GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT (GITAM)
(Deemed to be University)
VISAKHAPATNAM * HYDERABAD * BENGALURU

Accredited by NAAC with A^+ Grade

CURRICULUM AND SYLLABUS

OF

B.Tech. Aerospace Engineering

(w.e.f. 2019-20 admitted batch)

B. Tech. in Aerospace Engineering

REGULATIONS

(w.e.f. 2019-20 admitted batches)

1. ADMISSION

1.1 Admission into B. Tech. in Aerospace Engineering program of GITAM (Deemed to be University) is governed by GITAM admission regulations.

2. ELIGIBILITY CRITERIA

2.1 A first class in 10+2 or equivalent examination approved by GITAM (Deemed to be University) with subjects Physics, Chemistry and Mathematics.

2.2 Admission into B.Tech. will be based on an All-India Entrance Test (GITAM Admission Test - GAT) conducted by GITAM/Specified rank holders of JEE mains/EAMCET (AP & TS) and the rules of reservation of statutory bodies, wherever applicable, will be followed.

3. CHOICE BASED CREDIT SYSTEM

3.1 Choice Based Credit System (CBCS) was introduced with effect from the academic year of 2015-16 admitted batch and revised in 2019-20 academic year, based on guidelines of the statutory bodies in order to promote:

- Activity based learning
- Student centered learning
- Cafeteria approach
- Students to choose courses of their choice
- Learning at their own pace
- Interdisciplinary learning

3.2 Course Objectives, Learning Outcomes and Course Outcomes are specified, focusing on what a student should be able to do at the end of the course and program.

4. STRUCTURE OF THE PROGRAM

4.1 The program consists of humanities and social sciences, basic sciences, basic engineering, program core, program electives, open electives, interdisciplinary electives, industry internship, laboratory, mandatory courses and project work.

Core Courses	Branch specific	Compulsory
Elective courses	Program Electives	*Supportive to the discipline courses with expanded scope in a chosen track of specialization or cross track courses*
	Interdisciplinary Electives	*Interdisciplinary exposure & nurture*

		the student interests in other department courses.
	Open Electives	*Common to all disciplines that help general interest of a student*

4.2 Eachcourseisassignedacertainnumberofcreditsdependinguponthenumberofcontact hours (lectures/tutorials/practical) per week.

4.3 In general, credits are assigned to the courses based on the following contact hours per week per semester.

- One credit for each Lecture/Tutorial hour per week.
- One credit for two hours of Practical's per week.

4.4 The curriculum of the eight semesters B.Tech. Program is designed to have a total of 160 credits for the award of B.Tech. Degree.

5. MEDIUM OF INSTRUCTION

The medium of instruction (including examinations and project reports) shall be English.

6. REGISTRATION

Every student has to register himself/herself for the courses in each semester individually at the time as specified in the academic calendar.

7. ATTENDANCE REQUIREMENTS

7.1 Astudentwhoseattendanceislessthan75%inallthecoursesputtogetherinanysemester will not be permitted to attend the end-semester examination and he/she will not be allowed to register for subsequent semester of study. He/she must repeat the semester along with his/her juniors.

7.2 However, the Vice-Chancellor on the recommendation of the Principal / Director of the Institute/School may condone the shortage of attendance of the students whose attendance is between 65% and 74% on genuine medical grounds and on payment of prescribed fee.

8. EVALUATION

8.1 The assessment of the candidates' performance in a theory course shall be based on two components: Continuous Evaluation (40 marks) and Semester-end Examination (60 marks).

8.2 A candidate has to secure an aggregate of 40% in the course in the two components put together to be declared to have passed the course, subject to the condition that the candidate must have secured a minimum of 24 marks out of 60 marks (i.e. 40%) in the theory component at the semester-end examination.

8.3 Practical courses are assessed under Continuous Evaluation for a maximum of 100 marks, and a candidate has to obtain a minimum of 40% to secure a pass grade.The courses having theory and practical combined, 70% of the weightage will be given for theory component and 30% weightage for practical component. The candidate must acquire 40% in the semester end theory examination. However, candidates must have secured overall 40% (Theory + Practical) to secure a pass grade.

8.4 Project Work/ Industrial internship courses are assessed under continuous evaluation for a maximum of 100 marks, and a candidate must obtain a minimum of 40% to secure a pass grade.

8.5 MandatoryCoursesareassessedforPASSorFAILonly.Nogradewillbeassignedtothese courses. If a candidate secures more than 40 out of 100 marks, he / she will be declared PASS, else FAIL

8.6 Mandatory courses NCC/NSS/NSO/YOGA are assessed for satisfactory or not satisfactory only. No grade will be assigned. A candidate must undergo two hours training per week in any one of the above in both 1st and 2nd semesters.

Details of Assessment Procedure are furnished in Table 1.

Table 1: Assessment Procedure

S.No	Component of Assessment	Types of Assessment	Marks Allotted	Scheme of Evaluation
1	Theory courses	Continuous Evaluation	40	(i) Thirty (30) marks for mid semester examinations. Three mid examinations shall be conducted for 15 marks each; performance in best two shall be taken into consideration. ii) Ten (10) marks for Quizzes, Assignments and Presentations.
		Semester End Examinations	60	Sixty (60) marks for semester-end Examinations.
		Total	100	
2	Practical courses	Continuous Evaluation	100	(i) Fifty (50) marks for regularity and performance, records, and oral presentations in the laboratory. Weightage for each component shall be announced at the beginning of the semester. ii) Ten (10) marks for case studies. iii) Forty (40) marks for two tests of 20 marks each (one at the mid-term and the other towards the end of the semester) conducted by the concerned lab teacher.

3	Theory and Practical combined courses	(a) Theory component: continuous evaluation and semester end examination. (b) Practical component: continuous evaluation Total	100 100 200	70% of the weightage will be given for theory component. Evaluation for theory components will be the same as S. No 1 as above. 30% weightage for practical components. Evaluation for practical component will be same as S. No 2 as above
4	Project work (VII & VIII Semesters)	Continuous Evaluation	100	i) Forty (40) marks for periodic evaluation on originality, innovation, sincerity, and progress of the work assessed by the project supervisor. ii) Thirty (25) marks for mid-term evaluation for defending the project before a panel of examiners. iii) Thirty (35) marks for final Report presentation and Viva-voce by a panel of examiners.
5	Industrial Internship (VII Semester)	Continuous Evaluation	100	i) Thirty (30) marks for Project performance, assessed by the Supervisor of the host Industry/ Organization. Submission of Project Completion Certificate from host organization is mandatory. ii) Forty (40) marks for Report and Seminar presentation on the training, assessed by the Teacher Coordinator.

				iii) Thirty (30) marks for presentation on the training, before a panel of examiners.
6	Mandatory Courses	Continuous Evaluation	100	(i) Sixty (60) marks for mid semester Examinations. Three mid examinations shall be conducted for 30 marks each; performance in best two shall be taken into consideration. (ii) Forty (40) marks for Quizzes, Assignments and Presentations

9. RETOTALING & REVALUATION

9.1 Retotaling of the theory answer script of the semester-end examination is permitted on request by the candidate by paying the prescribed fee within one week after the announcement of the results.

9.2 Revaluation of the theory answer scripts of the semester-end examination is permitted on requestbythestudentbypayingtheprescribedfeewithinoneweekaftertheannouncement of the result.

9.3 A candidate who has secured 'F' grade in a theory course shall have to reappear at the subsequent examination held in that course. A candidate who has secured an 'F' grade can improve continuous evaluation marks up to a maximum of 50% by attending special instruction classes held during summer.

9.4 A candidate who has a secured 'F' grade in a practical course shall have to attend Special Instruction classes held during summer.

9.5 A candidate who has secured 'F' grade in a combined (theory and practical) course shall have to reappear for theory component at the subsequent examination held in that course. A candidate who has secured an 'F' grade can improve continuous evaluation marks up to a maximum of 50% by attending special instruction classes held during summer.

9.6 A candidate who has secured 'F' Grade in project work / Industrial Training shall be permitted to submit the report only after satisfactory completion of the work and viva- voce examination.

10. PROVISION FOR ANSWER BOOK VERIFICATION AND CHALLENGE EVALUATION

10.1 If a candidate is not satisfied with his/her grade after revaluation, the candidate can apply for, answer book verification on payment of prescribed fee for each course within one week after announcement of revaluation results.

10.2 After verification, if a candidate is not satisfied with revaluation marks/grade awarded, he/she can apply for challenge valuation within one week after announcement of answer book verification result/ two weeks after the announcement of revaluation results, which will be valued by the two examiners i.e., one Internal and one External examiner in the presence of the candidate on payment of prescribed fee. The challenge valuation fee will be returned, if the candidate is successful in the appeal with a change for a better grade.

11. SUPPLEMENTARY EXAMINATIONS AND SPECIAL EXAMINATIONS.

11.1 The odd semester supplementary examinations will be conducted on a daily basis after conducting regular even semester examinations during April/May.

11.2 The even semester supplementary examinations will be conducted on a daily basis after conducting regular odd semester examinations during October/November.

11.3 A candidate who has completed his/her period of study and still has "F" grade in final semestercoursesiseligibletoappearforSpecialExaminationnormallyheldduringsummer vacation.

12. PROMOTION TO THE NEXT YEAR OF STUDY

12.1 A student shall be promoted to the next academic year only if he/she completes the academic requirements of 50% of the credits till the previous academic year.

12.2 Whenever there is a change in syllabus or curriculum, he/she has to continue the course with new regulations after detention as per the equivalency established by the BoS to continue his/her further studies.

13. MASSIVE OPEN ONLINE COURSES

Greater flexibility to choose a variety of courses is provided through Massive Open Online Courses (**MOOCs**) during the period of study.Students Without Backlog Courses Upto Fourth semester are permitted to register for MOOCs from fifth semester onwards up to a maximum of 15 credits from program elective/ interdisciplinary elective/ open elective courses. However, the Departmental Committee (DC) of the respective campuses has to approve the courses under MOOCs. The grade equivalency will be decided by the respective Board of Studies (BoS).

14. BETTERMENT OF GRADES

14.1 A student who has secured only a pass or second class and desires to improve his/her class can appear for betterment examinations only in eight theory courses of any semester of his/her choice, conducted in summer vacation along with the Special Examinations.

14.2 Betterment of Grades is permitted 'only once', immediately after completion of the program of study.

15. HONORS

A student who secured 8 CGPA or above up to IV semester is eligible to register for B. Tech (Honors)degree. The student must complete additional 20credits (six theory courses + seminar) as approved by the respective Departmental Committee (DC) to secure B. Tech (Honors). The courses will be approved by the DC of respective campuses.

16 GRADING SYSTEM

16.1 Based on the student performance during a given semester, a final letter grade will be awarded at the end of the semester in each course. The letter grades and the corresponding grade points are as given in Table2.

Table 2: Grades and Grade Points

S.No.	Grade	Grade Points	Absolute Marks
1	O (Outstanding)	10	90 and above
2	A+(Excellent)	9	80 to 89
3	A (VeryGood)	8	70 to 79
4	B+(Good)	7	60 to 69
5	B (AboveAverage)	6	50 to 59
6	C (Average)	5	45 to 49
7	P (Pass)	4	40 to 44
8	F (Fail)	0	Less than 40
9	Ab.(Absent)	0	-

16.2 A student who earns a minimum of 4 grade points (P grade) in a course is declared to have successfully completed the course, subject to securing an average GPA of 5.0 (average of all GPAs in all semesters) at the end of the program to declare pass in the program.

