ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

M.E. AERONAUTICAL ENGINEERING (FT AND PT)

THE VISION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

The Department of Aerospace Engineering shall strive to be a globally known department, committed for its academic excellence, professionalism and societal expectations. The Department aims to impart state of the art technical knowledge, practical skills, leadership qualities, team spirit, ethical values and entrepreneurial skill to make all the students capable of taking up any task relevant to the area of Aerospace Engineering.

THE MISSION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

The Mission of the Department of Aerospace Engineering is to

- Prepare the students to have a very good fundamental knowledge to meet the present and future needs of industries.
- Improve the technical knowledge of the students in tune with the current requirements through collaboration with industries and research organization.
- Make the students gain enough knowledge in various aspects of system integration.
- Motivate the students to take up jobs in national laboratories and aerospace industries of our country.
- Take up inter and multidisciplinary research, sponsored and consultancy projects with industries and research establishments.
- Encourage the faculty members and students to do research and to update with the latest developments in the area of Aerospace Engineering.

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. **PEO 1:** Successful Moulding of Graduate into Aeronautical Engineering Professional: Graduates of the programme will acquire adequate knowledge both in practical and theoretical domains in the field of Aeronautical Engineering through rigorous post graduate education.

II. **PEO 2:** Successful Career Development: Graduates of the programme will have successful technical and managerial career in Aeronautical Engineering industries and the allied management.

III. **PEO 3:** Contribution to Aeronautical Engineering Field: Graduates of the programme will have innovative ideas and potential to contribute for the development and current needs of the Aviation industries.

IV. **PEO 4:** Sustainable interest for Lifelong learning: Graduates of the programme will have sustained interest to learn and adapt new technology developments to meet the changing industrial scenarios.

V. **PEO 5**: Motivation to pursue research in Aeronautical field: Graduates will have interest and strong desire to undertake research oriented jobs and responsibilities in Universities and Industries.

2. PROGRAMME OUTCOMES (POs)

On successful completion of the programme,

PO #	Graduate Attribute	Programme outcome
1.	Engineering knowledge	Postgraduate will be able to use the Engineering knowledge acquired from the basic courses offered in the programme to pursue either doctoral studies or a career as an academician / scientist or engineer.
2.	Problem analysis	Postgraduate will acquire the ability to diagnose problems and conduct experiments as well as to analyse and interpret the data in the field of aeronautical engineering.
3.	Design / Development of solutions	Postgraduate will have the ability to design a system or a component to meet the design requirements with constraints exclusively meant for aeronautical engineering.
4.	Conduct investigations of complex problems	Postgraduate will have a firm scientific, technological and communication base that helps him/her to conduct investigations of complex problems in the aircraft industry and R&D organizations related to aeronautical engineering and other professional fields.
5.	Modern tool usage	Postgraduate will become familiar with modern engineering tools and analyse problems within the domains of aeronautical engineering.
6.	The Engineer and society	Postgraduate will be capable of doing research in inter and multidisciplinary areas which will result in more efficient and cheaper products that are beneficial to society.

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7.	Environment and sustainability	Postgraduate will exhibit awareness of contemporary issues on environment focussing on the necessity to develop new materials design and testing methods for the solution of problems related to aircraft industry.
8.	Ethics	Postgraduate will acquire an understanding of professional and ethical responsibility with reference to their career in the field of aeronautical engineering and other allied professional fields.
9.	Individual and team work	Postgraduate will be trained towards developing and understanding the importance of design and development of airframes from system integration point of view which requires team work.
10.	Communications	Postgraduate will be able to communicate effectively both in verbal and nonverbal forms.
11.	Project management and finance	Postgraduate will show his ability for managerial skills in design or research teams and will be able to deliver cost effective solutions for products and services.
12.	Life-long learning	Postgraduate will be capable of understanding the value of life-long learning.

3. PROGRAMME SPECIFIC OUTCOMES

PSO1 : The postgraduate will become familiar with approach to analysis for aeronautical engineering problems and conversant with methods of solutions.

PSO2 : The post graduate will come well versed with usage of modern techniques, and software tools to design and develop aerospace subsystems and products.

PSO3 : The postgraduate will excel as an individual as well as team member in design and research teams in universities and aeronautical industries.

PSO4: The postgraduate will become an enthusiast to learn new technologies and methods life long in the area of aeronautical engineering.

Mapping of PEOs with POs

Programme Educational Objectives	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO 6	PO7	PO 8	PO 9	PO10	PO11	PO12
I	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓
II	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓
III	✓		✓	✓	✓	✓	✓	✓	✓		✓	
IV	✓	✓	✓			✓	✓					✓
V	✓	✓	✓	✓	✓				✓		✓	✓

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			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12
YEAR 1	Sem. 1	Advanced Mathematical Methods	✓	✓	✓	✓	✓	✓	✓					✓
		Aerospace Propulsion	✓	✓	✓	✓	✓	✓	✓					✓
		Aircraft Structural Mechanics	✓	✓	✓	✓	✓	✓	✓					✓
		Flight Vehicle Aerodynamics	✓	✓	✓	✓	✓	✓	✓					✓
		Program Elective-I												
		Research Methodology and IPR		✓	✓	✓					✓	✓		✓
		Audit course-I												
		Low Speed and High Speed Aerodynamics Laboratory	✓	✓	✓	✓	✓	✓			✓			✓
		Jet Propulsion Laboratory	✓	✓	✓		✓			✓	✓	✓		✓
	Sem.2	Advanced Flight Dynamics	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
		Finite Element Analysis	✓	✓	✓	✓	✓						✓	✓
		CFD for Aerospace Applications	✓	✓	✓	✓	✓	✓			✓			✓
		Program Elective-II												
		Program Elective-III												
		Audit course-II												
		Structures Laboratory	✓	✓	✓		✓	✓	✓		✓			✓
		Computation Laboratory	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
		Mini Project with Seminar	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
YEAR 2	Sem. 3	Program Elective – IV												
		Program Elective – V												
		Open Elective												
		Dissertation – I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Sem. 4	Dissertation – II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
PROGRAM CORE COURSES (PCC)	Aerospace Propulsion	✓	✓	✓	✓	✓	✓	✓					✓
	Aircraft Structural Mechanics	✓	✓	✓	✓	✓	✓	✓					✓
	Flight Vehicle Aerodynamics	✓	✓	✓	✓	✓	✓	✓					✓
	Low speed and High speed Aerodynamics Laboratory	✓	✓	✓	✓	✓	✓			✓			✓
	Jet Propulsion Laboratory	✓	✓	✓		✓			✓	✓	✓		✓
	Advanced Flight Dynamics	✓	✓	✓		✓		✓	✓	✓	✓		✓
	Finite Element Analysis	✓	✓	✓	✓	✓						✓	✓
	CFD for Aerospace Applications	✓	✓	✓	✓	✓	✓			✓			✓
	Structures Laboratory	✓	✓	✓		✓	✓	✓		✓			✓
	Computation Laboratory	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
PROFESSIONAL ELECTIVE COURSES (PEC)	**Program Elective – I**												
	Experimental Methods of Stress Analysis	✓	✓	✓	✓	✓	✓						✓
	Rocketry and Space Mechanics	✓	✓	✓	✓	✓				✓			✓
	Computational Heat Transfer	✓	✓	✓	✓	✓	✓			✓			✓
	Theory of Elasticity	✓	✓	✓	✓		✓						✓
	Experimental Aerodynamics	✓	✓	✓		✓	✓						✓
	Program Elective – II												
	Structural Dynamics	✓	✓	✓	✓	✓		✓				✓	
	Hypersonic Aerodynamics	✓	✓	✓	✓	✓	✓	✓					✓
	Advanced Propulsion Systems	✓	✓	✓	✓	✓	✓	✓					✓
	Aerospace Materials	✓	✓	✓	✓	✓	✓						✓
	Airworthiness and Air Regulations	✓	✓	✓	✓	✓				✓			✓
	Program Elective – III												
	Aeroelasticity	✓	✓	✓	✓	✓	✓			✓			✓
	Theory of Boundary Layers	✓	✓	✓	✓	✓	✓	✓					✓
	Combustion in Jet and Rocket Engines	✓	✓	✓	✓	✓	✓	✓					✓
	Analysis of Composite Structures	✓	✓	✓	✓	✓						✓	✓
	Fatigue and Fracture Mechanics	✓	✓	✓	✓	✓	✓					✓	✓
	Program Elective - IV												
	Vibration Isolation and Control	✓	✓	✓	✓	✓		✓					✓
	Non-Destructive	✓	✓	✓	✓	✓		✓				✓	✓

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	Evaluation												
	Component Design of Aircraft Engines	✓	✓	✓	✓	✓	✓	✓					✓
	Aircraft Systems Engineering	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
	Aircraft Design	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
	Program Elective – V												
	Helicopter Aerodynamics	✓	✓	✓	✓	✓	✓	✓					✓
	High Speed Jet Flows	✓	✓	✓	✓	✓	✓	✓					✓
	Smart Materials and Structural Health Monitoring	✓	✓	✓	✓	✓		✓				✓	✓
	Artificial Intelligence and Machine Learning	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
	Aircraft Guidance and Control	✓	✓	✓	✓	✓	✓	✓					✓

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UNIVERSITY DEPARTMENTS
REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM
M.E. AERONAUTICAL ENGINEERING (FULL -TIME)
I SEMESTER

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5152	Advanced Mathematical Methods	FC	3	1	0	4	4
2.	AL5101	Aerospace Propulsion	PCC	4	0	0	4	4
3.	AL5102	Aircraft Structural Mechanics	PCC	3	1	0	4	4
4.	AL5103	Flight Vehicle Aerodynamics	PCC	4	0	0	4	4
5.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
6.		Program Elective - I	PEC	3	0	0	3	3
7.		Audit course – I*	AC	2	0	0	2	0
PRACTICALS								
8.	AL5111	Low Speed and High Speed Aerodynamics Laboratory	PCC	0	0	4	4	2
9.	AL5112	Jet Propulsion Laboratory	PCC	0	0	4	4	2
			TOTAL	**21**	**2**	**8**	**31**	**25**

* Audit Course is optional.

II SEMESTER

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AL5201	Advanced Flight Dynamics	PCC	3	1	0	4	4
2.	AL5251	CFD for Aerospace Applications	PCC	3	0	0	3	3
3.	AL5252	Finite Element Analysis	PCC	3	0	0	3	3
4.		Program Elective - II	PEC	3	0	0	3	3
5.		Program Elective - III	PEC	3	0	0	3	3
6.		Audit course – II*	AC	2	0	0	2	0
PRACTICALS								
7.	AL5211	Structures Laboratory	PCC	0	0	4	4	2
8.	AL5261	Computation Laboratory	PCC	0	0	4	4	2
9.	AL5212	Mini Project with Seminar	EEC	0	0	4	4	2
			TOTAL	**17**	**1**	**12**	**30**	**22**

* Audit Course is optional.

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III SEMESTER

S. No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective-IV	PEC	3	0	0	3	3
2.		Program Elective-V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	AL5311	Dissertation-I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

IV SEMESTER

S. No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	AL5411	Dissertation-II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 74

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REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

M.E. AERONAUTICAL ENGINEERING (PART -TIME)

I SEMESTER

SL. No	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5152	Advanced Mathematical Methods	FC	3	1	0	4	4
2.	AL5103	Flight Vehicle Aerodynamics	PCC	4	0	0	4	4
3.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
4.		Audit course-I*	AC	2	0	0	2	0
PRACTICALS								
5.	AL5111	Low Speed and High Speed Aerodynamics Laboratory	PCC	0	0	4	4	2
			TOTAL	**11**	**1**	**4**	**16**	**12**

* Audit Course is optional.

