) - Human / Machine Interaction - - Human Factors in Control Design - Crew Accommodations

UNIT IV MISSION LOGISTICS AND PLANNING 10

Group Dynamics: Ground Communication and Support - Space Resources and Mission Planning - Space Mission Design: Rockets and Launch Vehicles - Orbital Selection and Astrodynamics , Entry, Descent, Landing, and Ascent, Designing and Sizing Space elements, Transfer, Entry, Landing, and Ascent Vehicles, Designing, Sizing, and Integrating a Surface Base, Planetary Surface Vehicles

UNIT V ALLIED TOPICS 9

Spacecraft Subsystems: Space Operations - Space Architecture, Attitude Determination and Control - Designing Power Systems - Extravehicular Activity (EVA) Systems - Space Robotics - Mission Operations for Crewed Spaceflight - Command, Control, and Communications Architecture.

TOTAL:45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able

CO1: To get updated with technical status on current knowledge manned and unmanned missions.

CO2: To apply space element architectures, design and sizing principles and processes for on-orbit, ascent and re-entry operations. Apply sizing principles to estimate mass and power for a given set of requirements.

CO3: To apply basic principles of orbital mechanics and how they apply to human missions.

CO4: To familiarize with human spaceflight mission design principles, limitations and processes and apply them to develop goals, objectives as well as top level requirements

CO5: To characterize the scope, functions and physical architecture options for human spaceflight support systems such as Environmental Control and Life Support, Thermal Control, EVA Systems, and others.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓			
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓			

REFERENCES:

1. Connors, MM, Harrison, AA, and Akins, FR,."Living Aloft: Human Requirements for Extended Spaceflight", University Press of the Pacific, Honolulu, 2005.
2. Eckart, P, "Spaceflight Life Support and Biospherics", Springer publishers, 1st t edition, 2010.
3. Larson, WJ and Pranke, LK, "Human Spaceflight: Mission Analysis andDesign", McGraw-Hill Higher Education, Washington, DC, 1999.
4. McNamara, Bernard, "Into the Final Frontier: The Human Exploration of Space", Brooks Cole Publishing, 1st edition, 2000.

AS4015 HIGH TEMPERATURE GAS DYNAMICS L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To realize the importance and influence of non-equilibrium real-gas effects in high temperature flows.
2. To know the physical mechanisms causing aerodynamic heating of high speed vehicles.
3. To study the parameters that influences the design of hypersonic vehicles.
4. To know the computational methods appropriate to high temperature flows.
5. To realize the effects of friction and heat addition to gasdynamic flow, typical in aerospace engines.

UNIT I INTRODUCTION 8

Nature of high temperature flows – Chemical effects in air – Real perfect gases – Gibb's free energy and entropy by chemical and non equilibrium – Chemically reacting mixtures and boundary layers.

UNIT II STATISTICAL THERMODYNAMICS 8

Introduction to statistical thermodynamics – Relevance to hypersonic flow - Microscopic description of gases – Boltzman distribution – Cartesian function

UNIT III KINETIC THEORY AND HYPERSONIC FLOWS 9

Chemical equilibrium calculation of equilibrium composition of high temperature air – equilibrium properties of high temperature air – collision frequency and mean free path – velocity and speed distribution functions.

UNIT IV INVISCID HIGH TEMPERATURE FLOWS 10

Equilibrium and non – equilibrium flows – governing equations for inviscid high temperature equilibrium flows – equilibrium normal and oblique shock wave flows – frozen and equilibrium flows – equilibrium conical and blunt body flows – governing equations for non equilibriuminviscid flows.

UNIT V TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES 10

Transport coefficients – mechanisms of diffusion – total thermal conductivity – transport characteristics for high temperature air – radiative transparent gases – radiative transfer equation for transport, absorbing and emitting and absorbing gases.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be

CO1: Able to identify the critical physical phenomena in high temperature flows.
CO2: Realize the importanceof kinetic theory of gases.
CO3: Having knowledge about the features and importance of high - enthalpy flows.
CO4: In a position to demonstrate the transport properties in High-Temperature gases.
CO5: Having knowledge on some of the basic phenomena in rarefied flows.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓										
CO2	✓	✓		✓								
CO3	✓	✓		✓								
CO4	✓	✓		✓								
CO5	✓	✓										

REFERENCES:

1. Anderson, JD, “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series, 2nd edition, 2006.
2. Anderson J D,“Modern compressible flow: with Historical Perspective”, McGraw Hill Education, 3rd edition, 2017.
3. Bose,TK, “High Temperature Gas Dynamics”,Springer-Verlag Berlin Heidelberg, 1st edition, 2004.
4. John T. Bertin, “Hypersonic Aerothermodynamics”, AIAA Education Series, 1993.
5. William H. Heiser&David T. Pratt, “Hypersonic Air Breathing propulsion”, AIAA Education Series, 1994.

AO4072 HIGH SPEED JET FLOWS L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To get insight into the basic aspects of jets and types of jets.
2. To learn the basic properties of jets and its characteristics.
3. To get knowledge on various active and passive jet control methods.
4. To gain knowledge into the basic aspects of jet acoustics
5. To acquire in-depth knowledge on how and what type of control methods can be implemented practically.

UNIT I INTRODUCTION 9

Properties of Turbulent Jets-Fundamental Concepts, Submerged Jets- Velocity Profiles in a Submerged Jet- Spread of a turbulent submerged jet- Lines of Constant Velocity in a Submerged Jet. Velocity Variation along the Axis of a Submerged jet, Velocity, Temperature, and Concentration Profiles in a Turbulent Jet Spreading into an External Stream of Fluid- Spread of a Turbulent Jet into a Co-flowing or Counter-flowing External Stream- Turbulence Characteristics in a Free Jet.

UNIT II JETS 9

Types of Jets-Plane free-jets. Round jets. Plane jets in a co-flowing stream. Round jet in Co flowing stream- Swirling jets-Radial jets- Wall jets- Jet Characteristics & Entrainment, Mathematical treatment of jet profiles- Semi-empirical Theories. Mixing Layers- Computational and Experimental Techniques for Studying the Jets.

UNIT III ACTIVE JETCONTROL METHODS 9

Active control methods- Actuators-Fluidic, Thermal, Acoustic, Piezoelectric, Electromagnetic, MEMS, Synthetic Jets, Controls and Sensors, Applications.

UNIT IV PASSIVE JET CONTROL METHODS 9

Passive control techniques- Tabs, Grooves, Chevrons, non-circular nozzles, Notches & wires, vortex generators. Optical Flow Visualization, Applications.

UNIT V JET ACOUSTICS 9

Introduction to Jet Acoustics – Types of jet noise – Source of generation- Travelling wave solution, standing wave solution – multi-dimensional acoustics-Theoretical Concepts of Jet Noise Generation and Suppression–Jet Noise suppression techniques – applications

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To acquire knowledge on the unique features of jet flows.
CO2: To analyse the characteristics of jets.
CO3: To have through knowledge on active and passive control methods of jets.
CO4: To acquire knowledge on jet acoustics and methods for suppression of jet noise.
CO5: To demonstrate various experimental techniques to determine jet characteristics.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	2	3	4	5	6
CO1			2		3	1
CO2	3		2	2	3	1
CO3			2	1	3	1
CO4			2		3	1
CO5	2		2	3	3	1
	1	0	2	1.2	3	1

REFERENCES:

1. Ethirajan Rathakrishnan, “Applied Gas Dynamics”, John Wiley, New York, 2010.
2. Liepmann and Roshko, “Elements of Gas Dynamics”, Dover Publishers, 2017.
3. Rathakrishnan E., “Gas Dynamics”, Prentice Hall of India, New Delhi, 5th edition, 2014.
4. Shapiro, AH, “Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I & II”, Ronald Press, New York, 1953.

AO4074 SMART MATERIALS AND STRUCTURAL HEALTH MONITORING L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To get basic idea on the fundamentals of structural health monitoring.
2. To impart knowledge in the areas of vibration based techniques in structural health monitoring, fibre optics and piezo electric sensors.
3. To gain knowledge on the fundamentals of fabrication, modelling, analysis, and design of smart materials and structures.
4. To get exposed to the state of the art of smart materials and systems,
5. To impart knowledge on spanning piezoelectrics, shape memory alloys, electro active polymers, mechanochromic materials and fibre optics.

UNIT I STRUCTURAL HEALTH MONITORING 8

An Overview of Structural Health Monitoring, Structural Health Monitoring and Smart Materials, Structural Health Monitoring versus Non Destructive Evaluation A broad Overview of Smart Materials Overview of Application Potential of SHM Notable Applications of SHM – Aerospace Engineering. Structural health monitoring of composites – Repair investigation using SHM.

UNIT II OVERVIEW OF SMART MATERIALS 10

Introduction to Smart Materials, Principles of Piezoelectricity, Perovskyte Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rheological Fluids.

UNIT III SMART COMPOSITES 10

Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beams , Vibration Control using SHM –introduction to FE formulation Constitutive Relationship - Element Stiffness Matrix for High Precision Finite Element -Element Mass Matrix for High Precision Finite Element - Developing Actuator and Sensor Influence Matrix .Delamination Sensing using Piezo Sensory Layer.

UNIT IV INTELLIGENT SYSTEMS AND NEURAL NETWORKS 9

Operational evaluation -.Data acquisition- Feature extraction-Statistical model development for feature discrimination -Data Cleansing – Normalization-Data Fusion – Compression – Statistical model building - Supervised pattern recognition - Unsupervised pattern recognition – Signal processing – Fuzzy C means- K means – Kohenon's Self organization mapping- Fundamentals of Wavelet analysis –Life Prediction.

UNIT V ADVANCES IN SMART STRUCTURES & MATERIALS 8

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design of Chemical and Bio-Chemical sensing in structural Assessment – Absorptive chemical sensors – Spectroscopes – Fibre Optic Chemical Sensing Systems and Distributed measurement.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To familiarize with the fundamentals of history of SHM.
CO2: To provide a systematic approach to SHM process.
CO3: To have knowledge of the various smart materials used for aerospace applications.
CO4: To familiarize with the non-destructive test techniques relevant to SHM.
CO5: To provide hands-on experience with experimental modal analysis.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	2	3	4	5	6
CO1	3		3		1	1
CO2			2		1	1
CO3			2		1	1
CO4	3		3		1	1
CO5			2		2	1

REFERENCES:

1. Brian Culshaw, "Smart Structures,and Materials", Artech House, 2000.
2. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, "Structural Health Monitoring", Wiley - ISTE, 2006.
3. Douglas E Adams, "Health Monitoring of Structural Materials and Components-Methods with Applications", John Wiley and Sons, 2007.
4. Gandhi and Thompson,"Smart Materials and Structures", Springer Netherlands, 1992.
5. Laurene Fausett**, "**Fundamentals Of Neural Networks",Pearson publishers, 1994
6. Victor Giurglutiu, "Structural Health Monitoring with Wafer Active Sensors", Academic Press Inc, 2007.

AS4016 **UNMANNED AERIAL SYSTEMS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To impart knowledge on the basic aspects of UAV and its types.
2. To realize the importance of airframe designs and types of propulsions in unmanned aerial vehicle.
3. Gain knowledge on various subsystems and testing procedure of an unmanned aerial vehicle.
4. To enhance the knowledge in the field of real time applications.
5. To get familiarize with the ground control procedures and operations.

UNIT I INTRODUCTION TO UAV **9**

History of UAV –classification –basic terminology-models and prototypes –applications

UNIT II BASICS OF AIRFRAME **9**

Airframe –dynamics –modeling- structures –wing design- engines and its types-equipment, maintenance and management-control surfaces-specifications.