17. GRADE POINT AVERAGE

17.1 A Grade Point Average (GPA) for the semester will be calculated according to the Formula:

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$$GPA = \frac{\sum [C * G]}{\sum C}$$

Where, C = number of credits for the course, G =grade points obtained by the student in the course.

17.2 To arrive at Cumulative Grade Point Average (CGPA),a similar formula is used considering the student's performance in all the courses taken, in all the semesters up to that particular semester.

17.3 CGPA required for classification of class after the successful completion of the program is shown in Table3.

Table 3: CGPA required for award of Class

Class	CGPA Required
First Class with Distinction	$\geq$8.0*
First Class	$\geq$ 6.5

Second Class	≥ 5.5
Pass Class	≥ 5.0

* In addition to the required CGPA of 8.0 or more, the student must have necessarily passed all the courses of every semester in the first attempt.

18. ELIGIBILITY FOR AWARD OF THE B. Tech. DEGREE

18.1 Duration of the program: A student is ordinarily expected to complete the B.Tech. Program in eight semesters of four years. However, a student may complete the program in not more than eight years including study period.

18.2 However, the above regulation may be relaxed by the Vice-Chancellor in individual cases for cogent and sufficient reasons.

18.3 A student shall be eligible for award of the B.Tech. Degree if he / she fulfills all the following conditions:

i) Registered and successfully completed all the courses and projects.
ii) Successfully acquired the minimum required credits as specified in the curriculum in the branch of his/her study within the stipulated time.
iii) Has no dues to the Institute, hostels, Libraries, NCC/NSS etc., and no disciplinary action is pending against him/her.

19. DISCRETIONARY POWER

Notwithstanding anything contained in the above sections, the Vice-Chancellor may review all exceptional cases, and give his decision, which will be final and binding.

PROGRAM EDUCATIONAL OBJECTIVES

PEO1	To demonstrate their expertise in solving contemporary problems through design, analysis, implementation and evaluation of hardware and software systems
PEO2	To engage in the Aerospace Engineering profession locally and globally by contributing ethically to the competent and professional practice of Engineering or other professional careers.
PEO3	To adapt to a constantly changing world through professional development and sustained learning
PEO4	To exhibit leadership and entrepreneurship skills by incorporating organizational goals and providing facilities for peer members with defined objectives
PEO5	To develop communication skills and show a commitment to teamwork necessary to function productively and professionally on multidisciplinary teams

Program Outcomes (POs) of Aerospace Engineering:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and Aerospace engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, research literature, and analyze complex Aerospace engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex Aerospace engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex Aerospace engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex Aerospace engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the Aerospace engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs) of Aerospace Engineering:

PSO1: Identify, formulate, and solve Aerospace engineering problems in the related domains to provide efficient solutions

PSO2: Analyze, design and develop applications of varying complexities in the emerging areas of Aerospace Engineering

PSO3: Provide a platform to engage in research with professional and ethical responsibility to meet the societal needs

Department of Aerospace Engineering

(Effective from the academic year 2019-20 admitted batch)

Semester I

S. No	Course Code	Course Name	Category	L	T	P	A	C	Remarks
1.	19EMA101	Engineering Mathematics -I (Calculus and Algebra)	BS	3	0	0		3	Common to all except BT
2.	GEL131	Communicative English	HS	2	0	2		3	Common to all
3.	19ECY133/ 19EPH133	Chemistry of materials/ Applied Physics	BS	3	0	3		4.5	Common to all
4.	19EID131/ 19EEE131	Problem Solving and Programming / Basic Electrical and Electronics Engineering	ES	3	1	3		5.5	Common to all
5.	19EME121/ 19EME131	Workshop / Engineering Graphics	ES	0/1	0	3		1.5/2.5	Common to all
6.	19EMC181A/ 19EMC181B/ 19EMC181C/ 19EMC181D	NCC/NSS/NSO/YOGA	MC	0	0	2		0	Common to all
Total								**17.5/18.5**	

Semester II

S. No	Course Code	Course Name	Category	L	T	P	A	C	Remarks
1.	19EMA102	Engineering Mathematics -II (ODE, PDE and Multivariable Calculus)	BS	3	0	0		3	Common to all
2.	19EPH133/ 19ECY133	Applied Physics/ Chemistry of materials	BS	3	0	3		4.5	Common to all
3.	19EID134/ 19EID132	AI tools / Design thinking	ES	2	0	2		3	
4.	19EME131/ 19EME121	Engineering Graphics/ Basic Workshop	ES	1/0	0	3		2.5/1.5	Common to all
5.	19EEE131/ 19EID131	Basic Electrical & Electronics Engineering/ Problem Solving and Programming	ES	3	1	3		5.5	Common to all
6.	19EAE102	Introduction to Aerospace Engineering	PC	2	0	0		2	Branch Specific
7.	19EAE122	Aeromodelling Workshop	PC	0	0	2		1	Branch Specific
8.	19EMC181A/ 19EMC181B/ 19EMC181C/ 19EMC181D	NCC/NSS/NSO/YOGA	MC	0	0	2		0	Common to all
9.	19EHS122	Comprehensive Skill Development I	HS	0	0	0	4	1	Common to all
10.	19VDC111	Venture Discovery	PW	0	0	4		2	Common to all
Total								**24.5/23.5**	

Semester III

S.No	Course Code	Course Name	Category	L	T	P	A	C	Remarks
1.	19EMA201	Engineering Mathematics -III (PDE, Complex Variables and Transform Techniques)	BS	3	0	0		3	Common to all
2.	19EID132/ 19EID134	Design Thinking / AI Tools	ES	2	0	2		3	Common to all
3.	19EME201	Engineering Mechanics	PC	2	1	0		3	Common With ME
4.	19EAE201	Thermodynamics	PC	2	1	0		3	Branch Specific
5.	19EAE203	Aerospace Materials Engineering	PC	3	0	0		3	Branch Specific
6	19EAE221	Computer Aided Aircraft Drawing	PC	0	0	3		1.5	Branch Specific
7	19EAE223	Materials and Machine tool lab	PC	0	0	3		1.5	Branch Specific
8	19EMC281 / 19EMC282	Constitution of India/Environmental Sciences	MC	3	0	0		0	Mandatory Course
9	19EHS221	Comprehensive Skill Development II	HS	0	0	0	4	1	
Total								19	

Semester IV

S.No	Course Code	Course Name	Category	L	T	P	A	C	Remarks
1	19EID234/ 19EID232	Life Sciences for Engineers/ Internet of Things	BS/ES	2	0	2		3	Common to All
2	19EAE202	Fluid Mechanics	PC	3	1	0		4	Branch Specific
3	19EAE204	Mechanics of Solids	PC	3	1	0		4	Branch Specific
4	19EAE206	Aircraft Propulsion	PC	3	1	0		4	Branch Specific
5	19EAE208	Computational Methods in Aerospace Engineering	PC	2	0	2		3	Branch Specific
6	19EAE222	Fluid Mechanics and Mechanics of Solids lab	PC	0	0	2		1	Branch Specific
7	19EAE224	Flight Systems Lab	PC	0	0	2		1	Branch Specific
8	19EMC282/ 19EMC281	Environmental Science/Constitution of India	MC	3	0	0		0	Mandatory Course
9	19EAE292	Comprehensive Skill Development III	PW	0	0	0	4	1	
Total								21	

Semester V

S.No	Course Code	Course Name	Category	L	T	P	A	C	Remarks
1	19EID232/ 19EID234	Internet of Things/ Life Sciences for Engineers	ES/BS	2	0	2		3	Common to All
2	19EAE301	Aerodynamics-I	PC	3	0	0		3	Branch Specific
3	19EAE303	Mechanics of Aerospace Structures	PC	3	1	0		4	Branch Specific
4.	19EAE305	Flight Mechanics	PC	3	0	0		3	Branch Specific
5.	19EOE3XX	Open Elective-I	OE	3	0	0		3	Open Elective
6.	19EAE321	Aircraft Propulsion Lab	PC	0	0	2		1	Branch Specific
7.	19EXX3XX	Interdisciplinary Elective I	ID	3	0	0		3	Interdisciplinary Elective
8.	19EAE391	Comprehensive Skill Development -IV	PW	0	0	0	4	1	
9	GSS115	Gandhi for the 21st Century	HS					1	Online Course
		Total						**22**	

Semester VI

S. No	Course Code	Course Name	Category	L	T	P	A	C	Remarks
1.	19EAE302	Aerodynamics-II	PC	3	1	2		5	Branch Specific
2.	19EAE304	Analysis of Aerospace Structures	PC	3	1	2		5	Branch Specific
3.	19EAE3XX	Program Elective-I	PE	3	0	0		3	Program Elective
4.	19EAE3XX	Program Elective-II	PE	3	0	0		3	Program Elective
5.	19EOE3XX	Open Elective-II	OE	3	0	0		3	Open Elective
6.	19EHS302	Engineering Economics and Management	HS	3	0	0		3	Humanities
7.	19EMC382	Engineering Ethics	MC	3	0	0		0	Mandatory Course
8	19EAE392	Comprehensive Skill Development V	PW	0	0	0	4	1	
		Total						**23**	

Semester VII

S.No	Course Code	Course Name	Category	L	T	P	A	C	Remarks
1.	19EAE401	Flight Vehicle Design	PC	2	0	2		3	Branch Specific
2.	19EXX4XX	Interdisciplinary Elective-II	ID	3	0	0		3	Inter disciplinary Elective
3.	19EAE4XX	Program Elective-III	PE	3	0	0		3	Program Elective
4.	19EAE4XX	Program Elective-IV	PE	3	0	0		3	Program Elective

5.	19EHS405	Operations Research	HS	3	0	0		3	Humanities
6.	19EAE421	Finite Element Analysis and Computational Fluid Dynamics Lab	PC	0	0	4		2	Branch Specific
6	19EAE491	Project Phase –I	PW	0	0	2		1	
7	19EAE493	Internship *	PW					1	
8	19EAE495	Comprehensive Skill Development VI	PW	0	0	0	6	1	
Total								**20**	

*Industrial Training / Research Projects in National Laboratories / Academic Institutions

Semester VIII

S.No	Course Code	Course Name	Category	L	T	P	C	Remarks
1.	19EXX4XX	Interdisciplinary Elective-III	ID	3	0	0	3	Interdisciplinary Elective
2.	19EAE4XX	Program Elective-V	PE	3	0	0	3	Program Elective
3.	19EAE4XX	Program Elective-VI	PE	3	0	0	3	Program Elective
4.	19EAE492	Project Phase II	PW	-	-	12	6	
Total							**15**	

Total Credits 162

Total Number of Credits

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credits	**17.5/18.5**	**24.5/21.5**	**19**	**21**	**22**	**23**	**20**	**15**	**162**

Category and Credits

Category	Category Code	Courses	Credits GITAM	Credits proposed by AICTE
Humanities & Social Sciences	HS	Communicative English	**11**	**12**
		HS1 and HS2 (elective)		
		Gandhi for the 21st Century		
Basic Sciences	BS	Engineering Physics	**21**	**25**
		Engineering Chemistry		
		Mathematics (3 Courses)		
		Life Sciences for Engineers		
Engineering Sciences	ES	Problem Solving and Programming	**24**	**24**
		Basic Electrical and Electronics Engineering		
		Engineering Graphics		
		Workshop		
		Design Thinking and Product Innovation		
		Internet of Things		
		AI Tools		
Open Electives	OE	OE1, OE2	**6**	**18**
Interdisciplinary Electives	ID	ID1, ID2, ID3	**9**	
Program Electives	PE	PE1, PE2, PE3, PE4, PE5, PE6	**18**	**18**
Program Core	PC	PC1 – PC21	**58**	**48**
Project	PW	Internship	**15**	**15**
		Skill Development III, IV, V, VI		
		Project I		
		Project II		
		Venture Discovery		
Mandatory	MC	Environmental Science, Constitution of India, Engineering Ethics	-	-
		Total	**162**	**160**