II SEMESTER

SL. No	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AL5102	Aircraft Structural Mechanics	PCC	3	1	0	4	4
2.	AL5101	Aerospace Propulsion	PCC	4	0	0	4	4
3.		Program Elective-I	PEC	3	0	0	3	3
PRACTICALS								
4.	AL5112	Jet Propulsion Laboratory	PCC	0	0	4	4	2
			TOTAL	**10**	**1**	**4**	**15**	**13**

III SEMESTER

SL. No	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AL5201	Advanced Flight Dynamics	PCC	3	1	0	4	4
2.	AL5252	Finite Element Analysis	PCC	3	0	0	3	3
3.		Program Elective-II	PEC	3	0	0	3	3
4.		Audit course-II*	AC	2	0	0	2	0
PRACTICALS								
5.	AL5211	Structures Laboratory	PCC	0	0	4	4	2
			TOTAL	**11**	**1**	**4**	**16**	**12**

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* Audit Course is optional.

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IV SEMESTER

SL. No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AL5251	CFD for Aerospace Applications	PCC	3	0	0	3	3
2.		Program Elective-III	PEC	3	0	0	3	3
3.		Program Elective-IV	PEC	3	0	0	3	3
PRACTICALS								
4.	AL5261	Computation Laboratory	PCC	0	0	4	4	2
5.	AL5212	Mini Project with Seminar	EEC	0	0	4	4	2
			TOTAL	**9**	**0**	**8**	**17**	**13**

V SEMESTER

SL. No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective-V	PEC	3	0	0	3	3
2.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
3.	AL5311	Dissertation-I	EEC	0	0	12	12	6
			TOTAL	**6**	**0**	**12**	**18**	**12**

VI SEMESTER

SL. No	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	AL5411	Dissertation-II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 74

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FOUNDATION COURSE (FC)

SL. No.	COURSE CODE	Course Title	Periods per week			Credits	Semester
			Lecture	Tutorial	Practical		
1.	MA5152	Advanced Mathematical Methods	3	1	0	4	1

PROGRAM CORE COURSES (PCC)

SL. No.	COURSE CODE	Course Title	Periods per week			Credits	Semester
			Lecture	Tutorial	Practical		
1.	AL5101	Aerospace Propulsion	4	0	0	4	1
2.	AL5102	Aircraft Structural Mechanics	3	1	0	4	1
3.	AL5103	Flight Vehicle Aerodynamics	4	0	0	4	1
4.	AL5111	Low speed and High speed Aerodynamics Laboratory	0	0	4	2	1
5.	AL5112	Jet Propulsion Laboratory	0	0	4	2	1
6.	AL5201	Advanced Flight Dynamics	3	1	0	4	2
7.	AL5252	Finite Element Analysis	3	0	0	3	2
8.	AL5251	CFD for Aerospace Applications	3	0	0	3	2
9.	AL5211	Structures Laboratory	0	0	4	2	2
10.	AL5261	Computation Laboratory	0	0	4	2	2

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PROGRAM ELECTIVE COURSES (PEC)

SEMESTER I , ELECTIVE – I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AL5001	Experimental Methods of Stress Analysis	PEC	3	0	0	3	3
2.	AL5076	Rocketry and Space Mechanics	PEC	3	0	0	3	3
3.	AS5071	Computational Heat Transfer	PEC	3	0	0	3	3
4.	AL5002	Theory of Elasticity	PEC	3	0	0	3	3
5.	AL5003	Experimental Aerodynamics	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.	AL5004	Structural Dynamics	PEC	3	0	0	3	3
2.	AS5251	Hypersonic Aerodynamics	PEC	3	0	0	3	3
3.	AL5005	Advanced Propulsion Systems	PEC	3	0	0	3	3
4.	AL5071	Aerospace Materials	PEC	3	0	0	3	3
5.	AL5006	Airworthiness and Air Regulations	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.	AL5007	Aeroelasticity	PEC	3	0	0	3	3
2.	AL5078	Theory of Boundary Layers	PEC	3	0	0	3	3
3.	AL5008	Combustion in Jet and Rocket Engines	PEC	3	0	0	3	3
4.	AL5072	Analysis of Composite Structures	PEC	3	0	0	3	3
5.	AL5073	Fatigue and Fracture Mechanics	PEC	3	0	0	3	3

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SEMESTER III , ELECTIVE – IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AL5079	Vibration Isolation and Control	PEC	3	0	0	3	3
2.	AL5075	Non-Destructive Evaluation	PEC	3	0	0	3	3
3.	AL5009	Component Design of Aircraft Engines	PEC	3	0	0	3	3
4.	AL5010	Aircraft Systems Engineering	PEC	3	0	0	3	3
5.	AL5011	Aircraft Design	PEC	3	0	0	3	3

SEMESTER III , ELECTIVE – V

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AL5012	Helicopter Aerodynamics	PEC	3	0	0	3	3
2.	AL5074	High Speed Jet Flows	PEC	3	0	0	3	3
3.	AL5077	Smart Materials and Structural Health Monitoring	PEC	3	0	0	3	3
4.	AL5013	Artificial Intelligence and Machine Learning	PEC	3	0	0	3	3
5.	AL5014	Aircraft Guidance and Control	PEC	3	0	0	3	3

RESEARCH METHODOLOGY AND IPR COURSE (RMC)

S. No.	Course Code	Course Title	Periods per week			Credits	Semester
			Lecture	Tutorial	Practical		
1.	RM5151	Research Methodology and IPR	2	0	0	2	1

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OPEN ELECTIVE COURSES [OEC]

(Out of 6 Courses one Course must be selected)

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OE5091	Business Data Analytics	OEC	3	0	0	3	3
2.	OE5092	Industrial Safety	OEC	3	0	0	3	3
3.	OE5093	Operations Research	OEC	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	OEC	3	0	0	3	3
5.	OE5095	Composite Materials	OEC	3	0	0	3	3
6.	OE5096	Waste to Energy	OEC	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.	AX5091	English for Research Paper Writing	2	0	0	0
2.	AX5092	Disaster Management	2	0	0	0
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0
4.	AX5094	Value Education	2	0	0	0
5.	AX5095	Constitution of India	2	0	0	0
6.	AX5096	Pedagogy Studies	2	0	0	0
7.	AX5097	Stress Management by Yoga	2	0	0	0
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

Sl. No.	Course Code	Course Title	Periods per week			Credits	Semester
			Lecture	Tutorial	Practical		
1.	AL5212	Mini Project with Seminar	0	0	4	2	2
2.	AL5311	Dissertation-I	0	0	12	6	3
3.	AL5411	Dissertation-II	0	0	24	12	4

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Summary

	Name of the Programme					
	Subject Area	**Credits per Semester**				**Total Credits**
		I	**II**	**III**	**IV**	
1.	FC	04	00	00	00	04
2.	PCC	16	14	00	00	30
3.	PEC	03	06	06	00	15
4.	RMC	02	00	00	00	02
5.	OEC	00	00	03	00	03
6.	EEC	00	02	06	12	20
7.	Non Credit/Audit Courses	✓	✓	00	00	
	Total Credit	**25**	**22**	**15**	**12**	**74**

Attested

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MA5152 **ADVANCED MATHEMATICAL METHODS** **L T P C**
3 1 0 4

COURSE OBJECTIVES:

- To familiarize the students in the field of differential equations.
- To enable them to solve boundary value problems associated with engineering applications using transform methods.
- To expose the students to the concepts of calculus of variations.
- To introduce conformal mappings and their applications to fluid flows and heat flows.
- To give the students a complete picture of tensor analysis.

UNIT I LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS **12**

Laplace transform: Definitions, properties –Transform of 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 Poison's equations.

UNIT III CALCULUS OF VARIATIONS **12**

Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries –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

OUTCOMES:

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

- develop the mathematical methods of applied mathematics and mathematical physics
- solve boundary value problems using integral transform methods
- apply the concepts of calculus of variations in solving various boundary value problems
- apply conformal mappings in fluid flows and heat flow problems
- familiarize with the concepts of tensor analysis.

REFERENCES:

1. Andrew L.C. and Shivamoggi B.K., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolts L., "Differential Equations and the Calculus of Variations", MIR Publishers, Moscow, 2003.

3. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 44th Edition, New Delhi, 2017.
4. Gupta A.S., “Calculus of Variations with Applications”, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5. James G., “Advanced Modern Engineering Mathematics”, Pearson Education, 4th Edition, Horlow, 2016.
6. Mathews J.H. and Howell R.W., “Complex Analysis for Mathematics and Engineering”, Narosa Publishing House, 6th Edition, New Delhi, 2012.
7. O’Neil P.V., “Advanced Engineering Mathematics”, Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.
8. Ramanaiah, G.T., “Tensor Analysis”, S. Viswanathan Pvt. Ltd., Chennai, 1990.
9. Sankara Rao K., “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt. Ltd., 3rd Edition, New Delhi, 2010.
10. Spiegel M.R., “Theory and Problems of Complex Variables and its Application” (Schaum’s Outline Series), McGraw Hill Book Co., Singapore, 2000.

AL5101 **AEROSPACE PROPULSION**

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

This course will enable the students

1. To gain knowledge on fundamental principles of aircraft and rocket propulsion.
2. To describe various types of propulsion system with their merits and challenges.
3. To gain adequate knowledge on propellers and its characteristics.
4. To be familiar with the working concept of inlets, nozzles and combustion chamber with their applications in a propulsion system.
5. To gain sufficient information about compressors and turbines. Students also will get an exposure on electric propulsion methods

UNIT I ELEMENTS OF AIRCRAFT PROPULSION **12**

Classification of power plants – Methods of aircraft propulsion – Propulsive efficiency – Specific fuel consumption – Thrust and power- Factors affecting thrust and power- Illustration of working of Gas turbine engine – Characteristics of turboprop, turbofan and turbojet , Ram jet, Scram jet – Methods of Thrust augmentation.

UNIT II PROPELLER THEORY **12**

Momentum theory, Blade element theory, combined blade element and momentum theory, propeller power losses, propeller performance parameters, prediction of static thrust- and in flight, negative thrust, prop fans, ducted propellers, propeller noise, propeller selection, propeller charts.

UNIT III INLETS, NOZZLES AND COMBUSTION CHAMBERS **12**

Subsonic and supersonic inlets – Relation between minimum area ratio and external deceleration ratio – Starting problem in supersonic inlets –Modes of inlet operation, jet nozzle – Efficiencies – Over expanded, under and optimum expansion in nozzles – Thrust reversal. Classification of Combustion chambers – Combustion chamber performance – Flame tube cooling – Flame stabilization.

UNIT IV AXIAL FLOW COMPRESSORS, FANS AND TURBINES **12**

Introduction to centrifugal compressors- Axial flow compressor- geometry- twin spools- three spools- stage analysis- velocity polygons- degree of reaction – radial equilibrium theory-

performance maps- axial flow turbines- geometry- velocity polygons- stage analysis- performance maps- thermal limit of blades and vanes.

UNIT V ROCKET AND ELECTRIC PROPULSION 12

Introduction to rocket propulsion – Reaction principle – Thrust equation – Classification of rockets based on propellants used – solid, liquid and hybrid – Comparison of these engines with special reference to rocket performance – electric propulsion – classification- electro thermal – electro static – electromagnetic thrusters- geometries of Ion thrusters- beam/plume characteristics – hall thrusters.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will

CO1: Get exposure with the different types of propulsive devices used for jet and rocket propulsion.

CO2: Have knowledge on propeller theory and its performance parameters.

CO3: Be able to distinguish different types of inlets and their performance trends in subsonic and supersonic flows.

CO4: Be able to describe the process of combustion and the parameters that affect combustion in jet engines.

CO5: Be able to acquire knowledge on the basic concepts of various types of electric propulsion systems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓						✓
CO2	✓	✓	✓	✓		✓	✓					✓
CO3	✓	✓	✓	✓	✓	✓						✓
CO4	✓	✓	✓	✓	✓		✓					✓
CO5	✓	✓	✓	✓	✓		✓		✓			✓

REFERENCES:

1. Cohen, H, Saravanamuttoo, HIH., Rogers, GFC, Paul Straznicky and Andrew Nix , “Gas Turbine Theory”, Pearson Education Canada; 7th edition, 2017.
2. Gill, WP, Smith, HJ & Ziurys, JE, “Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants”, Oxford & IBH Publishing Co., 1980.
3. Hill, PG. & Peterson, CR. “Mechanics & Thermodynamics of Propulsion” Pearson education, 2nd edition, 2009.
4. Oates, GC, “Aerothermodynamics of Aircraft Engine Components”, AIAA Education Series, 1985.
5. Sutton,GP, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8th Edition, 2016.