UNIT III DEVELOPMENT OF UAS SYSTEM **9**

System Development- Ground Testing-UAV component testing-Uav Sub-assembly and Sub-System Testing- Testing Complete UAV, Environmental testing – Testing Complete UAV-Control Station testing-Catapult Launch systems -System In flight Testing- Test sites-Test Crew training-Onsite preparation - System Certification.

UNIT IV DEPLOYMENT OF UNMANNED AERIAL SYSTEM **9**

Operational trails-network centric operations-Radar confusion-Missile Decoy-radio relay-Electronic Intelligence-Covert Reconnaissance and surveillance Target designation by laser, NBC contamination Monitoring-Long Range reconnaissance and strike- Aerial photography-Information services-communication relay- landmine detection and Destruction-other applications

UNIT V COMMUNICATION PAYLOADS AND PATH PLANNING **9**

Payloads-Telemetry-tracking-Aerial photography, Frequency range – Commands- Control, FPV videos - Flight computer sensor-displays, RF modems, Simulation and ground testing, Trouble shooting, waypoints navigation and ground control software.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able

CO1: To classify UAVs based on different parameters.
CO2: To demonstrate ability to design an efficient structure for an UAV of specific application.
CO3: To perform ground testing of UAVs.
CO4: To apply the knowledge gained on electronic intelligence and target designation for successful development of UAS.
CO5: To understand the basic concepts in the different types of navigation schemes for UAS.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓				✓						
CO2	✓	✓			✓	✓						
CO3	✓	✓			✓	✓						
CO4	✓					✓						
CO5	✓				✓	✓						

REFERENCES:
1. Armand J. Chaput, “Design of Unmanned Air Vehicle Systems”, Lockheed Martin Aeronautics Company, 2001.
2. Kimon P. Valavanis, “Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy”, Springer, 2007.
3. Paul G Fahlstrom, Thomas J Gleason, “Introduction to UAV Systems”, UAV Systems, Inc, 1998.
4. Reg Austin, “Unmanned Aircraft systems-UAVs Design, Development and Deployment”, WILEY Publication, 2010.
5. Robert C. Nelson, “Flight Stability and Automatic Control”, McGraw-Hill, Inc, 1998.
6. Swatton ,PJ, “Ground studies for pilots’ flight planning”, 6th edition, 2008.

AS4017 RELIABILITY AND QUALITY L T P C
3 0 0 3

OBJECTIVES:
- Provide basic knowledge of quality and reliability in engineering
- Introduce analyses of quality concepts
- Develop skills to analyse quality culture in companies.

UNIT I FUNDEMENTALS OF RELIABILITY 9

Reliability engineering fundamentals- Failure data analysis, Failure rate, mortality curve, Concept of burn in period - Useful life and wear out phase of a system - Mean time to failure (MTTF) - Mean time between failure, (MTBF) and mean time to repair (MTTR) - Reliability in terms of Hazard rate and failure density, Conditional probability and multiplication rules.

UNIT II RELIABILITY OF SIMPLE SYSTEMS AND MAINTAINABILITY 9

Series and parallel configurations – Reliability improvement – redundancy – combined series and parallel systems – High level and low level redundancy – k-out of n system – standby redundancy. Maintainability – Factors affecting maintainability of systems – Design for maintainability – MTTR – Maintenance – spare provisioning.

UNIT III MODERN QUALITY MANAGEMENT 9

Definitions and Principles of Operation - Tools and Techniques - Quality Circles, 5 S Practice, Total Quality Control (TQC), Total Employee Involvement (TEI), Problem Solving Process, Quality Function Deployment (QFD), Failure Mode and Effect analysis (FMEA), Fault Tree Analysis (FTA), Kizen, Poka-Yoke, QC Tools, PDCA Cycle, Quality Improvement Tools.

UNIT IV CONTEMPORARY TRENDS 9

Concurrent Engineering - Lean Manufacturing, Agile Manufacturing - World Class Manufacturing - Cost of Quality (COQ) system - Bench Marking, Business Process Re-engineering, Six Sigma - Basic Concept, Principle, Methodology, Implementation, Scope, Advantages and Limitation.

UNIT V CONTROL CHARTS 9

Control charts for individual measurements - Exponentially Weighted Moving Average (EWMA) and Deviation (EWMD) charts - Control charts for variables - X-bar and R charts, X-bar and S charts - SPC - Variables Control charts- SPC - Attributer Control charts.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able

- Apply continuous improvement techniques and basic quality concepts in analysis
- Analyse a manufacturing process using appropriate control charts
- The student can identify different areas of Quality and Reliability Engineering.
- Can find the applications of all the areas in industry.
- Use software for SPC analysis

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	-	2	3
CO2	-	-	-	-	2	3
CO3	-	-	-	-	2	3
CO4	-	-	-	-	2	3
CO5	-	-	-	-	2	3

REFERENCES:

1. Reliability Engineering by Srinath L. S., Affiliated East West Press.
2. Quality Control & Application by B. L. Hanson & P. M. Ghare, Prentice Hall of India.
3. Montgomery D. C. – 'Introduction to Statistical Quality Control' – John Wiley – 2010
4. Ebeling C. – 'An Introduction to Reliability and Maintainability Engineering' – Tata McGraw Hill Publishing Company Ltd. – 2004.

AUDIT COURSES

AX4091 ENGLISH FOR RESEARCH PAPER WRITING **L T P C**
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING **6**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS **6**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS **6**

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS **6**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS **6**

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX4092 DISASTER MANAGEMENT **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA **6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT **6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX4093 CONSTITUTION OF INDIA L T P C
2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION

History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

SUGGESTED READING

- The Constitution of India,1950(Bare Act),Government Publication.
- Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution, 1st Edition, 2015.
- M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
- D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX4094 நற்றமிழ் இலக்கியம் **L T P C**
2 0 0 0

UNIT I சங்க இலக்கியம் **6**

1. தமிழின் துவக்க நூல் தொல்காப்பியம்
– எழுத்து, சொல், பொருள்
2. அகநானூறு (82)
- இயற்கை இன்னிசை அரங்கம்
3. குறிஞ்சிப் பாட்டின் மலர்க்காட்சி
4. புறநானூறு (95,195)
- போரை நிறுத்திய ஔவையார்

UNIT II அறநெறித் தமிழ் **6**

1. அறநெறி வகுத்த திருவள்ளுவர்
- அறம் வலியுறுத்தல், அன்புடைமை, ஒப்புரவறிதல், ஈகை, புகழ்
2. பிற அறநூல்கள் - இலக்கிய மருந்து
– ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை (தூய்மையை வலியுறுத்தும் நூல்)

UNIT III **இரட்டைக் காப்பியங்கள்** **6**

1. கண்ணகியின் புரட்சி
   - சிலப்பதிகார வழக்குரை காதை
2. சமூகசேவை இலக்கியம் மணிமேகலை
   - சிறைக்கோட்டம் அறக்கோட்டமாகிய காதை

UNIT IV **அருள்நெறித் தமிழ்** **6**

1. சிறுபாணாற்றுப்படை
   - பாரி முல்லைக்குத் தேர் கொடுத்தது, பேகன் மயிலுக்குப் போர்வை கொடுத்தது, அதியமான் ஔவைக்கு நெல்லிக்கனி கொடுத்தது, அரசர் பண்புகள்
2. நற்றிணை
   - அன்னைக்குரிய புன்னை சிறப்பு
3. திருமந்திரம் (617, 618)
   - இயமம் நியமம் விதிகள்
4. தர்மச்சாலையை நிறுவிய வள்ளலார்
5. புறநானூறு
   - சிறுவனே வள்ளலானான்
6. அகநானூறு (4) - வண்டு
   நற்றிணை (11) - நண்டு
   கலித்தொகை (11) - யானை, புறா
   ஐ ஐந்திணை 50 (27) - மான்
   ஆகியவை பற்றிய செய்திகள்

UNIT V **நவீன தமிழ் இலக்கியம்** **6**

1. உரைநடைத் தமிழ்,
   - தமிழின் முதல் புதினம்,
   - தமிழின் முதல் சிறுகதை,
   - கட்டுரை இலக்கியம்,
   - பயண இலக்கியம்,
   - நாடகம்,
2. நாட்டு விடுதலை போராட்டமும் தமிழ் இலக்கியமும்,
3. சமுதாய விடுதலையும் தமிழ் இலக்கியமும்,
4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும்,
5. அறிவியல் தமிழ்,
6. இணையத்தில் தமிழ்,
7. சுற்றுச்சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்.

TOTAL: 30 PERIODS

தமிழ் இலக்கிய வெளியீடுகள் / புத்தகங்கள்

1. தமிழ் இணைய கல்விக்கழகம் (Tamil Virtual University)
- www.tamilvu.org
2. தமிழ் விக்கிப்பீடியா (Tamil Wikipedia)
-https://ta.wikipedia.org
3. தர்மபுர ஆதீன வெளியீடு
4. வாழ்வியல் களஞ்சியம்
- தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்
5. தமிழ்கலைக் களஞ்சியம்
- தமிழ் வளர்ச்சித் துறை (thamilvalarchithurai.com)
6. அறிவியல் களஞ்சியம்
- தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்

OCE431 INTEGRATED WATER RESOURCES MANAGEMENT L T P C
3 0 0 3

OBJECTIVE

- Students will be introduced to the concepts and principles of IWRM, which is inclusive of the economics, public-private partnership, water & health, water & food security and legal & regulatory settings.

UNIT I CONTEXT FOR IWRM 9

Water as a global issue: key challenges – Definition of IWRM within the broader context of development – Key elements of IWRM - Principles – Paradigm shift in water management - Complexity of the IWRM process – UN World Water Assessment - SDGs.

UNIT II WATER ECONOMICS 9

Economic view of water issues: economic characteristics of water good and services – Non-market monetary valuation methods – Water economic instruments – Private sector involvement in water resources management: PPP objectives, PPP models, PPP processes, PPP experiences through case studies.

UNIT III LEGAL AND REGULATORY SETTINGS 9

Basic notion of law and governance: principles of international and national law in the area of water management - Understanding UN law on non-navigable uses of international water courses – International law for groundwater management – World Water Forums – Global Water Partnerships - Development of IWRM in line with legal and regulatory framework.

UNIT IV WATER AND HEALTH WITHIN THE IWRM CONTEXT 9

Links between water and health: options to include water management interventions for health – Health protection and promotion in the context of IWRM – Global burden of Diseases - Health impact assessment of water resources development projects – Case studies.

UNIT V AGRICULTURE IN THE CONCEPT OF IWRM 9

Water for food production: 'blue' versus 'green' water debate – Water foot print - Virtual water trade for achieving global water and food security –- Irrigation efficiencies, irrigation methods - current water pricing policy– scope to relook pricing.

TOTAL: 45 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to

CO1	Describe the context and principles of IWRM; Compare the conventional and integrated ways of water management.
CO2	Select the best economic option among the alternatives; illustrate the pros and cons of PPP through case studies.
CO3	Apply law and governance in the context of IWRM.
CO4	Discuss the linkages between water-health; develop a HIA framework.
CO5	Analyse how the virtual water concept pave way to alternate policy options.

REFERENCES:

1. Cech Thomas V., Principles of water resources: history, development, management and policy. John Wiley and Sons Inc., New York. 2003.
2. Mollinga .P. etal " Integrated Water Resources Management", Water in South Asia Volume I, Sage Publications, 2006.

3. Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.
4. Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.
5. Technical Advisory Committee, Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003.