Engineering Mathematics-II (Elective)

S.No	Course Code	Course Title	Category	L	T	P	C	Remarks
1.	19EMA102	Engineering Mathematics-II (ODE, PDE and Multivariable Calculus)	BS	3	0	0	3	
2.	19EMA104	Engineering Mathematics-II (Probability and Statistics)	BS	3	0	0	3	
3.	19EMA106	Mathematics for Biotechnology –II	BS	3	0	0	3	

Mandatory Course

S. No	Course Code	Course Title	Category	L	T	P	C	Remarks
1.	19EMC181A	National Cadet Corps	MC	0	0	2	0	Mandatory Course
2.	19EMC181B	National Service Scheme	MC	0	0	2	0	Mandatory Course
3.	19EMC181C	National Sports Organization	MC	0	0	2	0	Mandatory Course

4.	19EMC181D	Yoga	MC	0	**0**	**2**	**0**	Mandatory Course

Engineering Mathematics-III (Elective)

S.No	Course Code	Course Title	Category	L	T	P	C	Remarks
1.	19EMA201	Engineering Mathematics-III (PDE, Complex Variables and Transform Techniques)	BS	3	0	0	3	
2.	19EMA203	Engineering Mathematics-III (Complex Variables & Transform Techniques)	BS	3	0	0	3	
3.	19EMA205	Engineering Mathematics-III (Discrete Mathematical Structures)	BS	3	0	0	3	
4.	19EMA207	Mathematics for Biotechnology –III	BS	3	0	0	3	

Engineering Physics (Elective)

S.No	Course Code	Course Title	Category	L	T	P	C	Remarks
1.	19EPH131	Engineering Physics	BS	3	0	3	4.5	
2.	19EPH 133	Applied Physics	BS	3	0	3	4.5	
3.	19EPH 135	Physics for Biotechnology	BS	3	0	3	4.5	

Engineering Chemistry (Elective)

S.No	Course Code	Course Title	Category	L	T	P	C	Remarks
1.	19ECY131	Engineering Chemistry	BS	3	0	3	4.5	
2.	19ECY133	Chemistry of materials	BS	3	0	3	4.5	
3.	19ECY135	Chemistry for Biotechnology	BS	3	0	3	4.5	

OPEN ELECTIVES

Open Elective –I

S. No.	Course Code	Course Title	Category	L	T	P	C	Remarks
1	19EOE301	Japanese for Beginners	OE	3	0	0	3	All Branches
2	19EOE303	French for Beginners	OE	3	0	0	3	All Branches
3	19EOE305	Biotechnology and Society	OE	3	0	0	3	All Branches
4	19EOE307	Contemporary Relevance of Indian Epics	OE	3	0	0	3	All Branches
5	19EOE309	Indian National Movement	OE	3	0	0	3	All Branches
6	19EOE313	Personality Development	OE	3	0	0	3	All Branches
7	19LOE301	Fundamentals of Cyber Law	OE	3	0	0	3	All Branches
8	19MOE303	Introduction to International Business	OE	3	0	0	3	All Branches
9	19EOE319	Introduction to Music	OE	3	0	0	3	All Branches
10	19EOE321	Environment and Ecology	OE	3	0	0	3	All Branches
11	19EOE323	Indian History	OE	3	0	0	3	All Branches
12	19EOE327	Professional Communication	OE	3	0	0	3	All Branches
13	GEL244	English for Higher Education	OE	3	0	0	3	All Branches
14	19EOE224	Virtual Reality	OE	1	0	4	3	All Branches

Open Elective II

S. No.	Course Code	Course Title	Category	L	T	P	C	Remarks
1	19EOE302	German for Beginners	OE	3	0	0	3	All Branches
2	19EOE304	Chinese for Beginners	OE	3	0	0	3	All Branches
3	19EOE306	Analytical Essay Writing	OE	3	0	0	3	All Branches
4	19EOE308	Indian Economy	OE	3	0	0	3	All Branches
5	19EOE310	Public Administration	OE	3	0	0	3	All Branches
6	19EOE312	Environmental Management	OE	3	0	0	3	All Branches
7	19EOE327	Professional Communication	OE	3	0	0	3	All Branches
8	19MOE301	Basics of Finance	OE	3	0	0	3	All Branches
9	19LOE301	Fundamentals of Cyber Law	OE	3	0	0	3	All Branches
10	19EOE313	Personality Development	OE	3	0	0	3	All Branches
11	19MOE305	Basics of Marketing	OE	3	0	0	3	All Branches
12	GEL345	Workplace Communication - Basic	OE	3	0	0	3	All Branches
13	GEL347	Workplace Communication -Advanced	OE	3	0	0	3	All Branches

PROGRAM ELECTIVES

Program Elective-I

S. No	Stream	Course Code	Course Name	Category	L	T	P	C	Remarks
1	Aerodynamics	19EAE342	Industrial Aerodynamics	PE	3	0	0	3	
2	Propulsion	19EAE344	Combustion Technology	PE	3	0	0	3	
3	Structures	19EAE346	Advanced Aerospace Structures	PE	3	0	0	3	
4	Flight Mechanics and Control	19EAE348	Flight Dynamics	PE	3	0	0	3	
5	General	19EAE350	Airport Planning and Management	PE	3	0	0	3	

Program Elective-II

S. No	Stream	Course Code	Course Name	Category	L	T	P	C	Remarks
1	Aerodynamics	19EAE352	Boundary Layer Theory	PE	3	0	0	3	
2	Propulsion	19EAE354	Aerospace Propulsion	PE	3	0	0	3	
3	Structures	19EAE356	Vibrations and Acoustics	PE	3	0	0	3	
4	Flight Mechanics and Control	19EAE358	Guidance and Control	PE	3	0	0	3	
5	General	19EAE360	Aircraft Systems and Instruments	PE	3	0	0	3	

Program Elective-III

S. No	Stream	Course Code	Course Name	Category	L	T	P	C	Remarks
1	Aerodynamics	19EAE441	Wind Tunnel Techniques	PE	3	0	0	3	
2	Propulsion	19EAE443	Theory of Cryogenics	PE	3	0	0	3	

3	Structures	19EAE445	Introduction to Finite Element Analysis	PE	3	0	0	3	
4	Flight Mechanics and Control	19EAE447	Space Technology	PE	3	0	0	3	
5	General	19EAE449	Instrumentation and Control	PE	3	0	0	3	

Program Elective-IV

S.No	Stream	Course Code	Course Name	Category	L	T	P	C	Remarks
1	Aerodynamics	19EAE451	Computational Fluid Dynamics	PE	3	0	0	3	
2	Propulsion	19EAE453	Aerodynamics of Turbomachinery	PE	3	0	0	3	
3	Structures	19EAE455	Theory of Elasticity	PE	3	0	0	3	
4	Flight Mechanics and Control	19EAE457	Satellite Attitude and Control	PE	3	0	0	3	
5	General	19EAE459	Helicopter Engineering	PE	3	0	0	3	

Program Elective- V

S.No	Stream	Course Code	Course Name	Category	L	T	P	C	Remarks
1	Aerodynamics	19EAE442	Hypersonic Aerodynamics	PE	3	0	0	3	
2	Propulsion	19EAE444	Rockets and Missiles	PE	3	0	0	3	
3	Structures	19EAE446	Introduction to Composite Materials	PE	3	0	0	3	
4	Flight Mechanics and Control	19EAE448	Avionics	PE	3	0	0	3	
5	General	19EAE450	Optimization Methods	PE	3	0	0	3	

Program Elective- VI

S. No	Stream	Course Code	Course Name	Categor y	L	T	P	C	Remarks
1	Aerodynamics	19EAE452	Flapping Wing Aerodynamics	PE	3	0	0	3	
2	Structures	19EAE454	Experimental Techniques	PE	3	0	0	3	
3	Structures	19EAE456	Aero Elasticity	PE	3	0	0	3	
4	Flight Mechanics and Control	19EAE458	Space Mechanics	PE	3	0	0	3	
5	General	19EAE460	Air Transportation Systems	PE	3	0	0	3	

INTERDISCIPLINARY ELECTIVES

Interdisciplinary Elective- I

S. No.	Stream	Course Code	Course Title	Category	L	T	P	C	Remarks Offered by
1	Professional Courses	19EEC373	Fundamentals of Global Positioning System	ID	3	0	0	3	EECE
2		19EEC371	Fundamentals of Communication System	ID	3	0	0	3	EECE
3		19EEI477	Industrial Automation	ID	3	0	0	3	EECE
4		19ECY373	Nanoscience and Nanotechnology	ID	3	0	0	3	CHEMISTRY

5	Computer Oriented Courses	19ECS371	Introduction to Database Management Systems	ID	2	0	2	3	CSE
6		19ECS373	Object Oriented Programming with C++	ID	2	0	2	3	CSE
7		19ECS375	Introduction to Programming with JAVA	ID	2	0	2	3	CSE
8	Management Courses	19EHS375	Business Ethics and Corporate Governance	ID	3	0	0	3	MANAGEMENT

Interdisciplinary Elective- II

S. No.	Stream	Course Code	Course Title	Category	L	T	P	C	Remarks Offered by
1	Professional Courses	19EEE471	Renewable Energy Sources	ID	3	0	0	3	EECE
2		19EEE473	Hybrid Electric Vehicles	ID	3	0	0	3	EECE
3		19EEI472	Micro electro mechanical Systems	ID	3	0	0	3	EECE
4		19EEI371	Sensors and Signal Conditioning	ID	3	0	0	3	EECE
5		19EME332	Heat and Mass Transfer	ID	3	0	3	3	MECH
6		19EME346	CAD/CAM	ID	3	0	0	3	MECH
7		19EME348	Robotics and Automation	ID	3	0	0	3	MECH
8	Computer Oriented Courses	19ECS471	Introduction to Operating Systems	ID	2	0	2	3	CSE
9		19ECS475	Introduction to Web Technologies	ID	2	0	2	3	CSE

10	Management Courses	19EIE475	Entrepreneurship Development	ID	3	0	0	3	MANAGEMENT

Interdisciplinary Elective- III

S. No.	Stream	Course Code	Course Title	Category	L	T	P	C	Remarks Offered by
1	Professional Courses	19ECE472	Disaster Management	ID	3	0	0	3	CE
2		19EEI473	Virtual Instrumentation	ID	3	0	0	3	EECE
3		19EEI475	Medical Instrumentation	ID	3	0	0	3	EECE
4	Computer Oriented Courses	19ECS344	Machine Learning	ID	2	0	2	3	CSE
5		19ECS472	Introduction to Augmented Reality and Virtual Reality	ID	2	0	2	3	CSE
6		19ECS474	Introduction to Cloud Computing	ID	2	0	2	3	CSE
7		19ECS476	Introduction to Big Data	ID	2	0	2	3	CSE
8		19ECS478	Introduction to Data Science	ID	2	0	2	3	CSE
9	Management Courses	19EHS479	Organizational Behavior	ID	3	0	0	3	MANAGEMENT

19EAE102: INTRODUCTION TO AEROSPACE ENGINEERING

L	T	P	C
2	0	0	2

Preamble:

This course is designed specifically for the branch of Aerospace engineering. This course will give a brief introduction of aircrafts and different streams in aerospace engineering which will help to understand the requirements for the design of an aircraft.