AL5102 AIRCRAFT STRUCTURAL MECHANICS

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

This course will enable the students

1. To gain important technical aspects on the theory of bending of structures.
2. To learn the key aspects of shear flow in open and closed sections.
3. To study the stability problems in structures with various modes of loading.
4. To analyse aircraft structural components under various forms of loading.
5. To have basic idea about the importance of flight envelope.

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 – Idealization of cross-section – Wing spar sizing

UNIT II SHEAR FLOW IN THIN-WALLED SECTION 9+3

General stress, strain and displacement relationships for open section thin-walled beams – Concept of shear flow – Shear flow in thin walled open sections – Determinations of the shear centre – Symmetrical and unsymmetrical cross-sections – Shear flow due to bending in open sections – Torsion of thin-walled open section members & determination of stresses – Design of thin-walled members

UNIT III SHEAR FLOW IN CLOSED SECTIONS 9+3

Shear flow in thin-walled closed sections – Symmetrical and unsymmetrical sections – Flexural shear flow in two flange, three flange and multi-flange box beams – Determinations of the shear centre – Bredt-Batho theory – Torsional shear flow in multi-cell tubes – Shear flow due to combined bending and torsion – Stress analysis of aircraft components – Tapered wing spar – Introduction to shear lag

UNIT IV STABILITY PROBLEMS 9+3

Stability problems of thin walled structures – Buckling of sheets under compression, shear, and combined loads – Plate buckling coefficient – Inelastic buckling of plates – Sheet-stiffener panels – Effective width – Failure stress in plates and stiffened panels – Crippling stress estimation – Local Buckling – Wagner beam theory – Experimental determination of critical load for a flat plate – Principles of stiffener/web construction

UNIT V ANALYSIS OF AIRCRAFT STRUCTURAL COMPONENTS 9+3

Aircraft Loads – Symmetric manoeuvre loads – Load factor determination – Inertia loads – Aerodynamic loads & Schrenk's curve – 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 – Analysis of rings and frames –– Introduction to aeroelasticity.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Apply the concept of normal stress variation in unsymmetrical sections subject to bending moments.

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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓		✓					✓
CO2	✓	✓	✓	✓	✓	✓						
CO3	✓	✓	✓	✓	✓	✓	✓					✓
CO4	✓	✓	✓	✓	✓	✓			✓			✓
CO5	✓	✓	✓	✓	✓		✓	✓				

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, R.M, “Theory and Analysis of Flight structures”, McGraw-Hill, N.Y., 1993.
6. Sun. CT, “Mechanics of Aircraft Structures”, Wiley publishers, 2nd edition, 2006.

AL5103	FLIGHT VEHICLE AERODYNAMICS	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES:

This course will enable the students

1. To gain insights into the basics of fluid flow, its model and tool to solve the fluid flow problems.
2. To be familiar with the conservation laws of fluid dynamics, and how to apply them to practical fluid flows.
3. To gain knowledge on elementary flows to combine and form realistic flows with suitable assumptions.
4. To analyse incompressible flow over three-dimensional bodies like wing and so on.
5. To gain knowledge on the basic concepts of viscous flows, boundary layers to practical flows.

UNIT I INTRODUCTION TO AERODYNAMICS 12

Aerodynamic force and moments, lift and Drag coefficients, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Continuity and Momentum equations, Point source and sink, doublet, Free and Forced Vortex, Uniform parallel flow, combination of basic flows, Pressure and Velocity distributions on bodies with and without circulation in ideal and real fluid flows, Magnus effect

UNIT II INCOMPRESSIBLE FLOW THEORY 12

Conformal Transformation, Karman ,Trefftz profiles, Kutta condition, Kelvin’s Circulation Theorem and the Starting Vortex, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot – Savart law, lifting line theory, effect of aspect ratio.

UNIT III COMPRESSIBLE FLOW THEORY 13

Compressibility, Isentropic flow through nozzles, Normal shocks, Oblique and Expansion waves, Moving shock waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, Small perturbation theory, Prandtl- Glauert Rule, Linearized supersonic flow, Method of characteristics.

UNIT IV AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS 11

Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, transonic area rule, Swept wings (ASW and FSW), Supersonic airfoils, Shock-Expansion Theory, Wave drag, Delta wings.

UNIT V VISCOUS FLOW THEORY 12

Basics of viscous flow theory, Boundary Layer, Flow separation, Displacement, momentum and Energy Thickness, Laminar and Turbulent boundary layers ,Boundary layer over flat plate, Blasius Solution, Estimation of skin friction drag in laminar and turbulent flow, The Reference Temperature Method.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will

CO1: Comprehend the behaviour of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime.
CO2: Be able to solve inviscid, incompressible and irrotational flows.
CO3: Be able to apply the conservation equations for fluid flows.
CO4: Be provided with the knowledge on thermodynamic state of the gas behind normal shock waves, oblique shock waves and expansion waves.
CO5: Be provided with adequate knowledge on the basic concepts of laminar and turbulent boundary layers.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓			✓						
CO2	✓	✓	✓	✓	✓	✓	✓					✓
CO3	✓	✓	✓	✓	✓		✓					✓
CO4	✓	✓	✓	✓	✓							✓
CO5	✓	✓	✓	✓		✓	✓					

REFERENCES:

1. J.D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill Education, 5th edition, 2010.
2. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 5th edition, 2013.
3. Shapiro, AH, "Dynamics & Thermodynamics of Compressible Fluid Flow", Ronald Press, 1982.
4. Houghton, EL and Caruthers, NB, "Aerodynamics for Engineering Students", Butterworth-Heinemann series, 5th edition 2003.
5. Zucrow, M.J, and Anderson, J.D, "Elements of gas dynamics" McGraw-Hill Book Co., New York, 1989.
6. Rae, WH and Pope, A, "Low speed Wind Tunnel Testing", John Wiley Publications, 3rd edition, 1999.

RM5151 RESEARCH METHODOLOGY AND IPR L T P C
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

AL5111	LOW SPEED AND HIGH SPEED AERODYNAMICS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

This laboratory course will enable the students

1. To gain knowledge on the principles of subsonic and supersonic wind tunnel and their operation.
2. To acquire practical knowledge on various aerodynamic principles related to inviscid incompressible fluids.
3. To calculate various aerodynamic characteristics of various objects.
4. To characterize laminar and turbulent flows.
5. To get practical exposure on flow visualization techniques pertaining to subsonic flows.

LIST OF EXPERIMENTS:

1. Calibration of subsonic wind tunnel.
2. Pressure distribution over a smooth cylinder.
3. Pressure distribution over a rough cylinder.
4. Pressure distribution over a symmetric aerofoil section.
5. Pressure distribution over a cambered aerofoil section.
6. Pressure distribution over a wing of cambered aerofoil section.
7. Force and moment measurements using wind tunnel balance.
8. Wake measurements behind a bluff body.
9. Velocity boundary layer measurements over a flat plate.
10. Force measurements on aircraft model using wind tunnel balance.
11. Moment measurements on aircraft model using wind tunnel balance.
12. Calibration of supersonic wind tunnel.

13. Subsonic flow visualization studies.

Any 10 experiments may be conducted.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be

CO1: Able to operate and calibrate subsonic and supersonic wind tunnel.
CO2: Able to analyse the pressure distribution over the streamlined and bluff bodies.
CO3: Able to carry out measurement of force and moments on aircraft models.
CO4: Capable of measuring boundary layer thickness over various models.
CO5: Able to carry out flow visualization at subsonic speeds.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓		✓	✓				✓			✓
CO2	✓	✓	✓		✓				✓			
CO3	✓	✓	✓	✓	✓				✓			✓
CO4	✓	✓	✓	✓	✓				✓			✓
CO5	✓	✓		✓	✓	✓			✓			

LABORATORY EQUIPMENTS REQUIRED

1. Subsonic wind tunnel
2. Rough and smooth cylinder
3. Symmetrical and Cambered aerofoil
4. Wind tunnel balance
5. Schlieren system
6. Pressure Transducers
7. Supersonic wind tunnel
8. Blower
9. Testing models like flat plate, bluff body

AL5112 JET PROPULSION LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

This course will enable the students

1. To gain knowledge on wall pressure distribution on subsonic and supersonic inlets and nozzles.
2. To perform testing on compressor blades.
3. To 23artesi and interpret the experimental data using software.
4. To get practical exposure on flow visualization techniques pertaining to supersonic jets.
5. To gain basic knowledge on cold flow studies.

LIST OF EXPERIMENTS:

1. Wall pressure measurements of a subsonic diffuser.
2. Cascade testing of compressor blades.
3. Pressure distribution on a cavity model.
4. Wall pressure measurements on non-circular combustor.
5. Wall pressure measurements on converging nozzle.
6. Wall pressure measurements on convergent-divergent nozzle.
7. Total pressure measurements along the jet axis of a circular subsonic jet.
8. Total pressure measurements along the jet axis of a circular supersonic jet.
9. Cold flow studies of a wake region behind flame holders.
10. Wall pressure measurements on supersonic inlets.

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11. Flow visualization on supersonic jets.

Only 10 experiments will be conducted.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be

CO1: Able to perform wall pressure distribution on subsonic and supersonic nozzles.

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

CO3: Provided with adequate knowledge on pressure distribution on cavity models.

CO4: Able to perform wake survey methods.

CO5: Able to carry out flow visualization on supersonic jets.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓						✓			✓
CO2	✓	✓	✓	✓			✓	✓	✓			✓
CO3	✓	✓	✓					✓	✓	✓		✓
CO4	✓	✓	✓				✓	✓	✓			✓
CO5	✓	✓	✓	✓					✓			

LABORATORY EQUIPMENTS REQUIRED

1. Subsonic wind tunnel
2. High speed jet facility
3. Blower
4. Pressure scanner
5. Schlieren system
6. Nozzle and cavity models

AL5201 **ADVANCED FLIGHT DYNAMICS** **L T P C**

3 1 0 4

COURSE OBJECTIVES:

This course will enable students

1. To gain in depth knowledge on aircraft performance in level, climbing, gliding flight modes.
2. To get familiarize the equations of motion in accelerated flight modes.
3. To impart knowledge on the basic aspects of stability and control of an airplane about three axis.
4. To provide adequate knowledge on various parameters that decide the stability level of an airplane.
5. To be familiar with the aspects of control in longitudinal, lateral and directional modes.

UNIT I STEADY FLIGHT PERFORMANCE 9+3

Overview of Aerodynamics and ISA – Straight and level flight: thrust and power required/ available, differences of propeller-driven and jet-powered airplanes, maximum speed, effects of altitude – Climb and Descent performance: climb angle and rate of climb, descent angle and rate of descent – Range, endurance of propeller driven and jet powered airplanes.

UNIT III MANEUVER PERFORMANCE 8+3

Level turn – maximum producible load factor – fastest and tightest turn – Vertical maneuver: pull-up and pull-out, pull-down – gust V-n diagram – Take off and landing performance.

UNIT III STATIC LONGITUDINAL STABILITY AND CONTROL 10+3

Static equilibrium and stability – Pitch stability of conventional and canard aircraft – control fixed neutral point and static margin – effect of fuselage and running propellers on pitch stability – control surface hinge moment – control free neutral point – limit on forward CG travel – maneuver stability: Pull – up & level turn – control force and trim tabs – control force for maneuver – measurement of neutral point and maneuver point by flight tests.

UNIT IV STATIC LATERAL, DIRECTIONAL STABILITY AND CONTROL 8+3

Yaw and side slip, effect of wing sweep, wing dihedral and vertical tail on directional stability – rudder fixed and rudder free – yaw control – rudder sizing – pedal force - dihedral effect: contribution of various components- roll control.

UNIT V AIRCRAFT DYNAMICS 10+3

Rigid body equations of motion - Axes systems and their significance – Euler angles – linearization of longitudinal equations – force and moment derivatives – short period and phugoid approximations – pure pitching motion – linearization of equations for lateral – directional motion – roll, spiral and dutch roll approximations- Pure rolling- Pure yawing – Inertia coupling.