OCE432 WATER, SANITATION AND HEALTH L T P C
3 0 0 3

OBJECTIVES:

- Understand the accelerating health impacts due to the present managerial aspects and initiatives in water and sanitation and health sectors in the developing scenario

UNIT I FUNDAMENTALS WASH 9

Meanings and Definition: Safe Water- Health, Nexus: Water- Sanitation - Health and Hygiene – Equity issues-Water security - Food Security. Sanitation And Hygiene (WASH) and Integrated Water Resources Management (IWRM) - Need and Importance of WASH

UNIT II MANAGERIAL IMPLICATIONS AND IMPACT 9

Third World Scenario – Poor and Multidimensional Deprivation--Health Burden in Developing Scenario -Factors contribute to water, sanitation and hygiene related diseases-Social: Social Stratification and Literacy Demography: Population and Migration- Fertility - Mortality-Environment: Water Borne-Water Washed and Water Based Diseases - Economic: Wage - Water and Health Budgeting -Psychological: Non-compliance - Disease Relapse - Political: Political Will.

UNIT III CHALLENGES IN MANAGEMENT AND DEVELOPMENT 9

Common Challenges in WASH - Bureaucracy and Users- Water Utilities -Sectoral Allocation:- Infrastructure- Service Delivery: Health services: Macro and Micro- level: Community and Gender Issues- Equity Issues - Paradigm Shift: Democratization of Reforms and Initiatives.

UNIT IV GOVERNANCE 9

Public health -Community Health Assessment and Improvement Planning (CHA/CHIP)-Infrastructure and Investments on Water, (WASH) - Cost Benefit Analysis – Institutional Intervention-Public Private Partnership - Policy Directives - Social Insurance -Political Will vs Participatory Governance -

UNIT V INITIATIVES 9

Management vs Development -Accelerating Development- Development Indicators -Inclusive Development-Global and Local- Millennium Development Goal (MDG) and Targets - Five Year Plans - Implementation - Capacity Building - Case studies on WASH.

TOTAL: 45 PERIODS

OUTCOMES:

CO1	Capture to fundamental concepts and terms which are to be applied and understood all through the study.
CO2	Comprehend the various factors affecting water sanitation and health through the lens of third world scenario.
CO3	Critically analyse and articulate the underlying common challenges in water, sanitation and health.
CO4	Acquire knowledge on the attributes of governance and its say on water sanitation and health.
CO5	Gain an overarching insight in to the aspects of sustainable resource management in the absence of a clear level playing field in the developmental aspects.

REFERENCES

1. Bonitha R., Beaglehole R.,Kjellstorm, 2006, "Basic Epidemiology", 2nd Edition, World Health Organization.
2. Van Note Chism, N. and Bickford, D. J. (2002), Improving the environment for learning: An expanded agenda. New Directions for Teaching and Learning, 2002: 91–98. doi: 10.1002/tl.83Improving the Environment for learning: An Expanded Agenda
3. National Research Council. *Global Issues in Water, Sanitation, and Health: Workshop Summary***.** Washington, DC: The National Academies Press, 2009.
4. Sen, Amartya 1997. On Economic Inequality. Enlarged edition, with annex by JamesFoster and Amartya Sen, Oxford: Claredon Press, 1997.
5. Intersectoral Water Allocation Planning and Management, 2000, World Bank Publishers www. Amazon.com
6. Third World Network.org (www.twn.org).

OCE433 PRINCIPLES OF SUSTAINABLE DEVELOPMENT L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge on environmental, social and economic dimensions of sustainability and the principles evolved through landmark events so as to develop an action mindset for sustainable development.

UNIT I SUSTAINABILITY AND DEVELOPMENT CHALLEGES 9

Definition of sustainability – environmental, economical and social dimensions of sustainability - sustainable development models – strong and weak sustainability – defining development-millennium development goals – mindsets for sustainability: earthly, analytical, precautionary, action and collaborative– syndromes of global change: utilisation syndromes, development syndromes, and sink syndromes – core problems and cross cutting Issues of the 21 century - global, regional and local environmental issues – social insecurity - resource degradation – climate change – desertification.

UNIT II PRINCIPLES AND FRAME WORK 9

History and emergence of the concept of sustainable development - our common future - Stockholm to Rio plus 20– Rio Principles of sustainable development – Agenda 21 natural step-peoples earth charter – business charter for sustainable development –UN Global Compact - Role of civil society, business and government – United Nations' 2030 Agenda for sustainable development – 17 sustainable development goals and targets, indicators and intervention areas

UNIT III SUSTAINABLE DEVELOPMENT AND WELLBEING 9

The Unjust World and inequities - Quality of Life - Poverty, Population and Pollution - Combating Poverty - - Demographic dynamics of sustainability - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of Women, Children, Youth, Indigenous People, Non-Governmental Organizations, Local Authorities and Industry for Prevention, Precaution , Preservation and Public participation.

UNIT IV SUSTAINABLE SOCIO-ECONOMIC SYSTEMS 10

Sustainable Development Goals and Linkage to Sustainable Consumption and Production – Investing in Natural Capital- Agriculture, Forests, Fisheries - Food security and nutrition and sustainable agriculture- Water and sanitation - Biodiversity conservation and Ecosystem integrity –Ecotourism - Sustainable Cities – Sustainable Habitats- Green Buildings - Sustainable Transportation –– Sustainable Mining - Sustainable Energy– Climate Change –Mitigation and Adaptation - Safeguarding Marine Resources - Financial Resources and Mechanisms

UNIT V ASSESSING PROGRESS AND WAY FORWARD 8

Nature of sustainable development strategies and current practice**-** Sustainability in global, regional and national context –Approaches to measuring and analysing sustainability– limitations of GDP- Ecological Footprint- Human Development Index- Human Development Report – National initiatives for Sustainable Development - Hurdles to Sustainability - Science and Technology for sustainable development –Performance indicators of sustainability and Assessment mechanism – Inclusive Green Growth and Green Economy – National Sustainable Development Strategy Planning and National Status of Sustainable Development Goals

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Explain and evaluate current challenges to sustainability, including modern world social, environmental, and economic structures and crises.
CO2	Identify and critically analyze the social environmental, and economic dimensions of sustainability in terms of UN Sustainable development goals
CO3	Develop a fair understanding of the social, economic and ecological linkage of Human well being, production and consumption
CO4	Evaluate sustainability issues and solutions using a holistic approach that focuses on connections between complex human and natural systems.
CO5	Integrate knowledge from multiple sources and perspectives to understand environmental limits governing human societies and economies and social justice dimensions of sustainability.

REFERENCES:

1. Tom Theis and Jonathan Tomkin, Sustainability: A Comprehensive Foundation, Rice University, Houston, Texas, 2012
2. A guide to SDG interactions:from science to implementation, International Council for Science, Paris,2017
3. Karel Mulder, Sustainable Development for Engineers - A Handbook and Resource Guide, Rouledge Taylor and Francis, 2017.
4. The New Global Frontier - Urbanization, Poverty and Environmentin the 21st Century - *George Martine,Gordon McGranahan,Mark Montgomery and Rogelio Fernández-Castilla,* IIED and UNFPA, Earthscan, UK, 2008

5. Nolberto Munier, Introduction to Sustainability: Road to a Better Future, Springer, 2006
6. Barry Dalal Clayton and Stephen Bass, Sustainable Development Strategies- a resource book", Earthscan Publications Ltd, London, 2002.

OCE434 ENVIRONMENTAL IMPACT ASSESSMENT L T P C
3 0 0 3

OBJECTIVES:

- To make the students to understand environmental clearance, its legal requirements and to provide knowledge on overall methodology of EIA, prediction tools and models, environmental management plan and case studies.

UNIT I INTRODUCTION 9

Historical development of Environmental Impact Assessment (EIA). Environmental Clearance- EIA in project cycle. legal and regulatory aspects in India – types and limitations of EIA –EIA process- screening – scoping - terms of reference in EIA- setting – analysis – mitigation. Cross sectoral issues –public hearing in EIA- EIA consultant accreditation.

UNIT II IMPACT INDENTIFICATION AND PREDICTION 10

Matrices – networks – checklists – cost benefit analysis – analysis of alternatives – expert systems in EIA. prediction tools for EIA – mathematical modeling for impact prediction – assessment of impacts – air – water – soil – noise – biological — cumulative impact assessment

UNIT III SOCIO-ECONOMIC IMPACT ASSESSMENT 8

Socio-economic impact assessment - relationship between social impacts and change in community and institutional arrangements. factors and methodologies- individual and family level impacts. communities in transition-rehabilitation

UNIT IV EIA DOCUMENTATION AND ENVIRONMENTAL MANAGEMENT PLAN 9

Environmental management plan - preparation, implementation and review – mitigation and rehabilitation plans – policy and guidelines for planning and monitoring programmes – post project audit – documentation of EIA findings – ethical and quality aspects of environmental impact assessment

UNIT V CASE STUDIES 9

Mining, power plants, cement plants, highways, petroleum refining industry, storage & handling of hazardous chemicals, common hazardous waste facilities, CETPs, CMSWMF, building and construction projects

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Understand need for environmental clearance, its legal procedure, need of EIA, its types, stakeholders and their roles
CO2	Understand various impact identification methodologies, prediction techniques and model of impacts on various environments
CO3	Understand relationship between social impacts and change in community due to development activities and rehabilitation methods
CO4	Document the EIA findings and prepare environmental management and monitoring plan
CO5	Identify, predict and assess impacts of similar projects based on case studies

REFERENCES:

1. EIA Notification 2006 including recent amendments, by Ministry of Environment, Forest and Climate Change, Government of India
2. Sectoral Guidelines under EIA Notification by Ministry of Environment, Forest and Climate Change, Government of India
3. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York. 1996
4. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey. 2003
5. Lee N. and George C. 2000. Environmental Assessment in Developing and Transitional Countries. Chichester: Willey
6. World Bank –Source book on EIA ,1999
7. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

OIC431 BLOCKCHAIN TECHNOLOGIES L T P C
3 0 0 3

COURSE OBJECTIVES:

- This course is intended to study the basics of Blockchain technology.
- During this course the learner will explore various aspects of Blockchain technology like application in various domains.
- By implementing, learners will have idea about private and public Blockchain, and smart contract.

UNIT I INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN 9

Introduction to Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain.

UNIT II BITCOIN AND CRYPTOCURRENCY 9

Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency.

UNIT III INTRODUCTION TO ETHEREUM 9

Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts.

UNIT-IV INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING 10

Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types.

UNIT V BLOCKCHAIN APPLICATIONS 8

Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After the completion of this course, student will be able to

CO1: Understand and explore the working of Blockchain technology

CO2: Analyze the working of Smart Contracts

CO3: Understand and analyze the working of Hyperledger
CO4: Apply the learning of solidity to build de-centralized apps on Ethereum
CO5: Develop applications on Blockchain

REFERENCES:

1. Imran Bashir, "Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained", Second Edition, Packt Publishing, 2018.
2. Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction" Princeton University Press, 2016
3. Antonopoulos, Mastering Bitcoin, O'Reilly Publishing, 2014. .
4. Antonopoulos and G. Wood, "Mastering Ethereum: Building Smart Contracts and Dapps", O'Reilly Publishing, 2018.
5. D. Drescher, Blockchain Basics. Apress, 2017.