Course Objectives:

- Familiarize the basic concepts of Airplanes and Aerospace vehicles.
- Provide 360-degree view in Aerodynamics, Propulsion, Structures, and Systems etc.

UNITI **8hours**

Introduction

Evolution of planes, pre-Wright brother era to present plane, progress in structure airplane design and applications, classification of aircrafts and space vehicles, functions of major components of an airplane, conventional control and power controls, role of DGCA in air safety and regulatory authority, accident investigation, human factors in flight safety,
Introduction to FAA.

Learning Outcomes:

At the end of the unit, learners will be able to

- Understand the evolution of planes
- Learn about the major parts of the aircraft and their functions
- Learn about the roles of DGCA in air safety
- Learn about the rules and regulations of FAA

UNIT-II **8 hours**

Basic Aerodynamics

Aerospace atmosphere, types, characteristics, pressure, temperature and density variations, lapse rate, airfoil nomenclature, forces acting on airfoil, characteristics of airfoils.
Flight Control Surfaces: Aircraft principle axes, main control surfaces- ailerons, elevators, rudders, spoilers and flaps, use of flaps during takeoff, landing and maneuvering.

Learning Outcomes:

At the end of the unit, learners will be able to

- Understand the atmosphere used in aviation
- Understand the effect of altitude in pressure, temperature and density variations
- Learn about the nomenclature of airfoil, aerodynamic forces on airfoils
- Learn about the control surfaces of an aircraft and their functions

UNIT-III **8 hours**

Structures

Structural arrangement of monocoque and semi-monocoque structures, geodesic construction. Structural layout of wing, fuselage and tail plane, types of wings, monoplanes, biplanes, triplanes and multiplanes, wing geometry - different types and purpose.

Learning Outcomes:

At the end of the unit, learners will be able to

- Understand about the different structures
- Understand about the layout of wing, fuselage and tail plane and types of wings

UNITIV **9 hours**

Propulsion

Piston engines and gas turbine engines, various means of thrust production, comparative merits. Ramjet, pulse jet and scramjet. Rockets - principle of operation, types and applications.

Helicopters: Rotorcraft, types of rotorcraft, autogyro, gyrodyne. Helicopters, main rotor system, fully articulated, semi rigid and rigid rotor system, transmission system.

Learning Outcomes:

At the end of the unit, learners will be able to

- Gain knowledge on working of piston and gas turbine engine.
- Exercise critical thinking of different means of thrust generation
- Distinguish between subsonic and supersonic jet engines
- Demonstrate knowledge of working of rocket engines, helicopters, rotor systems and power transmission systems
- Clearly identify different types of applications of engines

UNITV **8 hours**

Satellite Systems: Elements, operations, structures, power systems, satellite missions, communication and telemetry - Indian satellites and launch vehicles.

Learning Outcomes:

At the end of the unit, learners will be able to

- Gain knowledge on different elements of satellite systems
- Identify mission objective of different satellites
- Demonstrate good command on communication and telemetry systems of satellite
- Exercise command on different Indian satellites and launch vehicles
- Executes abstract design of satellite subsystems specific to a mission

Course Outcomes:

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

- Demonstrate knowledge on evolution of plates, functioning of different components, role of regulatory and authorities and safety aspects of flight.
- Gain knowledge on aerodynamic behavior of rigid curved surfaces and their significance in controlling flight
- Exercise good command on structured anatomy and strength aspects of different components of aircraft.
- Identify different types of engines that suit the needs of different aerospace vehicles
- Exhibit the science of flying an aerospace vehicle and controlling of crucial subsystems that make a full-fledged flight.

Text Book(s)

1. J. D. Anderson, Introduction to Flight, 6/e, McGraw Hill,2010.
2. R. S. Shevell, Fundamentals of Flight, 2/e, Pearson, 2004.

References

1. A. C. Kermode, Flight Without Formulae, 5/e, Pearson, 1989.

2. L. Gupta, Helicopter Engineering, Himalayan Books, 1996.
3. D. Newman, Interactive Aerospace Engineering and Design, McGraw Hill, 2002.
4. R. H. Barnard and D. R. Philpot, Aircraft Flight, 3/e, Pearson, 2004

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	3	2	1	0	2	0	2	0	0	1	0	2	2	1	1
CO 2	3	2	1	0	2	0	1	1	0	0	0	2	1	2	1
CO 3	3	1	1	2	0	0	1	0	1	1	0	1	1	1	2
CO 4	2	1	0	1	2	1	2	1	1	0	0	2	2	1	1
CO 5	2	1	1	1	1	0	1	0	0	0	0	1	1	1	2

19EAE122: AEROMODELLING WORKSHOP

L T P C
0 0 2 1

Preamble:

This course is intended to make students learn about the design of an RC plane and students will have hands-on experience to build and fly a RC plane.

Course Objectives:

- Facilitate to design, build and fly model airplanes.
- Train to have hands-on experience necessary for developing a practical aptitude.
- Demonstrate the flying characteristics like speed or duration of flight.

List of Experiments:

1. Making of symmetric airfoil
2. Making of Cambered airfoil
3. Modeling skeleton structure of wing
4. Skin molding of aircraft wing
5. Making of winglet
6. Sheet forming of empennage
7. Design, fabrication and flying of engine powered RC plane
8. Design, fabrication and flying of battery powered RC model airplane.
9. Design, fabrication and flying of quad-copter.
10. Design, fabrication and flying of glider.
11. Design, fabrication and flying of solar powered RC plane.
12. Design, fabrication and flying of blended wing body.
13. Design, fabrication and flying of parachute.

Note: Any 2 experiments can be performed out of above 7 to 13 experiments per batch.

Course Outcomes:

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

- Work with various types of wood crafting tools for preparing models
- Understand the requirements to prepare a new aircraft models with various propulsion systems
- Demonstrate logical, analytical, and strategic & critical thinking skills for developing new designs of different aircraft models.
- Hands on creation of electronic circuit, mechanical model using kits.
- Analyze the aerodynamics, stability and structural criteria of the model.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO 1	3	0	1	1	1	1	0	0	0	0	1	1	3	3	1
CO 2	2	2	3	1	2	1	0	1	1	0	1	0	1	3	1
CO 3	2	2	3	2	1	0	1	0	0	1	1	1	2	3	1
CO 4	2	2	3	1	1	1	1	1	1	0	2	1	2	3	1
CO 5	3	2	3	1	1	0	0	1	0	0	1	1	2	3	1

19EME201: ENGINEERING MECHANICS

L	T	P	C
2	1	0	3

Preamble: This course is an introduction to learning and applying the principles required to solve engineering mechanics problems. Concepts will be applied in this course from previous courses of basic mathematics and physics This course addresses the modeling and analysis of static equilibrium problems with an emphasis on real world engineering applications and problem solving. This course forms the backbone of mechanical engineering design and acts as a prerequisite to mechanics of solids, design of machines and kinematics and dynamics of machinery.

Course Objectives

- Explain the effect of force and moment and equilibrium in engineering applications.
- Compute geometric properties such as centroid and moment of inertia of various plane sections.
- Explain kinematics of particles and rigid bodies.
- Analyze the rigid bodies under dynamic conditions.
- Expose the concepts of work-energy, conservation of energy and momentum to rigid bodies.

UNITI **8 hours**

Introduction to Engineering Mechanics: Units, Significance of Engineering Mechanics, Composition and resolution of forces, parallelogram law, principle of transmissibility, types of force systems-concurrent non-concurrent,coplanar forces,resultant coplanar force systems,couple, moment of a force, Varignon's theorem, concept of free body diagrams, concept of equilibrium of coplanar force systems.

Learning Outcomes:

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

- Recognize the significance of Engineering Mechanics in design.(L1)
- Calculate the moments and resultant forces.(L3)
- Draw free body diagrams.(L3)
- Utilize the concept of equilibrium.(L3)

UNITII **8 hours**

Friction: Laws of friction, types of friction, equilibrium of force systems involving frictional forces, wedge friction. Free body diagrams involving frictional forces.
Analysis of Structures: Introduction to plane trusses, analysis of plane trusses by method of joints and method of sections.

Learning Outcomes:

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

- Comprehend the concept of friction.(l2)
- Identify different types of trusses.(l2)
- Analyze the plane trusses by method of joints and the method of sections.(l4)

UNITIII **8 hours**

Properties of Surfaces: Centroid and center of gravity, derivation of centroids from first moment of area, centroids of composite areas.
Moment of Inertia: Area moment of inertia of plane and composite shapes, parallel axis theorem, perpendicular axis theorem, polar moment of inertia, radius of gyration.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	1	1	2	1	1	2	1	3	2	1
CO2	3	2	2	1	1	1	1	1	1	1	2	1	3	2	1
CO3	3	3	2	1	1	1	1	2	1	1	2	1	3	2	1
CO4	2	2	2	1	1	1	1	2	1	1	2	1	2	2	1
CO5	3	3	2	1	1	1	1	1	1	1	1	1	1	1	0

Learning Outcomes:

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

- Identify the center of gravity of plane figures.(l2)
- Calculate the center of gravity of composite plane shapes.(l3)
- Understand the concepts of moment of inertia and radius of gyration.(l2)
- Determine moment of inertia for composite plane shapes.(l3)

UNITIV **8 hours**

Kinematics: Equations of motion for rigid bodies under constant and variable acceleration, rectilinear and curvilinear motion, projectile motion, use of rectangular coordinates, tangential and normal coordinates, radius of curvature, rotation of a rigid body about a fixed axis.

Learning Outcomes:

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

- Develop equations of motion for particles and rigid bodies in motion.(L3)
- Find velocity and acceleration in rectilinear and curvilinear motions.(l4)
- Trace the path of projectile.(l3)

UNITV **8 hours**

Kinetics: Principles of dynamics - Newton's Laws of motion, D'Alembert's principle in rectilinear translation, principle of work and energy.

Ideal Systems: Principle of conservation of energy, concept of power, conservation of linear momentum, principle of momentum and impulse, impact - types of impact.

Learning Outcomes:

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

- Apply Newton’s 2ndlaw and D'Alembert's principle in rectilinear translation.(L3)
- Utilize the principle of work and energy in dynamic systems.(L3)
- Make use of principle of momentum and impulse on dynamic bodies.(L4)

Course Outcomes:

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

- Obtain a basic understanding of the laws of solid mechanics.
- Comprehend the significance of the concepts of solid mechanics in engineering systems.
- Calculate the physical properties of rigid bodies required for the analysis of engineering systems.
- Apply the principles of statics and dynamics to solve engineering problems.
- Analyze various static and dynamic engineering systems and understand the underlying mechanics and drawbacks/problems.

Text Book(s):

1. N.H. Dubey, Engineering Mechanics: Statics and Dynamics, Tata McGraw Hill,2014.

2. S. Timoshenko, D.H. Young, J.V. Rao, Sukumar Pati, Engineering Mechanics (in SI units), 5/e, McGraw Hill, 2013.

References:

1. Basudeb Bhattacharya, Engineering Mechanics, 2/e, Oxford University Press (India),2015.
2. Irving Shames, G.K.M. Rao, Engineering Mechanics: Statics and Dynamics, 4/e, Pearson,2009.
3. K.L. Kumar, Venu Kumar, Engineering Mechanics, 4/e, Tata McGraw Hill,2010.
4. S.S. Bhavikatti, Engineering Mechanics, 4/e, New Age International,2008.