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

COURSE OUTCOMES:

At the end of this course, students will

CO1: Be able to assess the performance of aircraft in steady and maneuver flights.

CO2: Have thorough knowledge in order to perform preliminary design computations to meet static stability and trim requirements of aircrafts.

CO3: Be able to determine the fixed neutral point and the stick fixed static margin.

CO4: Be able to describe the effect of change in CG on the aircraft stability.

CO5: Apply the small disturbance equations of motion, and identify longitudinal and lateral sets of equations, construct state space models for longitudinal and lateral aircraft dynamics.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓	✓	✓				✓			
CO3	✓	✓	✓	✓	✓			✓				✓
CO4	✓	✓	✓	✓	✓		✓					
CO5	✓	✓	✓	✓				✓				✓

REFERENCES:

1. Anderson,JD, “Aircraft Performance & Design”**,** First edition, Mc Graw Hill India, 2010.
2. McCormick, BW, “Aerodynamics, Aeronautics, & Flight Mechanics”, 2nd edition, John Wiley & Sons, 1995.
3. Michael V. Cook, “Flight Dynamics Principles”, Second edition, Elsevier, 2007.
4. Nelson, RC, “Flight Stability & Automatic Control”, Second edition, McGraw-Hill, 2017.
5. Perkins CD & Hage, RE, “Airplane performance, stability and control”, Wiley India Pvt Ltd, 2011.

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AL5251 CFD FOR AEROSPACE APPLICATIONS 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 learn the techniques pertaining to transonic small perturbation force.
5. To make use of commercial CFD software for aerospace applications.

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 FINITE VOLUME METHOD 9
Introduction to Finite volume Method - Different Flux evaluation schemes, central, upwind and hybrid schemes - Staggered grid approach - Pressure-Velocity coupling - SIMPLE, SIMPLER algorithms- pressure correction equation (both incompressible and compressible forms) - Application of Finite Volume Method -artificial diffusion.

UNIT V CFD FOR INDUSTRIAL APPLICATIONS 9
Various levels of approximation of flow equations, turbulence modelling for viscous flows, verification and validation of CFD code, application of CFD tools to 2D and 3D configurations. CFD for kinetic heating analysis – Coupling of CFD code with heat conduction code, Unsteady flows – Grid movement method, Oscillating geometries, Computational aeroelasticity – Coupling of CFD with structural model – Aeroelasticity of airfoil geometry, Introduction to commercial CFD software for aerospace applications, High performance computing for CFD applications – Parallelization of codes –domain decomposition.

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	PO7	PO8	PO9	PO10	PO11	PO12
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. Sedat Biringen & Chuen-Yen Chow, “Introduction to Computational Fluid Dynamics by Example”, Wiley publishers, 2nd edition, 2011.
6. Wirz, HJ & Smeldern, JJ, “Numerical Methods in Fluid Dynamics”, McGraw-Hill & Co., 1978.

AL5252 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 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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓							
CO2	✓	✓	✓	✓	✓				✓			✓
CO3	✓	✓	✓	✓	✓		✓					✓
CO4	✓	✓	✓	✓	✓							✓
CO5	✓	✓	✓	✓	✓			✓				

REFERENCES:

1. Bathe, KJ & Wilson,EL, Numerical Methods in Finite Elements Analysis, Prentice Hall of India Ltd., 1983.
2. Dhanaraj, R & K.Prabhakaran Nair,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.

AL5211 STRUCTURES LABORATORY L T P C

0 0 4 2

COURSE OBJECTIVES:

This laboratory course enables the students

1. To get practical knowledge on calibration of photoelastic materials.
2. To gain practical exposures on calculating shear centre locations for closed and open sections.

3. To provide with the basic knowledge of fabricating a composite laminate.
4. To have basic knowledge on unsymmetrical bending of beams.
5. To design and conduct different types of practical tests involving various aircraft structural components.

LIST OF EXPERIMENTS

1. Strain gauge installation & testing
2. Fabrication & testing a simple strain gauge circuit
3. Calibration of photo elastic materials & photoelastic methods
4. Experimental modal analysis
5. Forced vibration testing
6. Fabrication and static testing of composite laminates
7. Non-destructive evaluation using acoustic emission
8. Non-destructive evaluation using ultrasonics
9. Whirling of composite shafts
10. Fabrication and testing of a 3-D printed specimen
11. Unsymmetrical bending of beams
12. Determination of influence coefficients and flexibility matrix
13. Shear centre location for open & closed thin-walled sections
14. Buckling of columns with different end conditions
15. Experimental verification of the Wagner beam theory

NOTE: Any 10 experiments will be conducted out of 15.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able

CO1: To conduct tests and interpret data involving strain gauges.
CO2: To get exposure on experimental methods in photoelasticity.
CO3: To design an experimental evaluation technique for a given application.
CO4: To comprehend non-destructive testing methods.
CO5: To fabricate of composite laminates and characterizes it.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓						✓			✓
CO2	✓	✓	✓	✓		✓			✓			
CO3	✓	✓	✓	✓	✓	✓			✓			✓
CO4	✓	✓	✓	✓	✓	✓			✓			✓
CO5	✓	✓	✓		✓				✓			

LABORATORY EQUIPMENTS REQUIRED

1. Electrical resistance strain gauges installation kit.
2. Circuit board with resistors, wires, clips, etc, and strain gauges.
3. Column testing set-up (with provision for different end conditions)
4. Unsymmetrical beam bending set-up.
5. Dial gauges & travelling microscope.
6. Experimental setup for location of shear centre (open & closed sections)
7. Whirling of shafts demonstration unit.
8. Photo-elastic models.
9. Equipment for the fabrication of composite laminates.
10. Testing instruments and equipment for acoustic emission testing.
11. Testing instruments and equipment for ultrasonics testing.
12. Diffuser transmission type polariscope with accessories
13. Experimental setup for vibration of beams & vibration measuring instruments.

14. Universal Testing Machine.
15. 3-D printing machine.
16. Wagner beam & accessories.

AL5261	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

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 able

CO1: To get solution of aerodynamic flows.

CO2: 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: To comprehend both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution.

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓				✓			
CO2	✓	✓	✓	✓	✓				✓			✓
CO3	✓	✓	✓	✓	✓	✓			✓			✓
CO4	✓	✓	✓	✓	✓				✓		✓	✓
CO5	✓	✓	✓	✓	✓				✓			✓

LABORATORY EQUIPMENTS REQUIREMENTS

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

AL5212 **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.

AL5001 **EXPERIMENTAL METHODS OF STRESS ANALYSIS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. This course introduces the basic principles and methods of experimental stress analysis.
2. This course helps to learn the principles and techniques of photoelastic measurements.
3. This course presents the principles and techniques of moire analysis.

Annexed

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4. This course helps to gain knowledge of the principles and a technique of strain gage measurements is presented.
5. This course also enables the students to learn basic principles of operation of electrical resistance strain gauges, interferometric techniques, and non destructive methods.

UNIT I BASIC CONCEPTS 9

Stresses, Strains and Displacements – Determination of Principal Values of Stresses and Strains in 2-D & 3-D – Maximum Shear Stress – Strain Measurement Using Mechanical Extensometers – Principles of Measurements – Basic Characteristics and Requirements of a Measuring System – Sources of error – Statistical Analysis of Experimental Data – Non-Contact Measurement.

UNIT II ELECTRICAL-RESISTANCE STRAIN GAGES 9

Strain Sensitivity in Metallic Alloys – Gage Construction – Gage Sensitivities and Gage Factor – Performance Characteristics of Foil Strain Gages – Environmental Effects – The Three-Element Rectangular Rosette – Corrections for Transverse Strain Effects – Other Types of Strain Gages – Semiconductor Strain Gages – Grid & Brittle Coating Methods of Strain Analysis.

UNIT III STRAIN-GAGE CIRCUITS & INSTRUMENTATION 9

The Potentiometer Circuit and Its Application to Strain Measurement – Variants From The Basic Potentiometer Circuit – Circuit Output – The Wheatstone Bridge Constant Current and Constant Voltage Circuits – Circuit Sensitivity – Calibrating Strain-Gage Circuits – Effects of Lead Wires and Switches – Electrical Noise Reduction – Strain Measurement in Bars, Beams and Shafts.

UNIT IV PHOTOELASTIC METHODS OF STRESS ANALYSIS 9

Introduction – Stress-Optic Law – Effects of a Stressed Model in a Plane Polariscope – Effects of a Stressed Model in a Circular Polariscope – Tardy Compensation – Two-Dimensional Photoelastic Stress Analysis – Fringe Multiplication and Fringe Sharpening – Properties of Commonly Employed Photoelastic Materials – Material Calibration – Introduction to Three-Dimensional Photoelasticity.

UNIT V NON-DESTRUCTIVE TESTING 8

Different types of NDT Techniques – Acoustic Emission Technique – Ultrasonic – Pulse-Echo – Through Transmission – Eddy Current Testing – X-Ray Radiography – Challenges in Non-Destructive Evaluation – Non-Destructive Evaluation in Composites – Concepts of Image Processing Theory.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will have

CO1: Knowledge of different methods of strain measurement.
CO2: Knowledge on electrical resistance strain gauge.
CO3: An ability to design experiments for strain measurements.
CO4: Acquired knowledge on photoelastic methods of stress analysis.
CO5: Exposure to non-destructive testing methods.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓		✓			✓					✓
CO2	✓	✓	✓			✓						
CO3	✓	✓	✓		✓	✓						✓
CO4	✓	✓	✓	✓	✓	✓	✓					✓
CO5	✓	✓	✓	✓	✓				✓			✓

REFERENCES:

1. Albert S. Kobayashi, “Handbook on Experimental Mechanics”, Prentice Hall Publishers, 1987.
2. James W. Dally & William F. Riley, “Experimental Stress Analysis”, McGraw-Hill College, 1991.
3. James F. Doyle & James W. Phillips, “Manual on Experimental Stress Analysis”, 5th Edition, Society for Experimental Mechanics, 1989.

4. Sharpe Jr & William N, Springer, “Handbook of Experimental Solid Mechanics”, Springer, 2008.
5. Udpa. S.S & Patrick O. Moore, “Non-destructive Testing Handbook”, Electromagnetic Testing, Third Edition: Volume 5, 2004.

AL5076 ROCKETRY AND SPACE MECHANICS L T P C
3 0 0 3

COURSE OBJECTIVES:

1. This course presents the fundamental aspects of rocket motion along with detailed estimation of rocket trajectories.
2. This course also imparts knowledge on optimization of multistage rockets.
3. This course provides the basics of space mechanics required for an aeronautical student
4. This course helps students to provide with the basics of orbit transfer of satellites.
5. This course will help students to gain knowledge on various control methods of rockets.

UNIT I ORBITAL MECHANICS 9

Description of solar system – Kepler’s Laws of planetary motion – Newton’s Law of Universal gravitation – Two body and Three-body problems – Jacobi’s Integral, Librations points – Estimation of orbital and escape velocities.

UNIT II SATELLITE DYNAMICS 9

Geosynchronous and geostationary satellites- factors determining life time of satellites – satellite perturbations – orbit transfer and examples –Hohmann orbits – calculation of orbit parameters– Determination of satellite rectangular coordinates from orbital elements.

UNIT III ROCKET MOTION 10

Principle of operation of rocket motor – thrust equation – one dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields – Description of vertical, inclined and gravity turn trajectories – determinations of range and altitude – simple approximations to burnout velocity.

UNIT IV ROCKET AERODYNAMICS 9

Description of various loads experienced by a rocket passing through atmosphere – drag estimation – wave drag, skin friction drag, form drag and base pressure drag – Boat-tailing in missiles – performance at various altitudes – rocket stability – rocket dispersion – launching problems.