CO-PO Mapping

CO	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
1	2	1	3	2	2	3
2	2	1	2	3	2	2
3	2	1	3	1	2	1
4	2	1	2	3	2	2
5						
Avg	2.00	1.00	2.50	2.25	2.00	2.00

OIC432 DEEP LEARNING **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- Develop and Train Deep Neural Networks.
- Develop a CNN, R-CNN, Fast R-CNN, Faster-R-CNN, Mask-RCNN for detection and recognition
- Build and train RNNs, work with NLP and Word Embeddings
- The internal structure of LSTM and GRU and the differences between them
- The Auto Encoders for Image Processing

UNIT I DEEP LEARNING CONCEPTS **6**

Fundamentals about Deep Learning. Perception Learning Algorithms. Probabilistic modelling. Early Neural Networks. How Deep Learning different from Machine Learning. Scalars. Vectors. Matrixes, Higher Dimensional Tensors. Manipulating Tensors. Vector Data. Time Series Data. Image Data. Video Data.

UNIT II NEURAL NETWORKS **9**

About Neural Network. Building Blocks of Neural Network. Optimizers. Activation Functions. Loss Functions. Data Pre-processing for neural networks, Feature Engineering. Overfitting and Underfitting. Hyperparameters.

UNIT III CONVOLUTIONAL NEURAL NETWORK **10**

About CNN. Linear Time Invariant. Image Processing Filtering. Building a convolutional neural network. Input Layers, Convolution Layers. Pooling Layers. Dense Layers. Backpropagation Through the Convolutional Layer. Filters and Feature Maps. Backpropagation Through the Pooling Layers. Dropout Layers and Regularization. Batch Normalization. Various Activation Functions. Various Optimizers. LeNet, AlexNet, VGG16, ResNet. Transfer Learning with Image Data. Transfer

Learning using Inception Oxford VGG Model, Google Inception Model, Microsoft ResNet Model. R-CNN, Fast R-CNN, Faster R-CNN, Mask-RCNN, YOLO

UNIT VI NATURAL LANGUAGE PROCESSING USING RNN 10

About NLP & its Toolkits. Language Modeling . Vector Space Model (VSM). Continuous Bag of Words (CBOW). Skip-Gram Model for Word Embedding. Part of Speech (PoS) Global Co-occurrence Statistics–based Word Vectors. Transfer Learning. Word2Vec. Global Vectors for Word Representation GloVe. Backpropagation Through Time. Bidirectional RNNs (BRNN) . Long Short Term Memory (LSTM). Bi-directional LSTM. Sequence-to-Sequence Models (Seq2Seq). Gated recurrent unit GRU.

UNIT V DEEP REINFORCEMENT & UNSUPERVISED LEARNING 10

About Deep Reinforcement Learning. Q-Learning. Deep Q-Network (DQN). Policy Gradient Methods. Actor-Critic Algorithm. About Autoencoding. Convolutional Auto Encoding. Variational Auto Encoding. Generative Adversarial Networks. Autoencoders for Feature Extraction. Auto Encoders for Classification. Denoising Autoencoders. Sparse Autoencoders

COURSE OUTCOMES:

CO1: Feature Extraction from Image and Video Data
CO2: Implement Image Segmentation and Instance Segmentation in Images
CO3: Implement image recognition and image classification using a pretrained network (Transfer Learning)
CO4: Traffic Information analysis using Twitter Data
CO5: Autoencoder for Classification & Feature Extraction

TOTAL : 45 PERIODS

REFERENCES

1. Deep Learning A Practitioner's Approach Josh Patterson and Adam Gibson O'Reilly Media, Inc.2017
2. Learn Keras for Deep Neural Networks, Jojo Moolayil, Apress,2018
3. Deep Learning Projects Using TensorFlow 2, Vinita Silaparasetty, Apress, 2020
4. Deep Learning with Python, FRANÇOIS CHOLLET, MANNING SHELTER ISLAND,2017
5. Pro Deep Learning with TensorFlow, Santanu Pattanayak, Apress,2017

OBA431 SUSTAINABLE MANAGEMENT LT P C
3 0 0 3

COURSE OBJECTIVES:

- To provide students with fundamental knowledge of the notion of corporate sustainability.
- To determine how organizations impacts on the environment and socio-technical systems, the relationship between social and environmental performance and competitiveness, the approaches and methods.

UNIT I MANAGEMENT OF SUSTAINABILITY 9

Management of sustainability -rationale and political trends: An introduction to sustainability management, International and European policies on sustainable development, theoretical pillars in sustainability management studies.

UNIT II CORPORATE SUSTAINABILITY AND RESPONSIBILITY 9

Corporate sustainability parameter, corporate sustainability institutional framework, integration of sustainability into strategic planning and regular business practices, fundamentals of stakeholder engagement.

UNIT III SUSTAINABILITY MANAGEMENT: STRATEGIES AND APPROACHES 9

Corporate sustainability management and competitiveness: Sustainability-oriented corporate strategies, markets and competitiveness, Green Management between theory and practice, Sustainable Consumption and Green Marketing strategies, Environmental regulation and strategic postures; Green Management approaches and tools; Green engineering: clean technologies and innovation processes; Sustainable Supply Chain Management and Procurement.

UNIT IV SUSTAINABILITY AND INNOVATION 9

Socio-technical transitions and sustainability, Sustainable entrepreneurship, Sustainable pioneers in green market niches, Smart communities and smart specializations.

UNIT V SUSTAINABLE MANAGEMENT OF RESOURCES, COMMODITIES AND COMMONS 9

Energy management, Water management, Waste management, Wild Life Conservation, Emerging trends in sustainable management, Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: An understanding of sustainability management as an approach to aid in evaluating and minimizing environmental impacts while achieving the expected social impact.
CO2: An understanding of corporate sustainability and responsible Business Practices
CO3: Knowledge and skills to understand, to measure and interpret sustainabilityperformances.
CO4: Knowledge of innovative practices in sustainable business and community management
CO5: Deep understanding of sustainable management of resources and commodities

REFERENCES:

1. Daddi, T., Iraldo, F., Testa, Environmental Certification for Organizations and Products: Management, 2015
2. Christian N. Madu, Handbook of Sustainability Management 2012
3. Petra Molthan-Hill, The Business Student's Guide to Sustainable Management: Principles and Practice, 2014
4. Margaret Robertson, Sustainability Principles and Practice, 2014
5. Peter Rogers, An Introduction to Sustainable Development, 2006

OBA432 MICRO AND SMALL BUSINESS MANAGEMENT L T P C
3 0 0 3

COURSE OBJECTIVES

- To familiarize students with the theory and practice of small business management.
- To learn the legal issues faced by small business and how they impact operations.

UNIT I INTRODUCTION TO SMALL BUSINESS 9

Creation, Innovation, entrepreneurship and small business - Defining Small Business –Role of Owner – Manager – government policy towards small business sector –elements of entrepreneurship –evolution of entrepreneurship –Types of Entrepreneurship – social, civic, corporate - Business life cycle - barriers and triggers to new venture creation – process to assist start ups – small business and family business.

UNIT II SCREENING THE BUSINESS OPPORTUNITY AND FORMULATING THE BUSINESS PLAN 9

Concepts of opportunity recognition; Key factors leading to new venture failure; New venture screening process; Applying new venture screening process to the early stage small firm Role planning in small business – importance of strategy formulation – management skills for small business creation and development.

UNIT III BUILDING THE RIGHT TEAM AND MARKETING STRATEGY 9

Management and Leadership – employee assessments – Tuckman's stages of group development - The entrepreneurial process model - Delegation and team building - Comparison of HR management in small and large firms - Importance of coaching and how to apply a coaching model.

Marketing within the small business - success strategies for small business marketing - customer delight and business generating systems, - market research, - assessing market performance- sales management and strategy - the marketing mix and marketing strategy.

UNIT IV FINANCING SMALL BUSINESS 9

Main sources of entrepreneurial capital; Nature of 'bootstrap' financing - Difference between cash and profit - Nature of bank financing and equity financing - Funding-equity gap for small firms. Importance of working capital cycle - Calculation of break-even point - Power of gross profit margin- Pricing for profit - Credit policy issues and relating these to cash flow management and profitability.

UNIT V VALUING SMALL BUSINESS AND CRISIS MANAGEMENT 9

Causes of small business failure - Danger signals of impending trouble - Characteristics of poorly performing firms - Turnaround strategies - Concept of business valuation - Different valuation measurements - Nature of goodwill and how to measure it - Advantages and disadvantages of buying an established small firm - Process of preparing a business for sale.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1. Familiarise the students with the concept of small business
CO2. In depth knowledge on small business opportunities and challenges
CO3. Ability to devise plans for small business by building the right skills and marketing strategies
CO4. Identify the funding source for small start ups
CO5. Business evaluation for buying and selling of small firms

REFERENCES

1. Hankinson,A.(2000). "The key factors in the profile of small firm owner-managers that influence business performance. The South Coast Small Firms Survey, 1997-2000." Industrial and Commercial Training 32(3):94-98.
2. Parker,R.(2000). "Small is not necessarily beautiful: An evaluation of policy support for small and medium-sized enterprise in Australia." Australian Journal of Political Science 35(2):239-253.
3. Journal articles on SME's.

MAPPING OF POs AND COs

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	-	-
CO2	3	3	3	3	2	3
CO3	3	3	2	2	3	3
CO4	3	2	2	2	1	1
CO5	3	2	2	3	2	1

OBA433 **INTELLECTUAL PROPERTY RIGHTS** **L T P C**
3 0 0 3

COURSE OBJECTIVE

- To understand intellectual property rights and its valuation.

UNIT I INTRODUCTION **9**

Intellectual property rights - Introduction, Basic concepts, Patents, Copyrights, Trademarks, Trade Secrets, Geographic Indicators; Nature of Intellectual Property, Technological Research, Inventions and Innovations, History - the way from WTO to WIPO, TRIPS.

UNIT II PROCESS **9**

New Developments in IPR, Procedure for grant of Patents, TM, GIs, Patenting under Patent Cooperation Treaty, Administration of Patent system in India, Patenting in foreign countries.

UNIT III STATUTES **9**

International Treaties and conventions on IPRs, The TRIPs Agreement, PCT Agreement, The Patent Act of India, Patent Amendment Act (2005), Design Act, Trademark Act, Geographical Indication Act, Bayh- Dole Act and Issues of Academic Entrepreneurship.

UNIT IV STRATEGIES IN INTELLECTUAL PROPERTY **9**

Strategies for investing in R&D, Patent Information and databases, IPR strength in India, Traditional Knowledge, Case studies.

UNIT V MODELS **9**

The technologies Know-how, concept of ownership, Significance of IP in Value Creation, IP Valuation and IP Valuation Models, Application of Real Option Model in Strategic Decision Making, Transfer and Licensing.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: Understanding of intellectual property and appreciation of the need to protect it
CO2: Awareness about the process of patenting
CO3: Understanding of the statutes related to IPR
CO4: Ability to apply strategies to protect intellectual property
CO5: Ability to apply models for making strategic decisions related to IPR

REFERENCES

1. V. Sople Vinod, Managing Intellectual Property by (Prentice hall of India Pvt.Ltd), 2006.
2. Intellectual Property rights and copyrights, EssEss Publications.
3. Primer, R. Anita Rao and Bhanoji Rao, Intellectual Property Rights, Lastain Book company.
4. Edited by Derek Bosworth and Elizabeth Webster, The Management of Intellectual Property, Edward Elgar Publishing Ltd., 2006.
5. WIPO Intellectual Property Hand book.

MAPPING OF POs AND COs

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	2	3	1	3
CO3	3	3	3	3	2	3
CO4	3	3	3	2	1	3
CO5	3	3	3	2	2	3

OBA434 **ETHICAL MANAGEMENT** **L T P C**
3 0 0 3

COURSE OBJECTIVE

- To help students develop knowledge and competence in ethical management and decision making in organizational contexts.