19EAE201: THERMODYNAMICS

L	T	P	C
2	1	0	3

Preamble:

This course deals with the fundamentals of thermodynamics including thermodynamic systems and properties, relationships among the thermo-physical properties, the laws of thermodynamics and applications of these basic laws in thermodynamic systems.

Course Objectives:

- Familiarizethelawsofthermodynamicstoestimatethepotentialforthermo-mechanicalenergy conversion in aerospace power and propulsion systems.
- Explain the role of internal energy, enthalpy, entropy and other thermodynamic properties.
- Impart the knowledge of exergy analysis for closed and open systems.
- Focus on understanding the phase diagrams of pure substances, properties of steam and dryness fraction measurement.
- Demonstrate the working of I.C. Engines and analysis of vapor and air standard cycles.

UNITI **9 hours**

Fundamental Concepts: Macroscopic and microscopic viewpoints, thermodynamic system, boundary, surrounding, control volume, state, property, process, cycle, thermodynamic equilibrium, quasi - static process, energy in state and in transition, types of work, heat, point and path function, Zeroth law of thermodynamics.

First law of Thermodynamics: Joule's experiment, first law of thermodynamics, corollaries, first law applied to a process, applied to a flow system, steady flow energy equation and its applications

Learning Outcomes:

After completion of this unit the student will be able to

- Understand the thermodynamic fundamental concepts. (l1)
- Apply first law to solve the open and closed system problems.(l3)
- Identify and evaluate the type of work and heat transfer involved in a given problem.(l2)
- Appreciate the qualitative difference between different forms of energy.(l2)

UNITII **7 hours**

Second Law of Thermodynamics: Kelvin - Planck statement and Clausius statement and their equivalence, corollaries, perpetual motion machines of first kind and second kind, reversibility and irreversibility, cause of irreversibility, Carnot cycle, heat engine, heat pump and refrigerator, Carnot theorem, Carnot efficiency.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand the concept of heat engine and heat pump devices.(l1)
- Understand and apply second law to solve the practical problems.(l3)
- Gain knowledge on ideal thermodynamic cycle formulation (Carnot cycle)(l2)

UNITIII **9 hours**

Entropy: Concept of entropy, Clausius theorem, Clausius inequality, principles of increase of entropy.

Availability and Irreversibility: Definition, availability in steady and non- flow process, exergy balance for a closed system and steady flow system, second law efficiency.earning Outcomes:

After completion of this unit the student will be able to

- Understand qualitatively, the concept of entropy.(l2)
- Apply the entropy principle for any process and cycle.(l3)
- Gain knowledge on the cause for irreversibility in a process(l2)
- Perform exergy analysis for an open and closed systems(l4)

UNITIV **7 hours**

Properties of pure substances: p-v, T-s, p-T and h-s diagram for a pure substance, dryness fraction, steam tables, measurement of steam quality.
Thermodynamic Relations: Maxwell equations, T-ds equations, difference in heat capacities, ratio of heat capacities, Joule-Kelvin effect, Clausius-Clapeyron equation.

Learning Outcomes:

After completion of this unit the student will be able to

- Calculate the dryness fraction of a given liquid-vapor mixture.(l4)
- Understand the properties of pure substances on thermodynamic state diagrams.(l2)
- Use the steam tables and mollier chart for solving the problems(l1)
- Understand the joule-kelvin throttling process and its practical significance.(l1)

UNITV **10hours**

POWER CYCLES

Vapor Power Cycles: Rankine cycle- thermodynamic variables affecting efficiency and output of Rankine cycle- improvements of efficiency.
Gas Power Cycles: I.C engines, classification, comparison of two stroke and four stroke engines, comparison of S.I .and C.I. Engines. Air standard cycles- Otto, Diesel, Dual, their analysis. Brayton cycle, effect of regeneration, pressure ratio, intercooling and reheating on Brayton Cycle.

Learning Outcomes:

After completion of this unit the student will be able to

- Represent the events occurring in any engine on a thermodynamic plot(L3)
- Understand the working of 2-stroke and 4- stroke engines.(L2)
- Analyze the methods of improving efficiency of vapor and gas power cycles(L4)

Course Outcomes:

After successful completion of this course the students will be able to:

- Explain the concepts of work, power, and heat in thermodynamics; determine work and heat sign conventions; determine work involved with moving boundary systems
- Apply the first law of thermodynamics for a control volume, including with turbines, compressors, nozzles, diffusers, heat exchangers, and throttling devices..
- Explain the second law of thermodynamics, including why it is necessary, how it is defined (Kelvin-Planck and Clausius), the nature of irreversibility, and the Carnot cycle.
- Determine thermodynamic properties of pure substances.
- Compute and analyze the thermal efficiency of systems based on various vapor power and gas power cycles.

Text Book(s)

1. P.K.Nag, Engineering Thermodynamics, 5/e, Tata McGraw Hill,2013.
2. Yunus A. Cengel, Michaela A. Boles, Thermodynamics, 7/e, Tata McGraw Hill,2011.

References

1. R.K. Rajput, S.Chand& Co., Thermal Engineering, 6/e, Laxmi publica-tions,2010.
2. J.B.Jones and G.A.Hawkins, Introduction to Thermodynamics, 2/e, John Wiley & Sons,2012.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO2	3	2	1	1	1	2	1	1	1	1	1	1	3	2	1
CO3	3	2	1	1	1	2	1	1	1	1	1	1	3	1	1
CO4	2	2	1	1	1	1	1	1	1	1	1	1	2	1	1
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1

19EAE203: AEROSPACE MATERIALS ENGINEERING

L	T	P	C
3	0	0	3

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students for the basic understanding of aerospace materials and processing technologies used.

Course Objectives:

- Facilitate the knowledge on recent developments in materials science and engineering within the framework of aerospace engineering.
- Demonstrate the introduction to metals, alloys and composites used for aerospace applications.
- Impart knowledge on manufacturing processes of aircraft parts.
- Train to understand the characterization of various types of composite materials.

UNITI **8 hours**

Introduction: Properties of flight vehicle materials, importance of strength/weight ratio of materials for aerospace vehicles structures, importance of temperature variations, factors affecting the selection of material for different parts of airplanes.

Learning Outcomes:

After completion of this unit the student will be able to

- Gain knowledge on the criteria for the selection of material.(l2)
- Understand the importance of strength/weight ratio for aerospace structures.(l1)
- Understand the limitations of existing materials and design of new materials for current challenges in aerospace engineering requirements.(l3)

UNITII **8 hours**

Light Metal Alloys: Aluminum and its alloys, high strength and high corrosion alloys. Titanium and its alloys: applications, machining, forming, welding and heat treatment; Classification of steels alloys, effect of alloying elements, magnesium alloys and their properties, heat treatment processes, maraging steels: properties and applications.

Learning Outcomes:

After completion of this unit the student will be able to

- Gain knowledge on light metal alloys applications(L2)
- Classify the steel and magnesium alloys(L1)
- Explain the effect of alloying elements(L3)

UNITIII **8 hours**

High Strength and Heat Resistant Alloys: Classification of heat resistant materials, iron, nickel and cobalt based alloys, refractory materials, ceramics, properties of inconel, monal, nimonic and super alloys; application of heat resistant alloy in aerospace vehicles. Heat treatment of steel and its alloys. Case hardening, initial stresses and stress alleviation procedures, corrosion prevention and protective treatments.

Learning Outcomes:

After completion of this unit the student will be able to

- Gain knowledge on high strength alloys and its properties (L1)
- Demonstrate the procedures for heat treatment of steel alloys(L2)

UNITIV **8 hours**

Composite Materials: Classification, characteristics of composite materials, volume fraction, laminated composites, particulate composites and fibrous composites. Types of reinforcements, their shape and size, production and properties of fiber reinforced plastics.

Learning Outcomes:

After completion of this unit the student will be able to

- Gain knowledge on classification and characteristics of composites. (l1)
- Understand the types of reinforcements(l2)
- Demonstrate the methods of processing of composite materials(l2)

UNITV **8 hours**

Aircraft Manufacturing Processes: Profiling, hydroforming, spar milling, spark erosion and powdered metal parts, integral machining, contour etching, high energy rate forming and manufacturing of honeycomb structures and general methods of construction of aircraft engine parts.

Learning Outcomes:

After completion of this unit the student will be able to

- Gain knowledge on various manufacturing process for different parts of aircraft(L1)
- Understand the methods of construction of aircraft engine parts(L2)

Course Outcomes:

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

- Demonstrateageneralunderstandingofaerospacematerialsandtheappropriatemanufacturing techniques for the major critical components.
- Select appropriate manufacturing processes for composites.
- Describe likely performance of classes of aerospace materials in the context of specific applications
- Describe methods of processing aerospace materials particularly joining issues and propose suitable routes for selected applications
- Apply the knowledge on the criteria for the selection of material.

Text Book(s)

1. G. F. Titterton, Aircraft Materials and Processes, 5/e, Sterling Book House,1998.
2. F. C. Campbell, Manufacturing Technology for Aerospace Structural Materials, 1/e, Elsevier Publications,2006.

References

1. R. H. Avner, Introduction to Physical Metallurgy, 2/e, Tata McGraw Hill,1997.
2. W. D. Callister, D. G. Rethwisch, An Introduction on Material Science and Engineering, John Wiley,2010.
3. G. E. Dieter, Mechanical Metallurgy, 1/e, McGraw Hill, 1976.
4. L. Gupta, Advanced Composite Materials, 2/e, Himalayan Books,2006.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	1		1	2	1	1	1	1	1	1	3	1	1

CO2	2	1		1	1	2		1	1	1	1	1	2	1	1
CO3	2	2	1	1	2	2	1	1	1	1	1	1	3	1	1
CO4	2	1	1		1	1		1	1	1	1	1	2	1	1
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1

19EAE221: COMPUTER AIDED AIRCRAFT DRAWING

L	T	P	C
0	0	3	1.5

Preamble: This course is designed for aerospace engineering students. It introduces the learning of CATIA software. This course is designed to acquaint the learners with basic modeling of 3D models used in aerospace and mechanical industry

Course Objectives:

- To introduce 2D and 3D Models of different types of Screw Threads used in aeronautical industries by using CATIA Software.
- To familiarize 2D and 3D Models of different types of Fasteners like Nuts, Bolts, Washers, Rivets etc. used in aeronautical industries by using CATIA Software.
- To introduce 2D and 3D Models of different types of Keys and Cotter Joints like Taper key, Sunk Key, Round Key, Feather key, Socket and Spigot Joint and Knuckle joints etc. used in aeronautical industries by using CATIA Software.
- Toenablestudentstodraw2Dand3DModelsofdifferenttypesofSymmetricalandcambered Airfoils, NACA 4- and 5-Digits Airfoil used in flying vehicles by using CATIA Software

Sectional Views: Principles involved in sectional plane, convention representation of sectional plane, hatching, sectional views of machining components. **2 Classes**

Fasteners: Bolted joints, screw joints, stud joints, riveted joints, welded joints and their conventional representation. **2Classes**

Aircraft Assembly Drawings: Different types of trusses used in wings, spars, ribs, stringers, skin, brackets, bulk head and rings (frame) longerons. Different types of fuselage, landing gear, hydraulic cylinder, connecting rod and piston engine. **3 Classes**

Airfoil and Wing Drawings: NACA 4-digit airfoil (symmetrical, cambered), NACA 5-digit airfoil. Rectangular wing, swept wing and delta wing configurations. **3 Classes**

Manufacturing Drawing: Dimensioning, representation of fits, dimensional tolerances, surface roughness and geometric tolerance. **2 Classes**

Text Book(s)

1. S. Tickoo, G. Verma, Catia V5-6R2012 for Engineers and Designers, Dreamtech Press,2013.

Course Outcomes:

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

- Apply drawing and modeling concepts by using CATIA Modeling Software.
- Acquire skills for applying the drawing methodology to different Joining parts of aircrafts.
- Analyzethedrawbackandlimitsofsoftwarewhilemakingdrawingandmodelinganyobjects.
- Apply different Software commands or alternative commands for a given drawing to reduce time and give more accurate drawing.
- Apply your own methodology to complete drawing and modeling.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	2	1	3		1	2	1	1	1	1	1	1	2	1	1
CO2	2	2	1	2	2	2	1	1	1	1	1	1	3	1	2
CO3	3	2	3	2	1	1	1	1	1	1	1	1	2	2	1
CO4	2	2	3		1	2	1	1	1	1	1	1	2	1	1
CO5	2	2	2	1	2	1	1	1	1	1	1	1	2	1	2

19EAE223: MATERIALS AND MACHINE TOOLS LAB

L	T	P	C
0	0	3	1.5

Preamble:
This course is designed for Aerospace Engineering undergraduate students. It is designed for the students for the understanding of material characterization and processing techniques.