UNIT V STAGING AND CONTROL OF ROCKET VEHICLES 9

Need for multi staging of rocket vehicles – multistage vehicle optimization – stage separation dynamics and separation techniques- aerodynamic and jet control methods of rocket vehicles – SITVC.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To knowledge on the fundamental laws of orbital mechanics with particular emphasis on interplanetary trajectories.
CO2: To calculate orbital parameters and perform conceptual trajectory designs for geocentric or interplanetary missions.
CO3: To familiarize themselves with trajectory calculations for planar motion of rockets.
CO4: To determine forces and moments acting on airframe of a missile.
CO5: To acquire knowledge on the need for staging and stage separation dynamics of rocket vehicles.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓				✓				✓	

CO2	✓	✓	✓	✓	✓		✓	✓			✓	
CO3	✓	✓	✓	✓	✓	✓	✓					✓
CO4	✓	✓	✓		✓	✓	✓					✓
CO5	✓	✓	✓	✓			✓	✓				✓

REFERENCES:

1. Cornelisse,JW, "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd., London, 1982.
2. Parker,ER, "Materials for Missiles and Spacecraft", McGraw-Hill Book Co., Inc., 1982.
3. Suresh. B N & Sivan. K, "Integrated Design for Space Transportation System", Springer India, 2015.
4. Sutton,GP, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 8th Edition, 2010.
5. Van de Kamp, "Elements of Astromechanics", Pitman Publishing Co., Ltd., London, 1980.

AS5071 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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓							
CO2	✓	✓	✓	✓	✓		✓					✓
CO3	✓	✓	✓	✓	✓	✓	✓					✓
CO4	✓	✓	✓	✓	✓							✓
CO5	✓	✓	✓	✓	✓			✓				

REFERENCES:

1. Chung,TJ, “Computational Fluid Dynamics”, Cambridge University Press, 2002.
2. Holman,JP, “Heat Transfer”, McGraw-Hill Book Co, Inc., McGraw-Hill College; 8th/Disk edition, 1997.
3. John D. Anderson, “Computational Fluid Dynamics”, McGraw Hill Education, 2017.
4. John H. Lienhard, “A Heat Transfer”, Text Book, Dover Publications, 4th edition, 2013.
5. Richard H. Pletcher, John C. Tannehill & Dale Anderson**, “**Computational Fluid Mechanics and Heat Transfer”, 3rd edition, CRC Press**,** 2012
6. Sachdeva,SC, “Fundamentals of Engineering Heat & Mass Transfer”, New age publisher, 4th edition Internationals, 2017

AL5002 THEORY OF ELASTICITY L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To learn the basic concepts and equations of elasticity.
2. To provide with the concepts of plain stress and strain related problems.
3. To gain knowledge on equilibrium and stress-strain equations of polar coordinates.
4. Will be exposed to axisymmetric problems.
5. To get insight into the basic concepts of plates and shells.

UNIT I BASIC EQUATIONS OF ELASTICITY 9

Definition & sign convention for stress and strain – Hooke’s law – Relation between elastic constants – Equilibrium and compatibility equations – Analysis of stress, strain and deformation –

Stress and strain transformations equations – Cauchy's formula – Principal stress and principal strains in 2D & 3D – Octahedral stresses and its significance – Boundary conditions.

UNIT II APPLIED CONCEPTS 9

Plane stress and plane strain problems – Airy stress function – Biharmonic equation – Compatibility equation in terms of stress – Solution of bar and beam problems using the elasticity approach – Torsion of bars – Determination of stresses, strain and displacements – Warping of cross-sections – Prandtl's stress function approach – St. Venant's method.

UNIT III POLAR COORDINATES 9

Strain-displacement relations in polar coordinates – Equilibrium and stress-strain equations in polar coordinates – Infinite plate with a small central hole – Stress concentration – Bending of a curved beam (Winkler-Bach theory) – Deflection of a thick curved bar – Stresses in straight and curved beams due to thermal loading – Thermal stresses in cylinders and spheres – Stress concentration in bending.

UNIT IV AXISYMMETRIC PROBLEMS 9

Equilibrium and stress-strain equations in cylindrical coordinates – Lame's problem – Thick-walled cylinders subject to internal and external pressure – Application of failure theories – Stresses in composite tubes – Shrink fitting – Stresses due to gravitation – Analysis of a rotating disc of uniform thickness – Discs of variable thickness – Rotating shafts and cylinders.

UNIT V PLATES AND SHELLS 9

Classical plate theory – Assumptions, governing equations and boundary conditions – Navier's method of solution – Levy's method of solution – Rectangular and circular plates – Solution techniques – Analysis of a shell – Membrane Theory – Deformation and stresses due to applied loads.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will

CO1: Have knowledge of basic elasticity relationships and equations.

CO2: Know how to carry out stress analysis in 2-D and 3-D.

CO3: Get exposure on the formulation of constitutive and governing equations for basic problems in cartesian and cylindrical coordinates.

CO4: Be able to analyse and solve practical problems in cartesian and cylindrical coordinates.

CO5: Be able to determine the stress, strain and displacement field for common axisymmetrical members.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓		✓								
CO2	✓	✓	✓		✓		✓					✓
CO3	✓	✓	✓		✓	✓		✓				✓
CO4	✓	✓	✓		✓	✓			✓			
CO5	✓	✓	✓		✓	✓						✓

REFERENCES:

1. Harry Kraus, "Thin Elastic Shells", John Wiley and Sons, 1987.
2. Flugge, W, "Stresses in Shells", Springer – Verlag, 1985.
3. Timoshenko, S.P. and Gere, J.M, "Theory of Elastic Stability", McGraw Hill Book Co. 2010.
4. Timoshenko, S.P. Winowsky. S., and Kreger, "Theory of Plates and Shells", McGraw Hill Book Co., 1990.
5. Varadan, TK and Bhaskar,K, "Analysis of plates-Theory and problems", Narosha Publishing Co., 2001.

AL5003 **EXPERIMENTAL AERODYNAMICS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. This course will enable the students to learn basics of wind tunnel operation and its associated measurements.
2. To present the concepts of different flow visualization methods.
3. This course also imparts knowledge on flow measurement variables
4. This course enables students to be familiar with data acquisition methods pertaining to experiments in aerodynamics.
5. This course will help students to do uncertainty analysis for their experiments.

UNIT I LOW SPEED TUNNEL **9**

Objective of experimental studies, Types of wind tunnels, Low speed tunnel, Energy ratio, Power losses in a wind tunnel – Calibration of subsonic wind tunnels – Speed Setting – Flow Direction – Three-Hole and Five-Hole Yaw Probes – Turbulence – Wind tunnel balance – Water tunnel.

UNIT II HIGH SPEED TUNNEL **9**

Transonic wind tunnel – Transonic Test Section – Supersonic wind tunnels – Losses in Supersonic Tunnels – Supersonic Wind Tunnel Diffusers – Effects of Second Throat – Runtime calculation – Calculating Air Flow Rates – Calibration of Supersonic Wind Tunnels – Hypersonic wind tunnel and Calibration – Ludwieg Tube – Shock tube and shock tunnels – Gun tunnel – Plasma arc tunnels – Measurement of shock speed.

UNIT III FLOW VISUALIZATION TECHNIQUES **9**

Visualization techniques – Smoke tunnel –- Dye Injection – Bubble Techniques – Surface Flow Visualization techniques – oil – Tufts – China Clay – Ultraviolet Fluorescence Photography – Interferometer – Fringe-Displacement method – Shadowgraph – Schlieren system – Background Oriented Schlieren (BOS) system – Laser sheet flow visualization.

UNIT IV MEASUREMENTS OF PROPERTIES **10**

Pressure measurement techniques-Pitot, Static, and Pitot-Static Tubes-Pitot-Static tube characteristics – Pressure Sensitive Paints - Pressure transducers – Velocity measurements – Hot-wire anemometry-Constant current and Constant temperature Hot-Wire anemometer – Hot-film anemometry - Laser Doppler Velocimetry (LDV) – Particle Image Velocimetry (PIV)- Temperature measurements – Measurement of heat flux – Foil type heat flux gauge – Transient analysis of foil gauge – Thin film sensors – Slug type heat flux sensor.

UNIT V DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS **8**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will

CO1: Have knowledge on measurement of flow properties in wind tunnels and their associated instrumentation.
CO2: Be able to demonstrate and conduct experiments related to subsonic and supersonic flows.
CO3: Gain idea on flow visualization of subsonic and supersonic flows.
CO4: Be familiar with calibration of transducers and other devices used for flow measurement.

CO5: Be able to estimate errors and to perform uncertainty analysis of the experimental data.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓					✓			
CO2	✓	✓	✓	✓				✓				✓
CO3	✓	✓	✓	✓	✓							✓
CO4	✓	✓	✓	✓	✓	✓						
CO5	✓	✓	✓	✓	✓		✓					✓

REFERENCES:

1. Allan Pope and Kenneth L Goin, "High Speed Wind Tunnel Testing", Krieger Publishing Company, 1978.
2. Jewel B. Barlow, Willian. H.Rae and Allan Pope, "Low-Speed Wind Tunnel Testing", Wiley-Interscience, 3rd edition, 1999.
3. Rathakrishnan, E, "Instrumentation, Measurements, and Experiments in Fluids", CRC Press – Taylor & Francis, 2007.
4. Robert B Northrop, "Introduction to Instrumentation and Measurements", Second Edition, CRC Press, Taylor & Francis, 2006.

AL5004 STRUCTURAL DYNAMICS L T P C
3 0 0 3

COURSE OBJECTIVES:

1. This course imparts knowledge on the force deflection properties of structures and natural modes of vibration.
2. This course also presents the principles of dynamics and energy methods pertaining to structures.
3. This course will make students to realise the importance of natural modes of vibration.
4. This course will provide in-depth knowledge on natural vibrations of beams and plates.
5. This course also provides a platform for better understanding of the approximate methods for aerospace structures.

UNIT I FORCE DEFLECTION PROPERTIES OF SYSTEMS 9

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

UNIT II PRINCIPLES OF DYNAMICS 9

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

UNIT III NATURAL MODES OF VIBRATION 9

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

UNIT IV ENERGY METHODS 9

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

UNIT V APPROXIMATE METHODS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will

CO1: Be able to solve the equation of motion of a linear system and use this solution to analyse the vibrational behaviour of the system.
CO2: Be capable to relate the results of a modal analysis relate to the vibration of a structure.
CO3: Acquire knowledge on equation of motion of a lumped MDOF mass-spring-damper system.
CO4: Have knowledge on vibration characteristics of continuous system such as strings, bar, shafts and beams.
CO5: Be able to assess the fundamental frequency of MDOF systems using approximate methods.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓						✓
CO2	✓	✓	✓	✓		✓		✓				
CO3	✓	✓	✓	✓	✓	✓						✓
CO4	✓	✓	✓	✓							✓	
CO5	✓	✓	✓	✓				✓				✓

REFERENCES:

1. Hurty,WC and Rubinstein,MF, "Dynamics of Structures", Prentice Hall of India Pvt.Ltd.,New Delhi 1987.
2. Ramamurthi,V, "Mechanical Vibration Practice and Noise Control", Narosa Publishing House Pvt. Ltd, 2008.
3. Timoshenko,SP and Young,DH, "Vibration Problems in Engineering", John Willey & Sons Inc., 1984.
4. Tse. FS, Morse, IE and Hinkle,HT, "Mechanical Vibrations: Theory and Applications", Prentice Hall of India Pvt. Ltd, New Delhi, 2004.
5. Vierck,RK, "Vibration Analysis", 2nd Edition, Thomas Y. Crowell/ Harper & Row Publishers, New York, U.S.A. 1989.

AS5251 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.

Attested

UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS 10

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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	PO7	PO8	PO9	PO10	PO11	PO12
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.

AL5005 ADVANCED PROPULSION SYSTEMS L T P C

3 0 0 3

COURSE OBJECTIVES:

1. This course will cover the basic aspects of thermodynamic cycle analysis of air-breating propulsion systems.
2. This course is intended to impart knowledge on advanced air breathing propulsion systems like air augmented rockets.
3. This course will give the knowledge on the basic aspects of scramjet propulsion system.
4. This course will provide in-depth knowledge about the nozzle performance.
5. This course also presents vast knowledge on the operating principles of nuclear, electric and ion propulsion.