UNIT I ETHICS AND SOCIETY **9**

Ethical Management- Definition, Motivation, Advantages-Practical implications of ethical management. Managerial ethics, professional ethics, and social Responsibility-Role of culture and society's expectations- Individual and organizational responsibility to society and the community.

UNIT II ETHICAL DECISION MAKING AND MANAGEMENT IN A CRISIS **9**

Managing in an ethical crisis, the nature of a crisis, ethics in crisis management, discuss case studies, analyze real-world scenarios, develop ethical management skills, knowledge, and competencies. Proactive crisis management.

UNIT III STAKEHOLDERS IN ETHICAL MANAGEMENT **9**

Stakeholders in ethical management, identifying internal and external stakeholders, nature of stakeholders, ethical management of various kinds of stakeholders: customers (product and service issues), employees (leadership, fairness, justice, diversity) suppliers, collaborators, business, community, the natural environment (the sustainability imperative, green management, Contemporary issues).

UNIT IV INDIVIDUAL VARIABLES IN ETHICAL MANJAGEMENT **9**

Understanding individual variables in ethics, managerial ethics, concepts in ethical psychology-ethical awareness, ethical courage, ethical judgment, ethical foundations, ethical emotions/intuitions/intensity. Utilization of these concepts and competencies for ethical decision-making and management.

UNIT V PRACTICAL FIELD-GUIDE, TECHNIQUES AND SKILLS **9**

Ethical management in practice, development of techniques and skills, navigating challenges and dilemmas, resolving issues and preventing unethical management proactively. Role modelling and creating a culture of ethical management and human flourishing.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: Role modelling and influencing the ethical and cultural context.
CO2: Respond to ethical crises and proactively address potential crises situations.
CO3: Understand and implement stakeholder management decisions.
CO4: Develop the ability, knowledge, and skills for ethical management.
CO5: Develop practical skills to navigate, resolve and thrive in management situations

REFERENCES

1. Brad Agle, Aaron Miller, Bill O' Rourke, The Business Ethics Field Guide: the essential companion to leading your career and your company, 2016.
2. Steiner & Steiner, Business, Government & Society: A managerial Perspective, 2011.
3. Lawrence & Weber, Business and Society: Stakeholders, Ethics, Public Policy, 2020.

MAPPING OF POs AND COs

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2		3	2	3	1	3
CO3	3	3	3	3	2	3

CO4	3	3	3	2	1	3
CO5	3	3	3	2	2	3

ET4251 IoT FOR SMART SYSTEMS LT P C
3 0 0 3

COURSE OBJECTIVES:

1. To study about **Internet of Things** technologies and its role in real time applications.
2. To introduce the infrastructure required for IoT
3. To familiarize the accessories and communication techniques for IoT.
4. To provide insight about the embedded processor and sensors required for IoT
5. To familiarize the different platforms and Attributes for IoT

UNIT I INTRODUCTION TO INTERNET OF THINGS 9

Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications.

UNIT II IOT ARCHITECTURE 9

IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture**,** IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.

UNIT III PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT 9

PROTOCOLS:

NFC, SCADA and RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell.

Wireless technologies for IoT: WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems-Recent trends.

UNIT IV IOT PROCESSORS 9

Services/Attributes: Big-Data Analytics for IOT, Dependability,Interoperability, Security, Maintainability.

Embedded processors for IOT :Introduction to Python programming -Building IOT with RASPERRY PI and Arduino.

UNIT V CASE STUDIES 9

Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, the students will have the ability to

CO1: Analyze the concepts of IoT and its present developments.

CO2: Compare and contrast different platforms and infrastructures available for IoT

CO3: Explain different protocols and communication technologies used in IoT

CO4: Analyze the big data analytic and programming of IoT
CO5: Implement IoT solutions for smart applications

CO	PO					
	1	2	3	4	5	6
1	1	2	1	-	-	-
2	-	2	-	-	-	-
3	1	2	-	1	3	-
4	2		3	3	3	3
5	3	2	3	3	3	3
Avg.	1.75	2	2.33	2.33	3	2

REFERENCES:

1. ArshdeepBahga and VijaiMadisetti : A Hands-on Approach "Internet of Things",Universities Press 2015.
2. Oliver Hersent , David Boswarthick and Omar Elloumi " The Internet of Things", Wiley,2016.
3. Samuel Greengard, " The Internet of Things", The MIT press, 2015.
4. Adrian McEwen and Hakim Cassimally"Designing the Internet of Things "Wiley,2014.
5. Jean- Philippe Vasseur, Adam Dunkels, "Interconnecting Smart Objects with IP: The Next Internet" Morgan Kuffmann Publishers, 2010.
6. Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley and sons, 2014.
7. Lingyang Song/DusitNiyato/ Zhu Han/ Ekram Hossain," Wireless Device-to-Device Communications and Networks, CAMBRIDGE UNIVERSITY PRESS,2015.
8. OvidiuVermesan and Peter Friess (Editors), "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series in Communication, 2013.
9. Vijay Madisetti , ArshdeepBahga, "Internet of Things (A Hands on-Approach)", 2014.
10. Zach Shelby, Carsten Bormann, "6LoWPAN: The Wireless Embedded Internet", John Wiley and sons, 2009.
11. Lars T.Berger and Krzysztof Iniewski, "Smart Grid applications, communications and security", Wiley, 2015.
12. JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, " Smart Grid Technology and Applications", Wiley, 2015.
13. UpenaDalal,"Wireless Communications & Networks,Oxford,2015.

ET4072 MACHINE LEARNING AND DEEP LEARNING L T P C

3 0 0 3

COURSE OBJECTIVES:

The course is aimed at

1. Understanding about the learning problem and algorithms
2. Providing insight about neural networks
3. Introducing the machine learning fundamentals and significance

4. Enabling the students to acquire knowledge about pattern recognition.
5. Motivating the students to apply deep learning algorithms for solving real life problems.

UNIT I LEARNING PROBLEMS AND ALGORITHMS 9

Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms

UNIT II NEURAL NETWORKS 9

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning.

UNIT III MACHINE LEARNING – FUNDAMENTALS & FEATURE SELECTIONS & CLASSIFICATIONS 9

Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.

UNIT IV DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS 9 Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.

UNIT V DEEP LEARNING: RNNS, AUTOENCODERS AND GANS 9 State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs

TOTAL : 45 PERIODS

COURSE OUTCOMES (CO):

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

CO1 : Illustrate the categorization of machine learning algorithms.

CO2: Compare and contrast the types of neural network architectures, activation functions

CO3: Acquaint with the pattern association using neural networks

CO4: Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks

CO5: Construct different feature selection and classification techniques and advanced neural network architectures such as RNN, Autoencoders, and GANs.

CO	PO					
	1	2	3	4	5	6
1	1	3	1	-	-	-
2	2	3	2	-	-	-
3	3	-	3	-	3	-
4	2	3	3	-	-	-
5	3	3	3	-	3	-
6	3	3	3	-	3	-
7	3	3	3	-	3	-
Avg.	2.42	3	2.57	-	3	-

REFERENCES:

1. J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
2. Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.
3. The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009.
4. Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.
5. Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.

PX4012 RENEWABLE ENERGY TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES:

To impart knowledge on

- Different types of renewable energy technologies
- Standalone operation, grid connected operation of renewable energy systems

UNIT I INTRODUCTION 9

Classification of energy sources – Co2 Emission - Features of Renewable energy - Renewable energy scenario in India -Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment Per Capital Consumption - CO_2 Emission - importance of renewable energy sources, Potentials – Achievements– Applications.

UNIT II SOLAR PHOTOVOLTAICS 9

Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector-Estimating Solar Radiation Empirically - Equivalent circuit of PV Cell- Photovoltaic cell-characteristics: P-V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics-Shading Impacts on I-V characteristics-Bypass diode -Blocking diode.

UNIT III PHOTOVOLTAIC SYSTEM DESIGN 9

Block diagram of solar photo voltaic system : Line commutated converters (inversion mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing - PV systems classification- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

UNIT IV WIND ENERGY CONVERSION SYSTEMS 9

Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz's limit-Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine- Aerodynamic Efficiency-Tip Speed-Tip Speed Ratio-Solidity-Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid connection Issues - Grid integrated SCIG and PMSG based WECS.

UNIT V OTHER RENEWABLE ENERGY SOURCES 9

Qualitative study of different renewable energy resources: ocean, Biomass, Hydrogen energy systems, Fuel cells, Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy, Geothermal Energy Resources.

TOTAL : 45 PERIODS

OUTCOMES:

After completion of this course, the student will be able to:

CO1: Demonstrate the need for renewable energy sources.
CO2: Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system.
CO3: Design a stand-alone and Grid connected PV system.

CO4: Analyze the different configurations of the wind energy conversion systems.
CO5: Realize the basic of various available renewable energy sources

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford UniversityPress, 2009.
2. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
3. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
4. Chetan Singh Solanki, “Solar Photovoltaics: Fundamentals, Technologies and Applications”, PHI Learning Private Limited, 2012.
5. John Twideu and Tony Weir, “Renewal Energy Resources” BSP Publications, 2006
6. Gray, L. Johnson, “Wind energy system”, prentice hall of India, 1995.
7. B.H.Khan, " Non-conventional Energy sources", , McGraw-hill, 2nd Edition, 2009.
8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013.

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2	2	2	1
CO2	3		2	3	3	3
CO3	3		2	3	3	3
CO4	3		2	3	3	2
CO5	3		2	2	2	2

PS4093 SMART GRID L T P C
3 0 0 3

COURSE OBJECTIVES

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

UNIT I INTRODUCTION TO SMART GRID 9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study.

UNIT II SMART GRID TECHNOLOGIES 9

Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts.

UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE 9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Unit V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9

Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

COURSE OUTCOME:

Students able to

CO1: Relate with the smart resources, smart meters and other smart devices.
CO2: Explain the function of Smart Grid.
CO3: Experiment the issues of Power Quality in Smart Grid.
CO4: Analyze the performance of Smart Grid.
CO5**:** Recommend suitable communication networks for smart grid applications

REFERENCES

1. Stuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions', CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012.
3. Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015
4. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014
5. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.

MAPPING OF CO'S WITH PO'S

CO	PO					
	1	**2**	**3**	**4**	**5**	**6**
1	3	2	-	2	2	2
2	3	-	2	2	-	2
3	2	-	1	-	-	-
4	1	-	-	3	3	1
5	-	2	2	2	2	3
AVG	2.25	2	1.66	2.25	2.3	2

CP4391 SECURITY PRACTICES L T P C

3 0 0 3

COURSE OBJECTIVES:

- To learn the core fundamentals of system and web security concepts
- To have through understanding in the security concepts related to networks
- To deploy the security essentials in IT Sector

- To be exposed to the concepts of Cyber Security and cloud security
- To perform a detailed study of Privacy and Storage security and related Issues

UNIT I SYSTEM SECURITY 9

Model of network security – Security attacks, services and mechanisms – OSI security architecture -A Cryptography primer- Intrusion detection system- Intrusion Prevention system - Security web applications- Case study: OWASP - Top 10 Web Application Security Risks.

UNIT II NETWORK SECURITY 9

Internet Security - Intranet security- Local Area Network Security - Wireless Network Security - Wireless Sensor Network Security- Cellular Network Security - Mobile security - IOT security - Case Study - Kali Linux.