Course Objectives:

- Impart the knowledge of various machine tools and its operations.
- Familiarize with the selection of suitable production process for the desired component
- Recognize the process of specimen preparation for testing of materials
- Acquire knowledge on basic elements of materials microstructures
- Train on various nondestructive testing methods of materials.

List of Exercises:

1. Lathe: Step turning, taper turning, knurling, thread cutting, chamfering,
2. Shaping: Round to square cutting, v-groove cutting, and semi hexagonal cutting.
3. Slotting: Internal key-way cutting.
4. Milling: Round to hexagonal nut cutting using direct indexing method.
5. Milling: Form cutting of spur gear using simple indexing method.
6. Grinding: Single-point tool grinding as per given signature.
7. Study of micro structures of ferrous and alloys.
8. Nondestructive testing of aircraft materials using dye penetrant and ultrasonic flow detection methods.

Course Outcomes:
After successful completion of this course the students will be able to

- Demonstratetheworkingofcommonmachinetoolslikelather,shaper,miller,grinderandCNC lathe and machining centre
- Identify the appropriate production process and machines.
- Prepare specimens for metallographic observation.
- Identify the microstructure of various metals.
- Explain the working principle of various machines used in manufacturing.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2	PSO 3

CO1	2	1	1	2	2	1	1	1	1	1	1	1	3	1	1
CO2	2	2	1	2	2	1	1	1	1	1	1	1	3	1	1
CO3	2	2	2	3	2	1	1	1	1	1	2	1	3	2	1
CO4	2	2	2	3	3	1	1	1	1	1	1	1	3	2	1
CO5	2	1	1	3	1	1	1	1	1	1	1	1	3	1	1

(IV Semester)

19EAE202: FLUID MECHANICS

L	T	P	C
3	1	0	4

Preamble:

This course is designed for Aerospace Engineering undergraduate students. This course aims to introduce and explain the basic concepts in fluid mechanics. Understanding these concepts will help in analyzing both internal and external flows.

Course Objectives:

- Explain different properties of Newtonian fluids.
- Familiarize governing equations of a fluid at rest and in motion.
- Demonstrate how the governing equations can be used to analyze different flow problems.
- Familiarize fundamental concepts in boundary layer flows.
- Introduce the concepts of modeling and similitude.

UNITI **10 hours**

Fluid Properties and Statics: Density, viscosity, vapor pressure, compressibility, surface tension and capillarity. Pressure definition, Pascal's law and hydrostatic law.

Measurement of Pressure: Piezometer, simple and differential manometers. Total pressure and center of pressure of horizontal, vertical and inclined plane surfaces.

Learning Outcomes

After completion of this unit the student will be able to

- Identify and explain different fluid properties(L2).
- Describe the effect of change in pressure and temperature on fluid properties(L2).
- Calculate fluid properties given appropriate information(L3).
- State Newton's law of viscosity and classify fluids based on it(L2).
- Determine the pressure at various locations in a fluid at rest(L3).
- Compare different types of manometers(L2).
- Demonstrate how manometers are used for pressure measurement(L3).
- Determine the magnitude, direction, and location of hydrostatic force on a submerged plane surface(L3).

UNITII **12 hours**

Fluid Kinematics: Types of flows, velocity and acceleration, stream function, potential function, types of motion, vorticity and circulation, free vortex flow and forced vortex flow.

Fluid Dynamics: Continuity equation in cartesian and cylindrical coordinates; Euler's and Bernoulli's equation of motion, applications of Bernoulli's equation.

Learning Outcomes

After completion of this unit the student will be able to

- Explain differences between Eulerian and Lagrangian description of fluid motion(L2).
- Determine various kinematic elements of the flow given a velocity field(L3).
- Summarize differences between streamlines, streak lines and path lines(L2).
- Calculate and plot streamlines for flows given the velocity field(L3).
- Explain different types of flows and motions(L2).
- Determine stream function and velocity potential for a given velocity field(L3).
- Discuss the differences between free- and forced-vortex flow (L2).
- Write the governing equations of a fluid in motion(L1).
- List the assumptions made in deriving Euler's and Bernoulli's equation of motion(L1).
- Interpret the physical meaning of different terms in Bernoulli's equation(L2).

UNIT III 12 hours

Closed Conduit Flow: Characteristics of real fluids, Reynolds experiment, Darcy's equation; Major and minor energy losses in pipes, total energy line and hydraulic gradient line, pipes in series, pipes in parallel, flow through circular pipes: Hagen-Poiseuille law and flow between two parallel plates.

Learning Outcomes

After completion of this unit the student will be able to

- Compare the differences between an ideal and real fluid(L2).
- Explain the general characteristics of flow in a pipe(L2).
- Distinguish between major and minor losses in pipes (L2).
- Calculate losses in the straight portions of pipes as well as those in various pipe system components (L3).
- Sketch hydraulic gradient line and total energy line for a given pipe setting (L3).
- Applyappropriateequationsandprinciplestoanalyzeavarietyofpipeflowsituationsandflow between two parallel plates (L3).

UNIT IV **10 hours**

Boundary Layer Flow: Definition, thickness of boundary layer, boundary layer growth along a thin flat plate, characteristics of laminar, transitional and turbulent boundary layer, governing equations of boundary layer, momentum integral equation of the boundary layer, boundary layer separation and its control.

Learning Outcomes

At the end of this unit the student will be able to

- Explain the reason for the formation of a boundary layer on the surface (L2).
- Determine different measures of boundary layer thickness (L3).
- Discuss the characteristics of the laminar, transitional and turbulent boundary layer (L2).
- Illustrate and explain the growth of the boundary layer over a flat plate (L2).
- Develop governing equations of boundary layer using the order of magnitude analysis (L3).
- Explain the effect of favorable and adverse pressure gradient on a boundary layer (L2).
- Describe various methods of controlling the boundary layer (L2).

UNIT V **10 hours**

Dimensional Analysis: Dimensional homogeneity, methods of dimensional analysis: Rayleigh method and Buckingham pi theorem, use of dimensional analysis in presenting experimental data, model testing, types of similarity, force ratios, dimensionless numbers.

Learning Outcomes

After completion of this unit the student will be able to

- Write the dimensions of common physical quantities(L3)
- Describe the principle of dimensional homogeneity(L2).
- DeterminedimensionlessvariablesforagivenflowsituationbyapplyingtheRayleighmethod and Buckingham pi theorem(L3).
- Interpret the physical meaning of common dimensionless numbers(L2).
- Describe the necessary conditions required to have a complete similarity between model and prototype (L2).
- Apply dimensional analysis to establish a set of similarity requirements between model and prototype (L3).
- Describe the importance of dimensional analysis in the efficient handling, interpretation and correlation of experimental data(L2).

Course Outcomes:

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

- Compute fluid properties and pressure in a fluid at rest given appropriate information.
- Apply Bernoulli's equation in combination with the continuity equation to solve simple flow problems.
- Applyappropriateequationsandprinciplestoanalyzeavarietyofpipeflowsituationsandflow between two parallel plates.
- Explain the characteristics of different types of boundary layers and the reason for flow separation.
- Developasetofdimensionlessvariablesforagivenflowsituationusingdifferentdimensional analysis methods.

Text Book(s)

1. F. M. White, Fluid Mechanics, 8/e, McGraw Hill,2017.
2. P. N. Modi and S. M. Seth, Hydraulics and Fluid Mechanics including Hydraulics Machines, 20/e, Standard Publishers,2015.

References

1. R. K. Bansal, A Textbook of Fluid Mechanics and Hydraulic Machines, 9/e, Laxmi Publications,2011.
2. K. L. Kumar, Engineering Fluid Mechanics, 8/e, Eurasia Publishing House,2010.
3. V.Gupta,S.K.Gupta,FluidMechanicsanditsApplications,2/e,NewAgeInternational,2011.
4. R.W.Fox,P.J.Pritchard,A.T.McDonald,IntroductiontoFluidMechanics,7/e,WileyIndia, 2011.
5. K. W. Bedford, V. Streeter, E. B. Wylie., Fluid Mechanics, 9/e, McGraw Hill,2010.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	1	1	1	1	1	1	3	1	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO4	2	2	1	1	1	1	1	1	1	1	1	1	2	1	1
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1

19EAE204: MECHANICS OF SOLIDS

L	T	P	C
3	1	0	4

Preamble

This course projects concepts connected to understanding the strength of different elements that forms the basis for a typical structural system. It focuses mainly on the initial design aspect of elements subjected to mechanical loads and their implications. Course finds appealing and enhances interest in aerospace structures.

Course Objectives:

- To make learn the fundamentals connected to mechanics of different structural members.
- To impart knowledge of complex stresses and strains.
- To teach concepts of shear force and bending moment section loads.
- To train basic design principles of flexural members
- To give exposure to analyzing strength of thin cylinders.

UNITI **8 hours**

Simple Stresses and Strains: Classification of loads, stress, strain, stress and elongation produced in a bar due to its self-weight, tie bar of uniform strength, stress in a bar due to rotation, elongation in case of a taper rod, Poisson's ratio, relation between the elastic units, stresses induced in compound bars, thermal stress and strain.

Learning Outcomes

At the end of unit student will be able to

- understand basic strength calculations of different structural elements(L2)
- gain knowledge on loaded members response through various applications(L2)
- develop strong command on deducing material constants with available inputs(L6)
- assess the impact of thermal loads on members(L4)
- exhibit design skills of different axial members(L4)

UNITII **12 hours**

Complex and principal Stresses: Introduction, stresses on an oblique plane under-uniaxial loading, stresses on an oblique plane under biaxial loading, biaxial stresses combined with shear stresses, principal stresses and principal planes, Mohr's circle for complex stresses.

Principal Strains: Introduction, strains on an oblique plane under uni-axial loading, strains on an oblique plane under biaxial loading, biaxial strains combined with shear strains, principal strains, and Mohr's circle for complex strains

Theories of Failure: Maximum normal stress theory, maximum shear stress theory, maximum strain energy theory and maximum distortion energy theory.