UNIT I THERMODYNAMIC CYCLE ANALYSIS OF AIR-BREATHING PROPULSION SYSTEMS **9**

Air breathing propulsion systems like Turbojet, turboprop, ducted fan, Ramjet and Air augmented rockets – Thermodynamic cycles – Pulse propulsion – Combustion process in pulse jet engines – inlet charging process – Subcritical, Critical and Supercritical charging.

UNIT II RAMJETS AND AIR AUGMENTED ROCKETS **8**

Preliminary performance calculations – Diffuser design with and without spike, Supersonic inlets – combustor and nozzle design – integral Ram rocket.

UNIT III SCRAMJET PROPULSION SYSTEM **10**

Fundamental considerations of hypersonic air breathing vehicles – Preliminary concepts in engine airframe integration – calculation of propulsion flow path – flow path integration – Various types of supersonic combustors – fundamental requirements of supersonic combustors – Mixing of fuel jets in supersonic cross flow – performance estimation of supersonic combustors.

UNIT IV NUCLEAR PROPULSION **9**

Nuclear rocket engine design and performance – nuclear rocket reactors – nuclear rocket nozzles – nuclear rocket engine control – radioisotope propulsion – basic thruster configurations – thruster technology – heat source development – nozzle development – nozzle performance of radioisotope propulsion systems.

UNIT V ELECTRIC AND ION PROPULSION **9**

Basic concepts in electric propulsion – power requirements and rocket efficiency – classification of thrusters – electrostatic thrusters – plasma thruster– Fundamentals of ion propulsion – performance analysis – ion rocket engine.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be

CO1: Able to Analyse in detail the thermodynamics cycles of air breathing propulsion systems.
CO2: Able to gain idea on the concepts of supersonic combustion for hypersonic vehicles and its performance.
CO3: Able to demonstrate the fundamental requirements of supersonic combustors.
CO4: Capable of estimating performance parameters of nuclear and electrical rockets.
CO5: Able to acquire knowledge on the concepts of engine-body installation on hypersonic vehicles.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓		✓		✓				
CO2	✓	✓	✓	✓	✓	✓	✓					✓
CO3	✓	✓	✓	✓		✓	✓					✓
CO4	✓	✓	✓		✓	✓			✓			✓
CO5	✓	✓	✓		✓	✓	✓	✓				

REFERENCES:

1. Cumpsty, “Jet propulsion”, Cambridge University Press, 2003.
2. Fortescue and Stark, “Spacecraft Systems Engineering”, Wiley, 4th edition, 2011.
3. Sutton, GP, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 1998.
4. William H. Heiser and David T. Pratt, “Hypersonic Air breathing propulsion”, AIAA Education Series, 2001.

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 MATERIALS FOR SANDWICH CONSTRUCTION 9

Aerospace application of honeycomb and sandwich type construction – Materials used – Typical properties – Fabrication techniques – Design principles involved in beams and panels of sandwich type construction – Numerical examples – Failure modes of sandwich panels – Inspection Techniques

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	PO7	PO8	PO9	PO10	PO11	PO12
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.

AL5006 AIRWORTHINESS AND AIR REGULATIONS L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To get insight into the basic aspects of aircraft rules.
2. To gain knowledge on the basic concepts of airworthiness.
3. To learn the basic aspects on certification and publication procedures.
4. To impart knowledge on licensing and material selections.
5. To provide with the concepts of case studies and civil aviation requirements.

UNIT I INTRODUCTION TO AIRCRAFT RULES 8

Airworthiness requirements for civil and military aircraft – CAA, FAA, JAR and ICAO regulations – Defence standards – Military standards and specifications.

UNIT II BASIC CONCEPTS OF AIRWORTHINESS 9

Privileges and responsibilities of various categories of AME license and approved persons – Knowledge of mandatory documents like certificate of Registration – Certificate of Airworthiness – Conditions of issue and validity – Export certificate of Airworthiness – Knowledge of Log Book, Journey Log Book, Technical Log Book etc.

UNIT III CERTIFICATION AND PUBLICATION PROCEDURES 10

Procedure for development and test flight and Certification – Certificate of Flight release – Certificate of Maintenance – Approved Certificates – Technical Publications – Aircraft Manual – Flight Manual – Aircraft Schedules – Registration Procedure, Certification, Identification and Marking of Aircraft**.**

UNIT IV LICENSING AND MATERIAL SELECTIONS 9

Modifications – Concessions – Airworthiness directives – Service bulletins – Crew training and their licenses – approved inspection – Approved materials – Identification of approved materials – Bonded and quarantine stores**.**

UNIT V CASE STUDIES AND CIVIL AVIATION REQUIREMENTS 9

Storage of various aeronautical products like rubber goods and various fluids – Accident investigation procedures – Circumstances under which C of A is suspended – ICAO and IATA regulations – Chicago and Warsaw conventions – Familiarization of recent issues of Advisory Circulars – Civil Aviation Requirements Section 2 – Airworthiness.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To realise the importance of aircraft rules.
CO2: To get exposure on the basic concepts of airworthiness.
CO3: To develop test flight and Certification.
CO4: To carry out inspections and can identify the approved materials.
CO5: To analyse the case studies and realise the importance of civil aviation requirements.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓			✓	✓	✓				
CO2	✓		✓	✓			✓	✓				✓
CO3	✓	✓			✓	✓	✓	✓				✓

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CO4	✓	✓		✓	✓		✓					✓
CO5	✓	✓	✓	✓	✓			✓	✓			

REFERENCES:

1. Civil Airworthiness Requirements (www.dgca.nic.in), 2016.
2. Civil Aircraft Airworthiness Information and Procedures (CAP 562).
3. Civil Aviation Requirements Section 2 - Airworthiness.
4. Gran E L and Richard Levenworth, Statistical Quality Control, 7th Edition McGraw Hill,1997
5. Manual of Civil Aviation/ Organisation Manual DGCA, 2017.
6. The Indian Aircraft Act and the Rules (www.dgca.nic.in), 2008.

AL5007 AEROELASTICITY L T P C

3 0 0 3

COURSE OBJECTIVES:

1. This course provides the basic knowledge on aero elastic phenomena and its impact on aircraft design.
2. This course will make students to illustrate the aeroelastic phenomena using simplified aerodynamic and structural models
3. This course provides insight into both static and dynamic aeroelastic phenomena and possible prevention methods.
4. This course imparts knowledge on the flutter phenomena in detail.
5. This course provides the basic knowledge on prevention and control of aeroelastic instabilities.

UNIT I AEROELASTIC PHENOMENA 8

Stability versus response problems – introduction to aeroelasticity and aeroelastic phenomena – Examples of aeroelastic phenomena – Galloping of transmission lines – Flow induced vibrations of tall slender structures – Instability of suspension bridges – Fluid structure interaction – The aero-elastic triangle of forces – Prevention of aeroelastic instabilities

UNIT II MODELLING OF AEROELASTIC PHENOMENA 9

Influence and stiffness co-efficients – illustration of aeroelastic phenomena using simplified aerodynamic and structural models – different subsonic and supersonic aerodynamic models for aeroelastic analysis – modelling techniques – aeroelastic models in state-space format Flexure – torsional oscillations of beams – Governing differential equation of motion and its solution

UNIT III STATIC AEROELASTIC PHENOMENA 10

Simple two dimensional idealisation – Strip theory – Exact solutions for simple rectangular wings – 'Semirigid' assumption and approximate solutions – Successive approximation method – Numerical approximations using matrix equations – Divergence of 2-D airfoil and Straight Wing – Aileron efficiency & reversal – Control Effectiveness – Wing deformations of swept wings

UNIT IV FLUTTER CALCULATIONS 10

Flutter analysis – Two dimensional thin airfoils in steady incompressible flow – Quasi-steady aerodynamic derivatives – Galerkin method for critical flutter speed – Stability of disturbed motion – Solution of the flutter determinant – Methods of determining the critical flutter speeds – Flutter Calculation – U-g Method – P-k Method – Exact Treatment of Bending –Torsion Flutter of a Uniform Wing – Flutter Analysis by Assumed Mode Method

UNIT V PREVENTION AND CONTROL 8

Stiffness criteria – dynamic mass balancing – dimensional similarity – effect of elastic deformation on static longitudinal stability – introduction to aeroelastic control – aeroelastic aspects in the design of aircraft – Panel flutter and its control – Prevention of tail buffeting – Aeroelastic instabilities in helicopter and engine blades and prevention methods

TOTAL: 45 PERIODS

Attested

COURSE OUTCOMES:

Upon completion of this course, students will

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CO1: Have knowledge of the role of aeroelasticity in aircraft design.
CO2: Interpret the use of semi-rigid body assumptions and numerical methods in airplane design.
CO3: Arrive at the solutions for steady state aeroelastic problem.
CO4: Be knowledge with the concept of flutter analysis of aircraft wings.
CO5: Have knowledge on practical examples of aeroelastic problems.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓	✓			✓					
CO2	✓	✓	✓	✓	✓	✓	✓					✓
CO3	✓	✓	✓	✓	✓							✓
CO4	✓	✓	✓		✓	✓						
CO5	✓	✓	✓			✓	✓					✓

REFERENCES:

1. Bisplinghoff.RL, Ashley,H and Halfmann,RL, "Aeroelasticity", 2nd Edition, Addison Wesley Publishing Co., Inc., 1996.
2. Blevins, RD,"Flow Induced Vibrations", Krieger Pub Co., 2001.
3. Broadbent,EG, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986.
4. Fung,YC, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 2008.
5. Scanlan, RH and R.Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.

AL5078 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 fluid flow.
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

CO1: To apply proper governing equations for various types of viscous flows in engineering applications.
CO2: To obtain solutions for various viscous flow problems in engineering.
CO3: To estimate skin friction over solid surfaces, over which laminar boundary layer persists.
CO4: To arrive at the solutions for turbulent boundary layer and the resulting drag.
CO5: To gain insights on the techniques for boundary layer control.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓			✓				
CO2	✓	✓	✓	✓	✓	✓						✓
CO3	✓	✓	✓	✓			✓	✓				
CO4	✓	✓	✓	✓	✓			✓				✓
CO5	✓	✓	✓	✓		✓	✓					✓

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.

AL5008 COMBUSTION IN JET AND ROCKET ENGINES L T P C

3 0 0 3

COURSE OBJECTIVES:

1. This course provides the basic principles of combustion, types of flames and also familiarizes the combustion process in gas turbine, ramjet, scram jet and rocket engines.
2. This course explains the concept of thermochemistry, enthalpy, adiabatic flame temperature, combustion products and their application to combustion related problems.
3. This course presents the concept of chemical rates of reaction, collision theory and Arrhenius equation for analysing the different types of reactions.
4. This course gives an idea to compare the properties and characteristics of different type of flames and apply the same to combustion phenomenon in rocket motors and its exhaust.
5. This course also imparts knowledge to interpret the various combustion processes that take place in chemical rockets.

UNIT I THERMODYNAMICS OF COMBUSTION 8

Stoichiometry – absolute enthalpy- enthalpy of formation- enthalpy of combustion- laws of thermochemistry- pressure and temperature effect on enthalpy of formation, adiabatic flame temperature, chemical and equilibrium products of combustion.

UNIT II PHYSICS AND CHEMISTRY OF COMBUSTION 9

Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow. Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

UNIT III PREMIXED AND DIFFUSED FLAMES 10

One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame. Gaseous and diffusion flame - Examples -. Differences between premixed flame and diffusion.

UNIT IV COMBUSTION IN GAS TURBINE, RAMJET AND SCRAMJET 9

Combustion in gas turbine chambers, recirculation, combustion efficiency, flame holders, subsonic combustion in ramjet, supersonic combustion in scramjet. Subsonic and supersonic combustion controlled by diffusion mixing and heat convection – peculiarities of supersonic combustion.