UNIT III SECURITY MANAGEMENT 9

Information security essentials for IT Managers- Security Management System - Policy Driven System Management- IT Security - Online Identity and User Management System. Case study: Metasploit

UNIT IV CYBER SECURITY AND CLOUD SECURITY 9

Cyber Forensics- Disk Forensics – Network Forensics – Wireless Forensics – Database Forensics – Malware Forensics – Mobile Forensics – Email Forensics- Best security practices for automate Cloud infrastructure management – Establishing trust in IaaS, PaaS, and SaaS Cloud types. Case study: DVWA

UNIT V PRIVACY AND STORAGE SECURITY 9

Privacy on the Internet - Privacy Enhancing Technologies - Personal privacy Policies - Detection of Conflicts in security policies- privacy and security in environment monitoring systems. Storage Area Network Security - Storage Area Network Security Devices - Risk management - Physical Security Essentials.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Understand the core fundamentals of system security
CO2: Apply the security concepts to wired and wireless networks
CO3: Implement and Manage the security essentials in IT Sector
CO4: Explain the concepts of Cyber Security and Cyber forensics
CO5: Be aware of Privacy and Storage security Issues.

REFERENCES

1. John R. Vacca, Computer and Information Security Handbook, Third Edition, Elsevier 2017
2. Michael E. Whitman, Herbert J. Mattord, Principles of Information Security, Seventh Edition, Cengage Learning, 2022
3. Richard E. Smith, Elementary Information Security, Third Edition, Jones and Bartlett Learning, 2019
4. Mayor, K.K.Mookhey, Jacopo Cervini, Fairuzan Roslan, Kevin Beaver, Metasploit Toolkit for Penetration Testing, Exploit Development and Vulnerability Research, Syngress publications, Elsevier, 2007. ISBN : 978-1-59749-074-0
5. John Sammons, “The Basics of Digital Forensics- The Primer for Getting Started in Digital Forensics”, Syngress, 2012
6. Cory Altheide and Harlan Carvey, “Digital Forensics with Open Source Tools”,2011 Syngress, ISBN: 9781597495875.
7. Siani Pearson, George Yee "Privacy and Security for Cloud Computing" Computer Communications and Networks, Springer, 2013.

CO-PO Mapping

CO	POs

	PO1	PO2	PO3	PO4	PO5	PO6
1	1	2	1	1	2	1
2	2	1	3	1	1	2
3			2	3	3	3
4	2	2	1	2	1	3
5	1		1	1	2	3
Avg	1.50	1.67	1.60	1.60	1.80	2.40

MP4251 CLOUD COMPUTING TECHNOLOGIES L T P C
3 0 0 3

COURSE OBJECTIVES:

- To gain expertise in Virtualization, Virtual Machines and deploy practical virtualization solution
- To understand the architecture, infrastructure and delivery models of cloud computing.
- To explore the roster of AWS services and illustrate the way to make applications in AWS
- To gain knowledge in the working of Windows Azure and Storage services offered by Windows Azure
- To develop the cloud application using various programming model of Hadoop and Aneka

UNIT I VIRTUALIZATION AND VIRTUALIZATION INFRASTRUCTURE 6

Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines –Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization –Management Virtualization –— Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization- Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data center automation

UNIT II CLOUD PLATFORM ARCHITECTURE 12

Cloud Computing: Definition, Characteristics - Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software- A Generic Cloud Architecture Design – Layered cloud Architectural Development – Architectural Design Challenges

UNIT III AWS CLOUD PLATFORM - IAAS 9

Amazon Web Services: AWS Infrastructure- AWS API- AWS Management Console - Setting up AWS Storage - Stretching out with Elastic Compute Cloud - Elastic Container Service for Kubernetes- AWS Developer Tools: AWS Code Commit, AWS Code Build, AWS Code Deploy, AWS Code Pipeline, AWS code Star - AWS Management Tools: Cloud Watch, AWS Auto Scaling, AWS control Tower, Cloud Formation, Cloud Trail, AWS License Manager

UNIT IV PAAS CLOUD PLATFORM 9

Windows Azure: Origin of Windows Azure, Features, The Fabric Controller – First Cloud APP in Windows Azure- Service Model and Managing Services: Definition and Configuration, Service runtime API- Windows Azure Developer Portal- Service Management API- Windows Azure Storage Characteristics-Storage Services- REST API- Blops

UNIT V PROGRAMMING MODEL 9

Introduction to Hadoop Framework - Mapreduce, Input splitting, map and reduce functions, specifying input and output parameters, configuring and running a job –Developing Map Reduce Applications - Design of Hadoop file system –Setting up Hadoop Cluster- Aneka: Cloud Application Platform, Thread Programming, Task Programming and Map-Reduce Programming

in Aneka

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Employ the concepts of virtualization in the cloud computing
CO2: Identify the architecture, infrastructure and delivery models of cloud computing
CO3: Develop the Cloud Application in AWS platform
CO4: Apply the concepts of Windows Azure to design Cloud Application
CO5: Develop services using various Cloud computing programming models.

REFERENCES

1. Bernard Golden, Amazon Web Service for Dummies, John Wiley & Sons, 2013.
2. Raoul Alongi, AWS: The Most Complete Guide to Amazon Web Service from Beginner to Advanced Level, Amazon Asia- Pacific Holdings Private Limited, 2019.
3. Sriram Krishnan, Programming: Windows Azure, O'Reilly,2010.
4. Rajkumar Buyya, Christian Vacchiola, S.Thamarai Selvi, Mastering Cloud Computing , MCGraw Hill Education (India) Pvt. Ltd., 2013.
5. Danielle Ruest, Nelson Ruest, —Virtualization: A Beginner"s Guidell, McGraw-Hill Osborne Media, 2009.
6. Jim Smith, Ravi Nair , "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005.
7. John W.Rittinghouse and James F.Ransome, "Cloud Computing: Implementation, Management, and Security", CRC Press, 2010.
8. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach", McGraw-Hill Osborne Media, 2009.
9. Tom White, "Hadoop: The Definitive Guide", Yahoo Press, 2012.

IF4072 **DESIGN THINKING** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To provide a sound knowledge in UI & UX
- To understand the need for UI and UX
- Research Methods used in Design
- Tools used in UI & UX
- Creating a wireframe and prototype

UNIT I UX LIFECYCLE TEMPLATE 8

Introduction. A UX process lifecycle template. Choosing a process instance for your project. The system complexity space. Meet the user interface team. Scope of UX presence within the team. More about UX lifecycles. Business Strategy. Value Innovation. Validated User Research. Killer UX Design. The Blockbuster Value Proposition. What Is a Value Proposition?.

UNIT II CONTEXTUAL INQUIRY 10

The system concept statement. User work activity data gathering. Look for emotional aspects of work practice. Abridged contextual inquiry process. Data-driven vs. model-driven inquiry. Organizing concepts: work roles and flow model. Creating and managing work activity notes. Constructing your work activity affinity diagram (WAAD). Abridged contextual analysis process. History of affinity diagrams.

UNIT III DESIGN THINKING, IDEATION, AND SKETCHING 9

Design-informing models: second span of the bridge . Some general "how to" suggestions. A

New example domain: slideshow presentations. User models. Usage models. Work environment models. Barrier summaries. Model consolidation. Protecting your sources. Abridged methods for design-informing models extraction. Design paradigms. Design thinking. Design perspectives. User personas. Ideation. Sketching

UNIT IV **UX GOALS, METRICS, AND TARGETS** **8**

Introduction. UX goals. UX target tables. Work roles, user classes, and UX goals. UX measures. Measuring instruments. UX metrics. Baseline level. Target level. Setting levels. Observed results. Practical tips and cautions for creating UX targets. How UX targets help manage the user experience engineering process.

UNIT V **ANALYSING USER EXPERIENCE** **10**

Sharpening Your Thinking Tools. UX Research and Strength of Evidence. Agile Personas. How to Prioritize Usability Problems. Creating Insights, Hypotheses and Testable Design Ideas. How to Manage Design Projects with User Experience Metrics. Two Measures that Will Justify Any Design Change. Evangelizing UX Research. How to Create a User Journey Map. Generating Solutions to Usability Problems. Building UX Research Into the Design Studio Methodology. Dealing with Common objections to UX Research. The User Experience Debrief Meeting. Creating a User Experience Dashboard.

SUGGESTED ACTIVITIES:

1: Hands on Design Thinking process for a product
2: Defining the Look and Feel of any new Project
3: Create a Sample Pattern Library for that product (Mood board, Fonts, Colors based on UI principles)
4: Identify a customer problem to solve.
5: Conduct end-to-end user research - User research, creating personas, Ideation process (User stories, Scenarios), Flow diagrams, Flow Mapping

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Build UI for user Applications
CO2: Use the UI Interaction behaviors and principles
CO3: Evaluate UX design of any product or application
CO4: Demonstrate UX Skills in product development
CO5: Implement Sketching principles

REFERENCES

1. UX for Developers: How to Integrate User-Centered Design Principles Into Your Day-to-Day Development Work, Westley Knight. Apress, 2018
2. The UX Book: Process and Guidelines for Ensuring a Quality User Experience, Rex Hartson, Pardha Pyla. Morgan Kaufmann, 2012
3. UX Fundamentals for Non-UX Professionals: User Experience Principles for Managers, Writers, Designers, and Developers, Edward Stull. Apress, 2018
4. Lean UX: Designing Great Products with Agile Teams, Gothelf, Jeff, Seiden, and Josh. O'Reilly Media, 2016
5. Designing UX: Prototyping: Because Modern Design is Never Static, Ben Coleman, and Dan Goodwin. SitePoint, 2017

MU4153 **PRINCIPLES OF MULTIMEDIA** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To get familiarity with gamut of multimedia and its significance

- To acquire knowledge in multimedia components.
- To acquire knowledge about multimedia tools and authoring.
- To acquire knowledge in the development of multimedia applications.
- To explore the latest trends and technologies in multimedia

UNIT I INTRODUCTION 9

Introduction to Multimedia – Characteristics of Multimedia Presentation – Multimedia Components – Promotion of Multimedia Based Components – Digital Representation – Media and Data Streams – Multimedia Architecture – Multimedia Documents, Multimedia Tasks and Concerns, Production, sharing and distribution, Hypermedia, WWW and Internet, Authoring, Multimedia over wireless and mobile networks.

Suggested Activities:

1. Flipped classroom on media Components.
2. External learning – Interactive presentation.

Suggested Evaluation Methods:

1. Tutorial – Handling media components
2. Quizzes on different types of data presentation.

UNIT II ELEMENTS OF MULTIMEDIA 9

Text-Types, Font, Unicode Standard, File Formats, Graphics and Image data representations – data types, file formats, color models; video – color models in video, analog video, digital video, file formats, video display interfaces, 3D video and TV: Audio – Digitization, SNR, SQNR, quantization, audio quality, file formats, MIDI; Animation- Key Frames and Tweening, other Techniques, 2D and 3D Animation.

Suggested Activities:

1. Flipped classroom on different file formats of various media elements.
2. External learning – Adobe after effects, Adobe Media Encoder, Adobe Audition.

Suggested Evaluation Methods:

1. Demonstration on after effects animations.
2. Quizzes on file formats and color models.

UNIT III MULTIMEDIA TOOLS 9

Authoring Tools – Features and Types – Card and Page Based Tools – Icon and Object Based Tools – Time Based Tools – Cross Platform Authoring Tools – Editing Tools – Painting and Drawing Tools – 3D Modeling and Animation Tools – Image Editing Tools – Sound Editing Tools – Digital Movie Tools.