Learning Outcomes

At the end of unit student will be able to

- understand significance of complex stresses and related strains(L2)
- asses the occurrence of principal stresses, strains and directions for biaxial members(L4)
- develop basic understanding of loaded member failure tendency(L2)
- appreciate and distinguish the simple, complex, and principal stresses(L4)
- develop interest on graphical method of assessment(L2)
- gain knowledge on different failure theories(L2)
- enhance learning of design theories associated with aircraft structures(L4)

UNIT III **10 hours**

Thin Cylinders and Spherical Shells: Stresses and strains (principal stress, principal strain, shear stress, shear strain and volumetric strain) in thin cylinders, thin spherical shell and wire wound cylinders.

Shear Force and Bending Moment: Basic definitions, classification of beams, types of loads, types of supports, shear force and bending moment diagrams for cantilever, simply supported and overhanging beams for different types of loadings, the point of contraflexure, general relation between the load, the shearing force and the bending moment.

Learning Outcomes

At the end of unit student will be able to

- understand the significance and applications of volumetric structural elements in aerospace engineering(l2)
- show command on design of cylinders and spherical shells(L4)
- develop understanding on design loads and their calculation(L2)
- exhibit strong skills of drawing BM and SF diagrams(L4)
- connect the interdependency of bending and shear loads(L6)
- learn different types of beams, supports and applied loads(L2)
- appreciate the variation of design loads and necessary variation in strength(L5)

UNITIV **8 hours**

Bending and Shear Stresses in Beams: Theory of simple bending (bending equation / flexural formula), position of neutral axis, section modulus, practical application of bending equation, shear stresses in beams, variation of shear stress distribution for rectangular, circular and I-sections.

Learning Outcomes

At the end of unit student will be able to

- understand theoretical model that fits strength aspects of members (L2)
- gain command on design knowledge of various beam members(L2)
- exhibit command on optimizing the design process(L4)
- effectively exercise the choice of suitable structural materials(L5)
- appreciate design philosophy and sizing of different beams as appropriate(L5)

UNITV

Deflection of Beams: Beam deflection, relation between slope, deflection and radius of curvature, slope and deflection at a section, double integration method, Macaulay's method and moment area method for cantilever, simply supported and fixed beams.

8 hours

Learning Outcomes

At the end of unit student will be able to

- understand the concept of deflection of beams (l2)
- apply different methods to find the deflection of beams (l3)
- effectively exercise the selection of suitable method based on the type of beam (l4)

Course Outcomes

At the end of course student will be able to

- Assess the response of axially and transversely loaded structural members
- Deduces the complexities associated with bi axial loaded members

- Appreciates the modulation of applied loads to design flexural loads
- Exhibit strong design knowledge of various beams carrying transverse loads
- Estimate the deflection of beams

Text Book(s)

1. R.K Bansal, Strength of Materials, S Chand, 6/e.
2. F. P. Beer, E. R. Johnston Jr. and J. T. Dewolf, Mechanics of Materials, 6/e, Tata McGraw Hill, 2013.

References

1. Timoshenko, Strength of Materials, Part - I and II, 3/e, CBS Publishers,2011.
2. E. P. Popov, Mechanics of Solids, 2/e, Pearson Education, 2003.
3. I. H. Shames and J. M. Pitarres, Introduction to Solid Mechanics, 3/e, Prentice Hall India,2009

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	1	1	2	1	1	2	1	3	2	1
CO2	3	2	2	1	1	1	1	1	1	1	2	1	3	2	1
CO3	3	3	2	1	1	1	1	2	1	1	2	1	3	2	1
CO4	2	2	2	1	1	1	1	2	1	1	2	1	2	2	1
CO5	3	3	2	1	1	1	1	1	1	1	1	1	1	1	0

19EAE206: AIRCRAFT PROPULSION

L	T	P	C
3	1	0	4

Preamble

These course projects concepts connected to power plants that are used in aircrafts. It focuses mainly on performance estimation, characterization and analysis of different subsystems used in aircraft engines. Course is appealing and enhances interest in gas turbine-based power plant engineering.

Course Objectives:

- To learn the principles of the several types of power plants.
- To impart knowledge on performance of Turbojet, Turbofan, Turboprop and turboshaft engines.
- To teach concepts of Ramjet and Scramjet engines.
- To train basic design of Compressors, Combustors, Turbine and Nozzle.
- To propel for Analyze and identify the cause of off design performance.

UNITI **12 hours**

Thermodynamics of Gas Turbine Engines:

Introduction: Nomenclature and air breathing engines, principle of gas turbine engine, thrust equation and related factors.

Aerothermodynamics of Engines: Turboprop engine, turbojet engine, turbo fan engine, turbo shaft engine, ramjet engine, and their performance characteristics, thermodynamic cycles, thrust, efficiencies, specific fuel consumption(thrust), specific thrust and Numerical.

Learning Outcomes

At the end of unit student will be able to

- Develop concepts related to air breathing gas turbine engines(l2)
- Understand the performance of different aircraft engines(l2)
- Distinguish across various engines and their significance(l5)
- Demonstrate basic knowledge of engine design(l4)
- Enhance critical thinking by practice of numerical(l6)

UNITII **12 hours**

Axial Flow Compressors:

Introduction: Geometry structure of stage and related terminology, Flow and airfoil angles, stage and multistage, standard airfoil profiles

Energy transfer: components of energy transfer, stage reaction, Rothalpy and total enthalpy, incidence and deviation angles, radial equilibrium, **Dimensional analysis:** Geometric and dynamic similarity, Buckingham pi theorem for turbomachines, specific speed and its design role, Compressor performance charts, polytropic efficiency, total and static efficiencies.

Real flow effects of incidence angle, Mach number and Reynold's number, tip clearance. Concepts of rotating stall and surge.

Learning Outcomes

At the end of unit student will be able to

- Understand fundamentals related to turbomachinery (L2)
- Connect rotating flow aerodynamics across different frames of reference(L2)
- Enhance knowledge on rotating flow dynamics and performance (L4)

- Develop critical design skills of axial flow compressors(L4)
- Appreciate the turbomachinery flow sensitivity and significance(L5)

UNIT III 10 hours

Axial Flow Turbines:

Introduction, geometry, comparison with axial flow compressor, velocity polygons, stage energy analysis- pressure ratio, degree of reaction – impulse, reaction turbines and related flow angles, dimensional analysis and mapping conventions. Study of performance charts, typical blade profiles, Blade cooling, blade and vane materials, blade and vane manufacture, turbine-compressor matching, Numerical.

Learning Outcomes

At the end of unit student will be able to

- Differentiate flow dynamics between turbines and compressor(L2)
- Analyses, deduces turbine performance from study of charts(L4)
- Demonstrate various turbine blade cooling methods(L4)
- Judge better choice of materials for different components of turbine(L5)
- Enhance critical design skills of axial flow turbines(L6)

UNITIV **9 hours**

Combustion System:

Introduction, geometries, primary combustor, afterburner, Flame stability, ignition and engine starting, adiabatic flame temperature thermodynamics, combustion process, pressure losses- Rayleigh, Fanno line flows, combined heat addition and friction. Performance maps, fuel types used.

Learning Outcomes

At the end of unit student will be able to

- Understand combustion process and associated dynamics in a typical jet engine(l2)
- Appreciates the significance and challenges of energy conversion in combustor(l5)
- Demonstrate the knowledge on flame tube cooling(l4)
- Exhibits design knowledge of typical combustor(l3)
- Deploy possible means to contain combustion losses(l6)

UNITV **7 hours**

Subsonic 1-D Flow:

Inlets: Introduction, geometry structure, subsonic inlets: capture area, low subsonic and high subsonic diffusers, internal flow, external flow decelerations and their implications, area ratio and design criteria.

Learning Outcomes

At the end of unit student will be able to

- Understand internal and external flow modulations for operation of subsonic diffuser(L2)
- Appreciates significance of boundary flow and its role in containing aerodynamic behavior(L6)
- Exhibits subsonic intake design knowledge(L4)
- Enhance interest on learning for high speed subsonic and supersonic intakes(L6)

Course Outcomes

At the end of course student will be able to

- Gain understanding on various gas turbine engines performance.
- Exhibit knowledge on axial flow compressor and turbines working.
- Appreciates combustion mechanism and its sensitivity.
- Exhibit knowledge on working and performance determination of axial flow turbines.
- Demonstrate knowledge of subsonic inlet of gas turbine engine.

Text Book(s)

1. R. D. Flack, Fundamentals of Jet Propulsion with Applications, 2/e, Cambridge University Press, 2010.
2. Erian A Baskharone, Principles of Turbomachinery in air breathing engines.
3. J. D. Mattingly, Elements of Gas Turbine Propulsion, 3/e, McGraw Hill,2011.
4. G. C. Oates, Aerothermodynamics of Aircraft Engine Components, AIAA,2007.

References

1. C. R Peterson and P. G. Hill, Mechanics and Thermodynamics of Propulsion, 2/e, Pearson,2009.
2. Cumpsty, Jet Propulsion, 2/e, Cambridge University Press,2008.
3. A. F. El-Sayed, Aircraft Propulsion and Gas Turbine Engines, 1/e, CRC Press,2008.
4. J. L. Kerrebrock, Aircraft Engines and Gas Turbines, 2/e, MIT Press,1992.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	1	1	1	1	1	1	3	1	1
CO2	3	2	2	1	1	1	1	2	1	1	2	1	3	2	1
CO3	2	1	1	1	1	2	1	1	1	1	1	1	2	1	1
CO4	2	2	2	1	1	1	1	1	1	1	2	1	2	1	1
CO5	2	2	1	1	1	1	1	1	1	1	2	1	2	1	1

19EAE208: COMPUTATIONAL METHODS IN AEROSPACE ENGINEERING

L	T	P	C
2	0	2	3

Preamble:
This course is designed for Aerospace Engineering undergraduate students. It is designed for the students for the basic understanding of techniques for numerical solution of algebraic equations, differentiation, integration used to solve aerospace engineering application problems.

Course Objectives:

- Develop the mathematical skills in the areas of numerical methods.
- Focus on the theory and applications of numerical methods in a large number of engineering subjects which require solutions of linear systems, finding eigenvalues, eigenvectors, interpolation and applications, solving ODEs, PDEs.
- Help in the foundation of computational mathematics for postgraduate courses, specialized studies and research.
- Train in developing the codes for implementing the numerical methods using any programming languages.
- Formulate a mathematical model for a given engineering problem.

UNITI **9 hours**

Mathematical Modeling of Engineering Problems:

Approximations: Accuracy and precision, round-off and truncation errors, error problem with example problems.

Roots of Equations: Formulations of linear and non-linear algebraic equations, solution with bisection, Newton-Raphson and Secant methods. Application to practical problems.

Algebraic Equations: Formulation of linear algebraic equations from engineering problems, solution of these problems by Gauss elimination method, pitfalls of elimination and techniques for improving the solutions, Gauss Seidel iteration for solving sparse equations by avoiding storage of zero coefficients in matrix, convergence of iteration methods. LU decomposition methods for symmetric (Chelosky) matrices.

Learning Outcomes:

After completion of this unit the student will be able to

- Find the root for linear and non-linear algebraic equations by using iterative methods. (l1)
- Estimate the true error and approximate error between the iterations of the mathematical procedure. (l5)
- Formulate system of linear equations from engineering problem and solve using any of the numerical procedure(l6)

UNITII **9 hours**

Eigenvalues and Eigenvectors Problems: Formulation of equations to column, truss, spring-mass and friction problems. Solutions for the largest and smallest eigenvalues and corresponding eigenvectors.

Interpolation Methods: Polynomial interpolation, Lagrange interpolation polynomials with equi-paced data.

Regression or Curve Fitting: Linear regression by least squares method.