UNIT V COMBUSTION IN CHEMICAL ROCKET 9

Combustion in liquid propellant rockets.Combustion of solid propellants- application of laminar flame theory to the burning of homogeneous propellants, Combustion in hybrid rockets.combustion instability in rockets.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Apply the basic concept of thermochemistry to combustion related problems
CO2: Demonstrate the concept of chemical kinetics in combustion reactions.
CO3: Differentiate between deflagration and detonation process and interpret the concept for computation and analysis of the transition phenomenon.
CO4: Demonstrate the peculiarities of supersonic combustion.
CO5: Evaluate the combustion processes taking place in different types of chemical rockets.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓			✓					✓
CO2	✓	✓	✓	✓	✓	✓	✓					✓
CO3	✓	✓	✓	✓	✓	✓	✓					✓
CO4	✓	✓	✓	✓		✓	✓					✓
CO5	✓	✓	✓	✓			✓					

REFERENCES:

1. Kuo, KK, “Principles of Combustion”, John Wiley and Sons, 2005.
2. Mishra, DP, “Fundamentals of Combustion”, Prentice Hall of India, New Delhi, 2008.
3. Mukunda, HS, “Understanding Combustion”, 2nd edition, Orient Blackswan, 2009.
4. Warren C. Strahle, “An Introduction to Combustion”, Taylor & Francis, 1993.

AL5072 ANALYSIS OF COMPOSITE STRUCTURES

L	T	P	C
3	0	0	3

Attested

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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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓			✓	✓		✓			
CO2	✓	✓	✓		✓	✓						✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓								✓

Attested

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CO5	✓	✓	✓	✓	✓			✓	✓			

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 & OriIshai ,“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.

AL5073 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

Attested

UNIT V FRACTURE TOUGHNESS TESTING 9

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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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓				✓					
CO2	✓	✓	✓			✓	✓					
CO3	✓	✓	✓			✓	✓					✓
CO4	✓	✓	✓			✓		✓				
CO5	✓	✓	✓			✓	✓					

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.

AL5079 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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓			✓					
CO2	✓	✓	✓		✓	✓						✓
CO3	✓	✓	✓	✓		✓						✓
CO4	✓	✓	✓	✓	✓		✓					✓
CO5	✓	✓	✓				✓	✓				

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.

AL5075 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: To have 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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓	✓	✓					
CO2	✓	✓	✓		✓	✓	✓					
CO3	✓	✓	✓		✓		✓					✓
CO4	✓	✓	✓	✓			✓					✓
CO5	✓	✓	✓		✓		✓					✓

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.

AL5009 COMPONENT DESIGN OF AIRCRAFT ENGINES L T P C
3 0 0 3

COURSE OBJECTIVES:

1. This course provides the fundamental principles of fluid mechanics and thermodynamics on jet engine design.
2. This course brings out the differences in the design of various types of gas turbine engines.
3. This course imparts knowledge on the effect of inlet design on aerodynamic and propulsive aspects of aircrafts.
4. This course also addresses the problems associated with the design of combustion chambers.
5. This course deals with the practical difficulties in the matching of compressor and turbine.

UNIT I DESIGN FUNDAMENTALS OF GAS TURBINE ENGINE 8

Design Process - Constraint Analysis - Preliminary estimates - Aircraft weight and fuel consumption data- Mission analysis – Performance cycle analysis – Engine installation drag and sizing – Current challenges in gas turbine technology.

UNIT II INLET DESIGN 9

Elements of an Inlet - Engine Integration – Subsonic inlet - Engine Operational Requirements - Supersonic Inlet - Engine Operational Requirements - Engine Impact on Inlet Design - Inlet Impact on Engine Design- Validation of Inlet-Engine System.

UNIT III DESIGN OF ROTATING COMPONENTS 10

Fan and Compressor Aerodynamics - Diffusion factor - Aerofoil geometry - Flow path dimensions - Radial variation - Turbine Aerodynamics - Constant axial velocity – adiabatic - selected Mach number - Mean line stage Design - tage pressure ratio - Airfoil geometry - Radial variation - Turbine cooling - Engine life - Design Examples.

UNIT IV COMBUSTION CHAMBER DESIGN 10

Combustion system components- Chemical reactor theory - Combustor Stability map-Stirring and mixing-Total pressure loss-Fuels-Ignition-Combustion Systems of Main Burner Design: Air partitioning- Main burner component Design: Diffuser-types of burner-inner and outer casing Design-Fuel- nozzle-Dome and liner-Primary zone- swirler-Secondary holes-Dilution holes-Transition duct-Example Design calculation: Design of Afterburners-Design parameters-Components-Diffuser-Fuel injection-Ignition-Flame stabilization-Flame spread and after burner length-Example design calculations.

UNIT V EXHAUST NOZZLE DESIGN 8

Different types of Nozzles – design of nozzles - Jet control methods for reduction of infrared signature on military aircrafts - Simple design problem - One dimensional nozzle flow.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able

CO1: To successfully design a gas turbine engine for given requirements.

CO2: To have thorough knowledge with the operational behavior of the major components of gas turbine engines.
CO3: To identify the factors those limit the performance of the components of gas turbine engines.
CO4: To find solutions for the compressor and turbine matching in gas turbine engines.
CO5: To overcome the problems associated with inlet on aircrafts.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓			✓	✓					
CO2	✓	✓	✓				✓	✓				✓
CO3	✓	✓	✓	✓		✓			✓			✓
CO4	✓	✓	✓					✓	✓			✓
CO5	✓	✓	✓	✓					✓			

REFERENCES:

1. Cumpsty,N, "Jet Propulsion: A Simple Guide to the Aerodynamics and Thermodynamics Design and Performance of Jet Engines", Cambridge University Press, 2nd edition, 2003.
2. Mattingly.JD, Heiser,WH and Pratt,DT, "Aircraft Engine Design", 2nd Edition, AIAA Education Series, 2002.
3. Oates. GC, "Aircraft Propulsion Systems Technology and Design", AIAA Education Series, 1989.
4. Saravanamuttoo, HIH and Rogers,GFC, "Gas Turbine Technology", Pearson Education Canada, 6th edition, 2008.
5. Treager,IE, "Aircraft Gas Turbine Engine Technology", 3rd edition, Glencoe McGraw-Hill, Inc.1995.

AL5010 AIRCRAFT SYSTEMS ENGINEERING **L T P C**
3 0 0 3

COURSE OBJECTIVES:
This course will make students
1. To provide exposure to basic concepts of Aircraft product system engineering and design
2. To provide exposure to different fault and failure analysis methods in aircraft systems.
3. To provide exposure on systems engineering process, System Architecture and integration
4. To provide exposure on the importance of Maintainability, reliability and availability of the product.
5. To provide exposure importance of formal planning and documentation in systems engineering.

UNIT I INTRODUCTION TO SYSTEMS ENGINEERING **9**
Overview of Systems Engineering- Systems Engineering Concept Map-Systems Definition-The seven steps Systems Engineering-Conceptual System Design- System Engineering Process-Requirements and Management-Trade Studies-Integrated Product And Process Development.

UNIT II THE AIRCRAFT SYSTEMS AND DESIGN **9**
Introduction- Everyday Examples of Systems- Aircraft Systems –Generic Systems-Product Life

Cycle- Different Phases-Whole Life Cycle Tasks- Systems Analysis-Design Drivers in the Project, Product, Operating Environment- Interfaces with the Subsystems-Mission analysis

UNIT III SYSTEM ARCHITECTURES AND INTEGRATION 9

Introduction- Systems Architectures –Modeling and Trade-Offs Evolution of Avionics Architectures- Systems Integration Definition-Examples of Systems Integration-Integration Skills-Management of Systems Integration.

UNIT IV PRACTICAL CONSIDERATIONS AND CONFIGURATION CONTROL 9

Stakeholders- Communications- Criticism- Configuration Control Process-Portrayal of a System-Varying Systems Configurations- Compatibility-Factors Affecting Compatibility–Systems Evolution. Considerations and Integration of Aircraft Systems- Risk Management.

UNIT V SYSTEMS RELIABILITY AND MAINTAINABILITY 9

Systems and Components-Analysis- Influence, Economics, Design for Reliability-Fault and Failure Analysis-System Life Cycle cost-Case Study-Maintenance Types-Program-Planning and Design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1: Describe the importance of systems engineering process in product development
CO2: Categorize different aircraft systems and will be able to differentiate the avionics architectures
CO3: Outline the different stages of product development and factors influencing in each stage
CO4: Analyze the different alternatives during design process
CO5: Plan, organize and document the task related to product design, development and testing.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓			✓	✓		✓			
CO2	✓	✓	✓	✓	✓	✓						✓
CO3	✓	✓	✓		✓	✓	✓	✓				✓
CO4	✓	✓	✓	✓	✓	✓						✓
CO5	✓	✓	✓	✓		✓	✓	✓				

REFERENCES:

1. Andrew P.Sage & James E.Armstrong, “Introduction to Systems Engineering”, 1st edition, 2000.
2. Erik Aslaksen & Rod Belcher, “Systems Engineering”, Prentice Hall, 1992.
3. Ian Moir & Allan Seabridge, “Design and Development of Aircraft Systems”, Wiley, 2nd edition, 2012.
4. Ian Moir & Allan Seabridge, “Aircraft Systems Mechanical, electrical, and avionics subsystems integration”, John Wiley & Sons Ltd, 2011.
5. Peter. Sydenham, “Systems Approach to Engineering Design”, Artech house, Inc, London, 2003.

AL5011 AIRCRAFT DESIGN L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To get in-depth knowledge about the preliminary concepts of aircraft design.

2. To provide with the basic knowledge on various aircraft loads.
3. To learn the design of aircraft wing.
4. To get exposed to different kinds of landing gear and its design.
5. To provide with the basic knowledge on integration of wing, fuselage, empennage and power plant.

UNIT I PRELIMINARY CONCEPTS 8

Aircraft Design Requirements - Specifications - Role of user - Aerodynamic and Structural considerations - Importance of weight fractions - Airworthiness requirements and standards - Classification of airplanes - Special features of an airplane - Airplane performance aspects - Range and endurance - Take-off and landing - Climbing performance - Engine Performance

UNIT II AIRCRAFT LOADS 10

Ground loads - Flight Loads - Symmetrical loads in flight - Basic flight loading conditions - Load factor calculation during a manouever - Velocity - Load factor diagram - Gust load and its estimation - Structural limits - Airplane weight estimation based on type of airplane - Trends in wing loading - Weight-estimation based on mission requirements - iterative approach - Span wise load distribution - Wing Loading

UNIT III WING DESIGN 10

Selection of airfoil selection - Influencing factors - Planform shapes of an airplane wing - Stalling, takeoff and landing considerations - Wing drag estimation - High lift devices - Supercritical Airfoils - Cockpit and aircraft passenger cabin layout for different aircraft - types of associated structure - structural layout - features of light airplanes using advanced composite materials - Structural design aspects - Bending moment and shear force diagram for wing and fuselage - Design principles of all metal stressed skin construction for civil and military applications

UNIT IV LANDING GEAR 8

Different kinds of landing gears and associated arrangement for civil and military airplanes - Preliminary calculations for locating main and nose landing gears - Integration of Structure and Power Plant - Estimation of Horizontal and Vertical tail volume ratios - Choice of power plant and various options of locations - Considerations of appropriate air-intakes - Power Plant Loading

UNIT V INTEGRATION OF WING, FUSELAGE, EMPENNAGE AND POWER PLANT 9

Estimation of center of gravity - Introduction to advanced concepts - Aircraft Stability - Relaxed static stability - Controlled configured vehicles - V/STOL aircraft & rotary wing vehicles - Design and layout of flying controls and engine controls - Design of a wing-fuselage joint

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will

CO1: Have overall knowledge of preliminary aircraft design.
CO2: Have basic knowledge of aircraft rules and airworthiness requirements imposed by governing bodies.
CO3: Be able to calculate and estimate aircraft loads under different loading conditions.
CO4: Be able to configure an aircraft wing based on aerodynamic considerations.
CO5: Be exposed the role of aircraft stability in the aircraft design process.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓	✓							✓
CO2	✓	✓	✓	✓	✓	✓	✓					
CO3	✓	✓	✓	✓	✓							✓
CO4	✓	✓	✓	✓	✓		✓		✓			
CO5	✓	✓	✓	✓	✓		✓					✓

Attested

REFERENCES:

1. Conway, HG, “Landing Gear Design”, Chapman & Hall; 1st edition, 1958.

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2. Daniel P Raymer, “Aircraft Design: A conceptual approach”, AIAA Educational Series, 5th edition 2012.
3. Darrol Stinton , “The Design of Airplane”, Wiley publishers,, 2nd edition, 2001.
4. John D Anderson, “Airplane Performance and Design”, McGraw Hill, 1st edition,1999.
5. Nicholai,LM, “Fundamentals of airplane Design”, Univ. of Dayton DHIO, 1975.
6. Torenbeek, Egbert, “Synthesis of Subsonic Airplane Design”, Springer publishers, 1982.