Suggested Activities:

1. Flipped classroom on multimedia tools.
2. External learning – Comparison of various authoring tools.

Suggested Evaluation Methods:

1. Tutorial – Audio editing tool.
2. Quizzes on animation tools.

UNIT IV MULTIMEDIA SYSTEMS 9

Compression Types and Techniques: CODEC, Text Compression: GIF Coding Standards, JPEG standard – JPEG 2000, basic audio compression – ADPCM, MPEG Psychoacoustics, basic Video compression techniques – MPEG, H.26X – Multimedia Database System – User Interfaces – OS Multimedia Support – Hardware Support – Real Time Protocols – Play Back

Architectures – Synchronization – Document Architecture – Hypermedia Concepts: Hypermedia Design – Digital Copyrights, Content analysis.

Suggested Activities:

1. Flipped classroom on concepts of multimedia hardware architectures.
2. External learning – Digital repositories and hypermedia design.

Suggested Evaluation Methods:

1. Quizzes on multimedia hardware and compression techniques.
2. Tutorial – Hypermedia design.

UNIT V MULTIMEDIA APPLICATIONS FOR THE WEB AND MOBILE PLATFORMS 9

ADDIE Model – Conceptualization – Content Collection – Storyboard–Script Authoring Metaphors – Testing – Report Writing – Documentation. Multimedia for the web and mobile platforms. Virtual Reality, Internet multimedia content distribution, Multimedia Information sharing – social media sharing, cloud computing for multimedia services, interactive cloud gaming. Multimedia information retrieval.

Suggested Activities:

1. External learning – Game consoles.
2. External learning – VRML scripting languages.

Suggested Evaluation Methods:

1. Demonstration of simple interactive games.
2. Tutorial – Simple VRML program.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Handle the multimedia elements effectively.
CO2: Articulate the concepts and techniques used in multimedia applications.
CO3: Develop effective strategies to deliver Quality of Experience in multimedia applications.
CO4: Design and implement algorithms and techniques applied to multimedia objects.
CO5: Design and develop multimedia applications following software engineering models.

REFERENCES:

1. Li, Ze-Nian, Drew, Mark, Liu, Jiangchuan, “Fundamentals of Multimedia”, Springer, Third Edition, 2021.
2. Prabhat K.Andleigh, Kiran Thakrar, “MULTIMEDIA SYSTEMS DESIGN”, Pearson Education, 2015.
3. Gerald Friedland, Ramesh Jain, “Multimedia Computing”, Cambridge University Press, 2018. (digital book)
4. Ranjan Parekh, “Principles of Multimedia”, Second Edition, McGraw-Hill Education, 2017

DS4015 BIG DATA ANALYTICS L T P C
3 0 0 3

COURSE OBJECTIVES:

- To understand the basics of big data analytics
- To understand the search methods and visualization
- To learn mining data streams
- To learn frameworks
- To gain knowledge on R language

UNIT I INTRODUCTION TO BIG DATA 9

Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis –Nature of Data - Analytic Processes and Tools - Analysis Vs Reporting - Modern Data Analytic Tools- Statistical Concepts: Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error.

UNIT II SEARCH METHODS AND VISUALIZATION 9

Search by simulated Annealing – Stochastic, Adaptive search by Evaluation – Evaluation Strategies –Genetic Algorithm – Genetic Programming – Visualization – Classification of Visual Data Analysis Techniques – Data Types – Visualization Techniques – Interaction techniques – Specific Visual data analysis Techniques

UNIT III MINING DATA STREAMS 9

Introduction To Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform(RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions

UNIT IV FRAMEWORKS 9

MapReduce – Hadoop, Hive, MapR – Sharding – NoSQL Databases - S3 - Hadoop Distributed File Systems – Case Study- Preventing Private Information Inference Attacks on Social Networks- Grand Challenge: Applying Regulatory Science and Big Data to Improve Medical Device Innovation

UNIT V R LANGUAGE 9

Overview, Programming structures: Control statements -Operators -Functions -Environment and scope issues -Recursion -Replacement functions, R data structures: Vectors -Matrices and arrays -Lists -Data frames -Classes, Input/output, String manipulations

COURSE OUTCOMES:

CO1:understand the basics of big data analytics
CO2: Ability to use Hadoop, Map Reduce Framework.
CO3: Ability to identify the areas for applying big data analytics for increasing the business outcome.
CO4:gain knowledge on R language
CO5: Contextually integrate and correlate large amounts of information to gain faster insights.

TOTAL:45 PERIODS

REFERENCE:

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition 2020.
3. Norman Matloff, The Art of R Programming: A Tour of Statistical Software Design, No Starch Press, USA, 2011.
4. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & sons, 2012.
5. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007.

CO-PO Mapping

CO	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
1	3	3	3	3	2	1
2	3	3	3	3	2	1
3	3	3	3	3	2	1
4	3	3	3	3	2	1
5	3	3	3	3	2	1
Avg	3	3	3	3	2	1

NC4201 INTERNET OF THINGS AND CLOUD L T P C
3 0 0 3

COURSE OBJECTIVES:

- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols
- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular applications

UNIT I FUNDAMENTALS OF IoT 9

Introduction to IoT – IoT definition – Characteristics – IoT Complete Architectural Stack – IoT enabling Technologies – IoT Challenges. Sensors and Hardware for IoT – Hardware Platforms – Arduino, Raspberry Pi, Node MCU. A Case study with any one of the boards and data acquisition from sensors.

UNIT II PROTOCOLS FOR IoT 9

Infrastructure protocol (IPV4/V6/RPL), Identification (URIs), Transport (Wifi, Lifi, BLE), Discovery, Data Protocols, Device Management Protocols. – A Case Study with MQTT/CoAP usage-IoT privacy, security and vulnerability solutions.

UNIT III CASE STUDIES/INDUSTRIAL APPLICATIONS 9

Case studies with architectural analysis: IoT applications – Smart City – Smart Water – Smart Agriculture – Smart Energy – Smart Healthcare – Smart Transportation – Smart Retail – Smart waste management.

UNIT IV CLOUD COMPUTING INTRODUCTION 9

Introduction to Cloud Computing - Service Model – Deployment Model- Virtualization Concepts – Cloud Platforms – Amazon AWS – Microsoft Azure – Google APIs.

UNIT V IoT AND CLOUD 9

IoT and the Cloud - Role of Cloud Computing in IoT - AWS Components - S3 – Lambda - AWS IoT Core -Connecting a web application to AWS IoT using MQTT- AWS IoT Examples. Security Concerns, Risk Issues, and Legal Aspects of Cloud Computing- Cloud Data Security

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the various concept of the IoT and their technologies..
CO2: Develop IoT application using different hardware platforms
CO3: Implement the various IoT Protocols
CO4: Understand the basic principles of cloud computing.
CO5: Develop and deploy the IoT application into cloud environment

REFERENCES

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman ,CRC Press, 2017
2. Adrian McEwen, Designing the Internet of Things, Wiley,2013.
3. EMC Education Services, “Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data”, Wiley publishers, 2015.
4. Simon Walkowiak, “Big Data Analytics with R” PackT Publishers, 2016
5. Bart Baesens, “Analytics in a Big Data World: The Essential Guide to Data Science and its Applications”, Wiley Publishers, 2015.

MX4073 **MEDICAL ROBOTICS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To explain the basic concepts of robots and types of robots
- To discuss the designing procedure of manipulators, actuators and grippers
- To impart knowledge on various types of sensors and power sources
- To explore various applications of Robots in Medicine
- To impart knowledge on wearable robots

UNIT I INTRODUCTION TO ROBOTICS **9**

Introduction to Robotics, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Dynamic Stabilization

Sensors and Actuators

Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors, force sensors Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, PD and PID feedback actuator models

UNIT II MANIPULATORS & BASIC KINEMATICS **9**

Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator, Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems

Navigation and Treatment Planning

Variable speed arrangements, Path determination – Machinery vision, Ranging – Laser – Acoustic, Magnetic, fiber optic and Tactile sensor

UNIT III SURGICAL ROBOTS **9**

Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump, CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric and General Surgery, Gynecologic Surgery, General Surgery and Nanorobotics. Case Study

UNIT IV REHABILITATION AND ASSISTIVE ROBOTS **9**

Pediatric Rehabilitation, Robotic Therapy for the Upper Extremity and Walking, Clinical-Based Gait Rehabilitation Robots, Motion Correlation and Tracking, Motion Prediction, Motion Replication. Portable Robot for Tele rehabilitation, Robotic Exoskeletons – Design considerations, Hybrid assistive limb. Case Study

UNIT V WEARABLE ROBOTS **9**

Augmented Reality, Kinematics and Dynamics for Wearable Robots, Wearable Robot technology, Sensors, Actuators, Portable Energy Storage, Human–robot cognitive interaction (cHRI), Human–robot physical interaction (pHRI), Wearable Robotic Communication - case study

TOTAL:45 PERIODS

COURSE OUTCOMES:

CO1: Describe the configuration, applications of robots and the concept of grippers and actuators
CO2: Explain the functions of manipulators and basic kinematics
CO3: Describe the application of robots in various surgeries
CO4: Design and analyze the robotic systems for rehabilitation
CO5: Design the wearable robots

REFERENCES

1. Nagrath and Mittal, “Robotics and Control”, Tata McGraw Hill, First edition, 2003
2. Spong and Vidhyasagar, “Robot Dynamics and Control”, John Wiley and Sons, First edition, 2008

3. Fu.K.S, Gonzalez. R.C., Lee, C.S.G, “Robotics, control”, sensing, Vision and Intelligence, Tata McGraw Hill International, First edition, 2008
4. Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, 1st Edition, Springer, 2008
5. Shane (S.Q.) Xie, Advanced Robotics for Medical Rehabilitation - Current State of the Art and Recent Advances, Springer, 2016
6. Sashi S Kommu, Rehabilitation Robotics, I-Tech Education and Publishing, 2007
7. Jose L. Pons, Wearable Robots: Biomechatronic Exoskeletons, John Wiley & Sons Ltd, England, 2008
8. Howie Choset, Kevin Lynch, Seth Hutchinson, “Principles of Robot Motion: Theory, Algorithms, and Implementations”, Prentice Hall of India, First edition, 2005
9. Philippe Coiffet, Michel Chirouze, “An Introduction to Robot Technology”, Tata McGraw Hill, First Edition, 1983
10. Jacob Rosen, Blake Hannaford & Richard M Satava, “Surgical Robotics: System Applications & Visions”, Springer 2011
11. Jocelyn Troccaz, Medical Robotics, Wiley, 2012
12. Achim Schweikard, Floris Ernst, Medical Robotics, Springer, 2015

CO-PO Mapping

CO	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
1				1		
2				2		
3	2		2	2	2	2
4	2		2	2	3	2
5	2		2	2	3	3
Avg	2		2	1.8	2.6	2.3

VE4202 EMBEDDED AUTOMATION L T P C
3 0 0 3

COURSE OBJECTIVES:

- To learn about the process involved in the design and development of real-time embedded system
- To develop the embedded C programming skills on 8-bit microcontroller
- To study about the interfacing mechanism of peripheral devices with 8-bit microcontrollers
- To learn about the tools, firmware related to microcontroller programming
- To build a home automation system

UNIT - I INTRODUCTION TO EMBEDDED C PROGRAMMING 9

C Overview and Program Structure - C Types, Operators and Expressions - C Control Flow - C Functions and Program Structures - C Pointers And Arrays - FIFO and LIFO - C Structures - Development Tools