AL5012 HELICOPTER AERODYNAMICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. This course will make students to provide with introductory concepts of types of rotorcraft.
2. This course imparts knowledge on the fundamental aspects of helicopter aerodynamics and performance of helicopters.
3. This course will provide basic knowledge on the performance of helicopters.
4. This course presents stability and control aspects of helicopters.
5. This course will explore the basic aerodynamic design aspects of helicopters.

UNIT I INTRODUCTION 9

Types of rotorcraft – autogyro, gyrodyne, helicopter, Main rotor system – articulated, semi rigid, rigid rotors, Collective pitch control, cyclic pitch control, anti torque pedals.

UNIT II HELICOPTER AERODYNAMICS 10

Momentum / actuator disc theory, Blade element theory, combined blade element and momentum theory, vortex theory, rotor in hover, rotor model with cylindrical wake and constant circulation along blade, free wake model, Constant chord and ideal twist rotors, Lateral flapping, Coriolis forces, reaction torque, compressibility effects, Ground effect.

UNIT III PERFORMANCE 9

Hover and vertical flight, forward level flight, Climb in forward flight, optimum speeds, Maximum level speed, rotor limits envelope – performance curves with effects of altitude

UNIT IV STABILITY AND CONTROL 9

Helicopter Trim, Static stability – Incidence disturbance, forward speed disturbance, angular velocity disturbance, yawing disturbance, Dynamic Stability.

UNIT V AERODYNAMIC DESIGN 9

Blade section design, Blade tip shapes, Drag estimation – Rear fuselage upsweep, vibration problem of Helicopter blades.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able to

CO1: Describe and compare possible helicopter structures and configurations.
CO2: Identify features of aerodynamic components of rotary wing aircraft and its performance.
CO3: Describe the aerodynamic characteristics that affect rotary wing flight.
CO4: Idea about the factors that influence helicopter stability.
CO5: Gain knowledge of helicopter controls and vibration analysis of helicopter blades.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓								✓
CO2	✓	✓	✓		✓	✓			✓			

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CO3	✓	✓	✓	✓	✓	✓						✓
CO4	✓	✓	✓		✓	✓	✓					
CO5	✓	✓	✓	✓			✓	✓				✓

REFERENCES:

1. Gessow.A and Meyers,GC, "Aerodynamics of the Helicopter", Macmillan and Co., New York,1982.
2. John Fay, "The Helicopter", Himalayan Books, New Delhi, 1995.
3. Lalit Gupta, "Helicopter Engineering", Himalayan Books, New Delhi, 1996.
4. Lecture Notes on Helicopter Technology, Department of Aerospace Engineering, IIT –Kanpur and Rotary Wing aircraft R&D center, HAL, Bangalore, 1998.
5. Seddon,J, "Basic Helicopter Aerodynamics", AIAA Education series, Blackwell scientific publications, U.K, 1990.

AL5074 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 JET CONTROL 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.

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓			✓					✓
CO2	✓	✓	✓		✓		✓		✓			
CO3	✓	✓	✓	✓	✓	✓	✓					
CO4	✓	✓	✓		✓	✓	✓	✓	✓			
CO5	✓	✓	✓	✓			✓					✓

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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.

AL5077 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.

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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.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓		✓					✓
CO2	✓	✓	✓	✓		✓	✓					✓
CO3	✓	✓	✓	✓	✓		✓					✓
CO4	✓	✓	✓	✓	✓		✓	✓				✓
CO5	✓	✓	✓		✓		✓		✓			✓

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.

AL5013 ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To learn the basic aspects of machine learning.
2. To get basic knowledge on supervised learning.
3. To realize the importance of unsupervised learning.
4. To exposed on direct and indirect neuro control schemes.
5. To get insight into the basic knowledge on fuzzy logic systems

UNIT- I INTRODUCTION TO MACHINE LEARNING 9

Course objectives of machine learning – Human learning/ Machine learning – Types of Machine learning:- Supervised Learning – Unsupervised learning – Reinforcement Learning – Evolutionary Learning -Regression – Classification – The Machine Learning Process:- Data Collection and Preparation – Feature Selection – Algorithm Choice – Parameter and Model Selection – Training – Evaluation

UNIT-II SUPERVISED LEARNING 9

Linearly separable and nonlinearly separable populations – Introduction to ANN: Biological neuron, artificial neuron, activation function, Perceptron, Multi Layer Perceptron– Back propagation

Learning Algorithm – Radial Basis Function Network – Support Vector Machines: - Kernels – Risk and Loss Functions - Support Vector Machine Algorithm –Multi Class Classification – Support Vector Regression

UNIT-III UNSUPERVISED LEARNING 9

Introduction – Clustering:-Partitioning Methods:- K-means algorithm - Hierarchical clustering – Fuzzy Clustering – Clustering High-Dimensional Data:- Problems – Challenges – Subspace Clustering – Biclustering- Self Organizing Map (SOM) - SOM algorithm

UNIT-IV NEURAL NETWORKS FOR MODELING AND CONTROL 9

Need for using ANN in Modeling and Control – Modeling of non-linear systems using ANN: Generation of training data, Identification of Optimal architecture, Model validation – Control of nonlinear systems using ANN: Direct and Indirect neuro control schemes – Adaptive neuro controller

UNIT-V FUZZY LOGIC SYSTEMS 9

Fuzzy set theory – Operation on fuzzy sets: Scalar cardinality, Fuzzy cardinality, Fuzzy union and intersection, Fuzzy complement (Yager and Sugeno), Aggregation, Projection, Composition, Cylindrical extension, Fuzzy relation – Fuzzy membership functions - Modeling of non-linear systems using fuzzy models: Fuzzification, Knowledge base, Decision making logic, Defuzzification.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To get familiarize with the basic aspects of machine learning.
CO2: To get exposure on supervised and unsupervised learning.
CO3: To demonstrate the need for neutral networks for modelling and control
CO4: To get familiarize with the fuzzy logic systems.
CO5: To realize the importance of machine learning and its applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓	✓							✓	✓
CO2	✓	✓	✓		✓	✓			✓			
CO3	✓	✓	✓	✓			✓				✓	✓
CO4	✓	✓	✓		✓	✓	✓					
CO5	✓	✓	✓	✓	✓	✓	✓				✓	✓

REFERENCES:

1. Ethem Alpydin, “Introduction to Machine learning (Adaptive Computation and Machine Learning series)”, MIT Press, 2004.
2. Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, Classification, Parameter Estimation, and State Estimation: An Engineering Approach Using MATLAB, John Wiley & Sons, 2005.
3. Klir GJ, and Bo, Yuan, “Fuzzy sets and fuzzy logic, Theory and applications”, Prentice Hall, 1995.
4. Millon WT, Sutton RS and Webrose PJ, “Neural Networks for Control”, MIT press, 1992.

AL5014 AIRCRAFT GUIDANCE AND CONTROL L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To learn about the aircraft equations of motion and method of linearization.
2. To impart knowledge on the operating principle of guidance law.
3. To gain knowledge on various augmentation systems.

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4. To get familiarize with the concepts of longitudinal stability and to design the longitudinal autopilot.
5. To study lateral stability and to design the lateral autopilot.

UNIT I INTRODUCTION 8

Introduction to Guidance and control-Definition, Historical background – Coordinate Frame - Equations of motion – Linearization

UNIT II AUGMENTATION SYSTEMS 8

Need for automatic flight control systems, Stability augmentation systems, control augmentation systems, Design of Limited authority and Full Authority Augmentation systems - Gain scheduling concepts.

UNIT III LONGITUDINAL AUTOPILOT 9

Displacement Autopilot-Pitch Orientation Control system, Acceleration Control System, Glide Slope Coupler and Automatic Flare Control and Flight path stabilization, Longitudinal control law design using back stepping algorithm.

UNIT IV LATERAL AUTOPILOT 10

Damping of the Dutch Roll, Methods of Obtaining Coordination, Yaw Orientation Control system, turn compensation, Automatic lateral Beam Guidance. Introduction to Fly-by-wire flight control systems, Lateral control law design using back stepping algorithm.

UNIT V MISSILE AND LAUNCH VEHICLE GUIDANCE 10

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: Explain the equations governing the aircraft dynamics and the process of linearizing them.
CO2: Define the various guidance schemes & requirements for aircrafts and missiles.
CO3: Explain the principle of stability and control augmentation systems.
CO4: Explain the oscillatory modes and methods of suppressing them
CO5: Design the controller for lateral, longitudinal and directional control of aircrafts.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓						✓		✓	✓
CO2	✓	✓	✓		✓	✓						
CO3	✓	✓	✓	✓	✓	✓	✓					✓
CO4	✓	✓	✓	✓		✓	✓				✓	
CO5	✓	✓	✓	✓	✓		✓		✓			✓

REFERENCES:

1. Blake Lock,JH, "Automatic control of Aircraft and missiles", John Wiley Sons, New York, 1990.
2. Collinson RPG, "Introduction to Avionics", Chapman and Hall,India,1996.
3. Garnel.P & East DJ, "Guided Weapon control systems", Pergamon Press, Oxford, 1977.
4. Michael V Cook, "Flight Dynamics Principles: A Linear Systems Approach to Aircraft Stability and Control", Elsevier, 2013.
5. Nelson RC, "Flight stability & Automatic Control", McGraw Hill,1989.
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7. Stevens BL and Lewis FL, "Aircraft control & simulation",John Wiley Sons, NewYork,1992.

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8. Thomas R Yechout, Steven L Morris, David E Bossert, Wayne F Hallgren, James K Hall, "Introduction to Aircraft Flight Mechanics", AIAA Education series, 2014.

OPEN ELECTIVE COURSES (OEC)

OE5091	BUSINESS DATA ANALYTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

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Suggested Evaluation Methods:

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- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop – RDBMS versus Hadoop – Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop – Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.

- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. Vignesh Prajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, Umesha Nayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. Anand Rajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

OE5092 INDUSTRIAL SAFETY L T P C
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment’s like, I. Any one machine tool,

ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook, Eighth Edition,2008

OE5093 OPERATIONS RESEARCH L T P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENT OF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING *CONCEPTS* 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2–Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C

3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, West Germany.

Attested

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2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 **WASTE TO ENERGY** **L T P C**
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
  - Develop knowledge on biomass pyrolysis process and its applications
  - Develop knowledge on various types of biomass gasifiers and their operations
  - Invent knowledge on biomass combustors and its applications on generating energy
  - Summarize the principles of bio-energy systems and their features

UNIT I INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT II BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT IV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL:30 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy

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CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

AUDIT COURSES (AC)

AX5091 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

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

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.

AX5092 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

Attested

TOTAL : 30 PERIODS

OUTCOMES

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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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

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.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS **6**

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES **6**

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS **6**

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE **6**

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING **6**

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.

- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 VALUE EDUCATION L T P C

2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

Suggested reading

1. Chakroborty, S.K."Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

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AX5095 **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.

Attested

SUGGESTED READING

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

AX5096 **PEDAGOGY STUDIES** **L T P C**
2 0 0 0

OBJECTIVES

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT II INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT III THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT IV EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT V PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT VI RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to understand:

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Attested

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SUGGESTED READING

1. Ackers J, HardmanF (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004)Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1.London:DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097	STRESS MANAGEMENT BY YOGA	L T P C 2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do`s and Don't's in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTED READING

1. 'Yogic Asanas for Group Tarining-Part-I":Janardan Swami Yoga bhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT I

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

SUGGESTED READING

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda, Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.