UNIT - II AVR MICROCONTROLLER 9

ATMEGA 16 Architecture - Nonvolatile and Data Memories - Port System - Peripheral Features : Time Base, Timing Subsystem, Pulse Width Modulation, USART, SPI, Two Wire Serial Interface, ADC, Interrupts - Physical and Operating Parameters

UNIT – III HARDWARE AND SOFTWARE INTERFACING WITH 8-BIT SERIES CONTROLLERS 9

Lights and Switches - Stack Operation - Implementing Combinational Logic - Expanding I/O - Interfacing Analog To Digital Convertors - Interfacing Digital To Analog Convertors - LED Displays : Seven Segment Displays, Dot Matrix Displays - LCD Displays - Driving Relays -

Stepper Motor Interface - Serial EEPROM - Real Time Clock - Accessing Constants Table - Arbitrary Waveform Generation - Communication Links - System Development Tools

UNIT – IV VISION SYSTEM 9

Fundamentals of Image Processing - Filtering - Morphological Operations - Feature Detection and Matching - Blurring and Sharpening - Segmentation - Thresholding - Contours - Advanced Contour Properties - Gradient - Canny Edge Detector - Object Detection - Background Subtraction

UNIT – V HOME AUTOMATION 9

Home Automation - Requirements - Water Level Notifier - Electric Guard Dog - Tweeting Bird Feeder - Package Delivery Detector - Web Enabled Light Switch - Curtain Automation - Android Door Lock - Voice Controlled Home Automation - Smart Lighting - Smart Mailbox - Electricity Usage Monitor -Proximity Garage Door Opener - Vision Based Authentic Entry System

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of this course, students will be able to

CO1: analyze the 8-bit series microcontroller architecture, features and pin details
CO2: write embedded C programs for embedded system application
CO3: design and develop real time systems using AVR microcontrollers
CO4: design and develop the systems based on vision mechanism
CO5: design and develop a real time home automation system

REFERENCES:

1. Dhananjay V. Gadre, "Programming and Customizing the AVR Microcontroller", McGraw-Hill, 2001.
2. Joe Pardue, "C Programming for Microcontrollers ", Smiley Micros, 2005.
3. Steven F. Barrett, Daniel J. Pack, "ATMEL AVR Microcontroller Primer : Programming and Interfacing", Morgan & Claypool Publishers, 2012
4. Mike Riley, "Programming Your Home - Automate With Arduino, Android and Your Computer", the Pragmatic Programmers, Llc, 2012.
5. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2011.
6. Kevin P. Murphy, "Machine Learning - a Probabilistic Perspective", the MIT Press Cambridge, Massachusetts, London, 2012.

CO-PO Mapping

CO	POs					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1		1	1	1	
2	1	3	1	1	1	3
3	1	3	1	1	1	3
4	1	3	1	1	1	3
5	1	3	1	1	1	3
Avg	(5/5)=1	(12/4)=3	(5/5)=1	(5/5)=1	(5/5)=1	(12/4)=3

CX4016 ENVIRONMENTAL SUSTAINABILITY L T P C

3 0 0 3

UNIT I INTRODUCTION 9

Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems

UNIT II CONCEPT OF SUSTAINABILITY 9

Sustainable Development: Defining the Concept, the Population Problem, Natural Resource Economics: An Overview, Energy, Water, Agriculture

UNIT III SIGNIFICANCE OF BIODIVERSITY 9

Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary - Source Local Air Pollution, Acid Rain and Atmospheric Modification, Transportation

UNIT IV POLLUTION IMPACTS 9

Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes, Global Warming.

UNIT V ENVIRONMENTAL ECONOMICS 9

Development, Poverty, and the Environment, Visions of the Future, Environmental economics and policy by Tom Tietenberg, Environmental Economics

TOTAL : 45 PERIODS

REFERENCES

1. Andrew Hoffman, Competitive Environmental Strategy - A Guide for the Changing Business Landscape, Island Press.
2. Stephen Doven, Environment and Sustainability Policy: Creation, Implementation, Evaluation, the Federation Press, 2005
3. Robert Brinkmann., Introduction to Sustainability, Wiley-Blackwell., 2016
4. Niko Roorda., Fundamentals of Sustainable Development, 3rd Edn, Routledge, 2020
5. Bhavik R Bakshi., Sustainable Engineering: Principles and Practice, Cambridge University Press, 2019

TX4092 TEXTILE REINFORCED COMPOSITES L T P C
3 0 0 3

UNIT I REINFORCEMENTS 9

Introduction – composites –classification and application; reinforcements- fibres and its properties; preparation of reinforced materials and quality evaluation; preforms for various composites

UNIT II MATRICES 9

Preparation, chemistry, properties and applications of thermoplastic and thermoset resins; mechanism of interaction of matrices and reinforcements; optimization of matrices

UNIT III COMPOSITE MANUFACTURING 9

Classification; methods of composites manufacturing for both thermoplastics and thermosets- Hand layup, Filament Winding, Resin transfer moulding, prepregs and autoclave moulding, pultrusion, vacuum impregnation methods, compression moulding; post processing of composites and composite design requirements

UNIT IV TESTING 9

Fibre volume and weight fraction, specific gravity of composites, tensile, flexural, impact, compression, inter laminar shear stress and fatigue properties of thermoset and thermoplastic composites.

UNIT V MECHANICS 9

Micro mechanics, macro mechanics of single layer, macro mechanics of laminate, classical lamination theory, failure theories and prediction of inter laminar stresses using at ware

TOTAL: 45 PERIODS

REFERENCES

1. BorZ.Jang,"Advanced Polymer composites",ASM International,USA,1994.
2. Carlsson L.A. and Pipes R.B., "Experimental Characterization of advanced composite Materials",SecondEdition,CRCPress,NewJersey,1996.
3. George LubinandStanley T.Peters, "Handbook of Composites", Springer Publications,1998.
4. Mel. M. Schwartz, "Composite Materials", Vol. 1 &2, Prentice Hall PTR, New Jersey,1997.
5. RichardM.Christensen,"Mechanics of compositematerials",DoverPublications,2005.
6. Sanjay K. Mazumdar, "Composites Manufacturing: Materials, Product, and Process Engineering",CRCPress,2001

NT4002 NANOCOMPOSITE MATERIALS L T P C
3 0 0 3

UNIT I BASICS OF NANOCOMPOSITES 9

Nomenclature, Properties, features and processing of nanocomposites. Sample Preparation and Characterization of Structure and Physical properties. Designing, stability and mechanical properties and applications of super hard nanocomposites.

UNIT II METAL BASED NANOCOMPOSITES 9

Metal-metal nanocomposites, some simple preparation techniques and their properties. Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Fractal based glass-metal nanocomposites, its designing and fractal dimension analysis. Core-Shell structured nanocomposites

UNIT III POLYMER BASED NANOCOMPOSITES 9

Preparation and characterization of diblock Copolymer based nanocomposites; Polymer Carbon nanotubes based composites, their mechanical properties, and industrial possibilities.

UNIT IV NANOCOMPOSITE FROM BIOMATERIALS 9

Natural nanocomposite systems - spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposites material; Use of synthetic nanocomposites for bone, teeth replacement.

UNIT V NANOCOMPOSITE TECHNOLOGY 9

Nanocomposite membrane structures- Preparation and applications. Nanotechnology in Textiles and Cosmetics-Nano-fillers embedded polypropylene fibers – Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes), Sun-screen dispersions for UV protection using titanium oxide – Colour cosmetics. Nanotechnology in Food Technology - Nanopackaging for enhanced shelf life - Smart/Intelligent packaging.

TOTAL : 45 PERIODS

REFERENCES:

1. Introduction to Nanocomposite Materials. Properties, Processing, Characterization- Thomas E. Twardowski. 2007. DEStech Publications. USA.
2. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V.Braun 2006.
3. Physical Properties of Carbon Nanotubes- R. Saito 1998.
4. Carbon Nanotubes (Carbon , Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus 1997.
5. The search for novel, superhard materials- Stan Veprįek (Review Article) JVST A, 1999
6. Nanometer versus micrometer-sized particles-Christian Brosseau, Jamal BeN Youssef, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003
7. Diblock Copolymer, - Aviram (Review Article), Nature, 2002
8. Bikramjit Basu, Kantesh Balani Advanced Structural Ceramics, A John Wiley & Sons, Inc.,
9. P. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead publication, London, 2006

BY4016 IPR, BIOSAFETY AND ENTREPRENEURSHIP L T P C
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UNIT I IPR 9

Intellectual property rights – Origin of the patent regime – Early patents act & Indian pharmaceutical industry – Types of patents – Patent Requirements – Application preparation filing and prosecution – Patentable subject matter – Industrial design, Protection of GMO's IP as a factor in R&D,IP's of relevance to biotechnology and few case studies.

UNIT II AGREEMENTS, TREATIES AND PATENT FILING PROCEDURES 9

History of GATT Agreement – Madrid Agreement – Hague Agreement – WIPO Treaties – Budapest Treaty – PCT – Ordinary – PCT – Conventional – Divisional and Patent of Addition – Specifications – Provisional and complete – Forms and fees Invention in context of "prior art" – Patent databases – Searching International Databases – Country-wise patent searches (USPTO,espacenet(EPO) – PATENT Scope (WIPO) – IPO, etc National & PCT filing procedure – Time frame and cost – Status of the patent applications filed – Precautions while patenting – disclosure/non-disclosure – Financial assistance for patenting – Introduction to existing schemes Patent licensing and agreement Patent infringement – Meaning, scope, litigation, case studies

UNIT III BIOSAFETY 9

Introduction – Historical Backround – Introduction to Biological Safety Cabinets – Primary Containment for Biohazards – Biosafety Levels – Biosafety Levels of Specific Microorganisms – Recommended Biosafety Levels for Infectious Agents and Infected Animals – Biosafety guidelines – Government of India.

UNIT IV GENETICALLY MODIFIED ORGANISMS 9

Definition of GMOs & LMOs – Roles of Institutional Biosafety Committee – RCGM – GEAC etc. for GMO applications in food and agriculture – Environmental release of GMOs – Risk Analysis – Risk Assessment – Risk management and communication – Overview of National Regulations and relevant International Agreements including Cartegana Protocol.

UNIT V ENTREPRENEURSHIP DEVELOPMENT 9

Introduction – Entrepreneurship Concept – Entrepreneurship as a career – Entrepreneurial

personality – Characteristics of successful Entrepreneur – Factors affecting entrepreneurial growth – Entrepreneurial Motivation – Competencies – Mobility – Entrepreneurship Development Programmes (EDP) - Launching Of Small Enterprise - Definition, Characteristics – Relationship between small and large units – Opportunities for an Entrepreneurial career – Role of small enterprise in economic development – Problems of small scale industries – Institutional finance to entrepreneurs - Institutional support to entrepreneurs.

TOTAL : 45 PERIODS

REFERENCES

1. Bouchoux, D.E., “Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets for the Paralegal”, 3rd Edition, Delmar Cengage Learning, 2008.
2. Fleming, D.O. and Hunt, D.L., “Biological Safety: Principles and Practices”, 4th Edition, American Society for Microbiology, 2006.
3. Irish, V., “Intellectual Property Rights for Engineers”, 2nd Edition, The Institution of Engineering and Technology, 2005.
4. Mueller, M.J., “Patent Law”, 3rd Edition, Wolters Kluwer Law & Business, 2009.
5. Young, T., “Genetically Modified Organisms and Biosafety: A Background Paper for Decision- Makers and Others to Assist in Consideration of GMO Issues” 1st Edition, World Conservation Union, 2004.
6. S.S Khanka, “Entrepreneurial Development”, S.Chand & Company LTD, New Delhi, 2007.

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