Learning Outcomes:

After completion of this unit the student will be able to

- Interpolate a polynomial with any given data(L4)
- Fit a curve using linear regression (L3)
- Calculate Eigenvalues and corresponding Eigenvectors for a given system of equations. (L3)

UNIT III **8 hours**

Initial Value Problems: Ordinary differential equations, Euler, Heun's and Ralston methods. Runge-Kutta method of 2nd and 4th order, application to vibration and heat transfer problems.

Boundary Value Problems: Linear and nonlinear ordinary differential equations, boundary value problems over semi-infinite domain, solution of nonlinear equations by finite difference method.

Learning Outcomes:

After completion of this unit the student will be able to

- Solve ODE's with R-K 2^{nd} and 4^{th}order methods. (L3)
- Interpret the boundary conditions for initial value and boundary value problems. (L2)
- Appreciate the merits of various numerical methods for solving ODE's. (L5)

UNIT IV **8 hours**

Laplace Equations: Finite difference discretization of computational domain, different types of boundary conditions, solution to elliptic equations.

Parabolic Transient Diffusion Equations: Explicit and implicit formulation, Crank Nicolson Method.

Learning Outcomes:

After completion of this unit the student will be able to

- Classify the given partial differential equation. (L2)
- Discretize the given domain by finite difference method for both elliptic and parabolic pdes. (L3)
- Apply the boundary conditions for any given problem satisfying the physics of the problem. (L2)

UNIT V **8 hours**

Numerical Integration: Trapezoidal, Simpson's 1/3 and 3/8 rule and Gauss quadrature method.

Learning Outcomes:

After completion of this unit the student will be able to

- Solve the integration problem by using numerical methods.(L3)
- Understand the application of Simpson's $1/3^{rd}$and $3/8^{th}$methods.(L2)

List of exercises for code development:

1. Determine the real root for a given polynomial equation by(i)Bisection,(ii)Newton-Raphson until the approximate error falls below 0.5%.
2. Solve the system of simultaneous linear equations by
   (i) Naïve –Gauss elimination
   (ii) Gaussian elimination with partial pivoting
   (iii) Gauss -Seidel method.
   (iv) LU decomposition
3. Implement power method to find Eigenvalues and Eigenvectors for Spring mass system
4. Solve the parabolic partial differential equations by using explicit, implicit and semi-implicit methods
5. Solve the elliptic partial differential equations by finite difference techniques.
6. Finding the integral for a second-order polynomial using Gauss quadrature formula.
7. Solve numerical differentiation problems using Runge-Kutta 2^{nd} and 4^{th}order methods.
8. Find the integral by numerical methods such as Trapezoidal and Simpson's rule.

Course Outcomes:

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

- Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.

- Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and nonlinear equations, and the solution of differential equations.
- Analyze and evaluate the accuracy of common numerical methods.
- Implement numerical methods using any programming language (matlab, scilab, python…)
- Write efficient, well-documented code and present numerical results in an informative way.

Text Book(s)

1. S.P. Venkateshan, P. Swaminathan, Computational Methods in Engineering, 1/e, Ane Publisher,2014.
2. S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6/e, Tata McGraw-Hill, 2012.

Reference

1. S.K. Gupta, Numerical Methods for Engineers, 1/e, New Age International, 2005.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	2	1	1	1	1	1	1	3	2	1
CO2	3	3	2	2	2	1	1	1	1	1	1	1	3	2	1
CO3	3	3	2	3	2	1	1	1	1	1	1	1	3	2	1
CO4	3	3	2	3	3	1	1	1	1	1	2	2	3	2	1
CO5	3	3	2	3	3	1	1	1	1	1	2	2	3	2	1

19EAE222: FLUID MECHANICS AND MECHANICS OF SOLIDS LAB

L	T	P	C
0	0	2	1

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students for the experimental understanding of fluid flows and solid mechanics.

Course Objectives:

- Use various flow measuring devices for making engineering judgments.
- Provide practice in estimating friction losses
- Understand experimentally, the performance of hydraulic turbine and compressor
- Understand the procedure of doing different tests like hardness, compression, torsion, tension and impact etc., on various materials
- Impart knowledge about the testing of springs, beams and behavior of materials.

List of Experiments: (Any 10 may be performed)

1. Calibration of venturimeter, orifice meter and flow nozzle.
2. Calibration of Pitot tube.
3. Determination of friction factor of a given pipe.
4. Calculation of force exerted by a jet on a stationary flat plate, inclined plate and curved vane.
5. Performance characteristics of centrifugal and reciprocating pump
6. Performance characteristics of Pelton wheel and Francis turbine
7. Stress-strain characteristics of tension and compression members using UTM.
8. Determination of hardness of metals using Brinnel's and Rockwell's hardness test.
9. Impact test by using Izod's method and Charpy's method
10. Bending test on simply supported and cantilever beams to find load deflection relation.
11. Modulus of rigidity by compression and tension test on springs.
12. Shear and Torsion test on circular shafts.

Course Outcomes:

After successful completion of this course the students will be able to

- Understand the concepts of fluid mechanics in a more practical way.
- Estimate the friction and measure the frictional losses in fluid flow.
- Experiment with flow measurement devices like venturimeter and orificemeter.
- Predict the behavior of the material under impact conditions.
- Recognize the mechanical behavior of materials from tensile, torsion and compression tests.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	2	1	1	1	1	1	1	1	1	3	2	1
CO2	3	1	1	2	2	1	1	1	2	2	1	1	3	2	1
CO3	3	1	1	3	2	1	1	1	2	2	2	1	3	2	2
CO4	3	2	1	3	3	1	1	1	2	2	2	2	3	2	2
CO5	3	2	1	3	3	1	1	1	2	2	2	2	3	2	2

19EAE224: FLIGHT SYSTEMS LABORATORY

L	T	P	C
0	0	2	1

Preamble: This course is intended for graduate students in Flight systems and instruments, Pneumatics systems and Hydraulic systems

Course Objectives:

- To introduce the knowledge of aircraft systems and the steps to be carried out in every procedure.
- To educate students with the safety precautions and Hands-on experience in Jacking up, Leveling and many other experiments
- To train the students "ON HAND" experience in maintenance of various air frame systems in aircraft and rectification of common snags.

List of Experiments:

1. Operation of aircraft fuel system (to find fuel tank quantity by using float type and capacitance type).
2. Aircraft jacking and leveling procedure (to jack the aircraft from its steady position and to level the aircraft for inspection purpose).
3. Aircraft "Symmetry Check" procedure.
4. Airplane rigging check procedure (to find the defection angle of aircraft control surfaces).
5. Assembly and disassembly of aircraft instruments like gyro, altimeter, and Pitot system.
6. Demonstration and operation of aircraft hydraulic system.
7. Demonstration and operation of aircraft pneumatic system.
8. Demonstration and operation of aircraft landing gear system.
9. Demonstration and operation of aircraft oxygen system.
10. Demonstration and operation of aircraft engine starting and ignition systems.
11. Demonstration and operation of aircraft de-icing and anti-icing system.
12. Brake Torque Load Test" on wheel brake units

Course Outcomes:

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

- Obtain the knowledge of aircraft maintenance procedures and the tools required for it with operational manuals.
- Illustrate the operations of Jacking up and leveling of aircraft with DGCA guidelines.
- Demonstrate rigging and symmetry check on an aircraft.
- Report and analyze results for Flow test, Pressure test, Functional test and brake torque load test.
- Review, inspect and safely perform maintenance and troubleshooting on hydraulic and fuel systems as per Airworthiness standards.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO1	3	0	1	3	1	1	0	1	0	2	1	1	3	3	1
CO2	3	2	3	1	2	2	1	1	1	0	1	1	1	2	1
CO3	2	2	2	2	1	2	1	1	2	1	1	1	2	2	2
CO4	3	1	2	2	2	1	1	2	1	2	2	1	1	3	2
CO5	3	2	3	1	1	0	0	1	0	0	1	1	2	3	1

(V SEMESTER)

19EAE301: AERODYNAMICS – I

L T P C
3 1 0 4

Preamble:

This course is designed for Aerospace Engineering undergraduate students. This course aims to introduce and explain the fundamental concepts of aerodynamics. Understanding these concepts will help in estimating aerodynamic forces and moments.

Course Objectives:

- Introduce governing equations of the fluid flow.
- Provide insight on flow characteristics over an airfoil and wing.
- Familiarize different theoretical and numerical methods used in the analysis of potential flow over an airfoil and wing.
- Introduce different sources of drag.

UNIT I **10 hours**

Governing Equations of Fluid Flow: Flow regimes, definition of incompressible and compressible flows, governing equations of inviscid incompressible and compressible flow in integral and differential forms, communication in gases, isentropic relations, stagnation state, stagnation properties and its use.

Learning Outcomes

After the completion of this unit the student will be able to

- Classify different flow regimes based on the Mach number and describe their characteristics (L2).
- Compare the propagation of disturbances in different flow regimes (L2).
- Write the integral and differential form of the governing equations (L1).
- Interpret the physical meaning of different terms in the governing equations (L2).
- Modify governing equations for an inviscid incompressible and compressible flow (L3).
- Write isentropic relations and apply these relations to determine pressure, temperature and density (L3).
- Explain stagnation properties (L2).
- Calculate the stagnation properties of a flow given appropriate information (L3).

UNIT II **10 hours**

Basic Aerodynamics: Wing and airfoil geometry, aerodynamic force and moments, estimation of lift, drag and pitching moment from the pressure distribution, aerodynamic center, center of pressure, types of drag, characteristics of symmetric and cambered airfoils.

Learning Outcomes

After the completion of this unit the student will be able to

- Classify different types of airfoils and wings (L2).
- Illustrate and explain the nomenclature of an airfoil and wing (L1).
- Describe aerodynamic forces and moments acting on an aircraft (L2).
- Calculate lift, drag and pitching moment from the pressure distribution on a 2D body (L3).
- Explain the difference between aerodynamic center and center of pressure (L2).
- Calculate aerodynamic center and center of pressure given appropriate information (L3)
- Explain different sources of drag, their causes and characteristics (L2).
- Describe the effect of angle of attack, camber, thickness and Reynolds number on the

aerodynamic characteristics of an airfoil (L2).

UNIT III **10 hours**

Potential Flows: Laplace's equations, boundary conditions, basic elementary flows: uniform flow, source flow, doublet flow and vortex flow, superimposition of elementary flows, non-lifting and lifting flow over a circular cylinder. Kutta - Joukowski theorem and the generation of lift, numerical source panel method, comparison of an ideal and real flow over a circular cylinder, D'Alembert's paradox.

Learning Outcomes

After the completion of this unit the student will be able to

- Write the governing equation for irrotational, incompressible flow (L1).
- Summarize the general approach to the solution of irrotational, incompressible flows (L2).
- Determine the stream function and velocity potential for basic elementary flows (L3).
- Compute potential flow over 2D bodies 'by superposition of basic elementary flows (L3).
- Compute lift using Kutta-Joukowski theorem (L3).
- Describe the basic philosophy behind source panel method (L2).
- Explain the advantages and limitations of the superposition and source panel method (L2).
- Summarize the differences between an ideal and real flow over a cylinder (L2).

UNIT IV **10 hours**

Thin Airfoil Theory: Vortex sheet, Kutta condition and Kelvin's circulation theorem. Classical thin airfoil theory: symmetric and cambered airfoil, vortex panel numerical method, experimental characteristics of airfoils and comparison with theoretical results.

Learning Outcomes

After the completion of this unit the student will be able to

- Describe the Kutta condition and obtain corresponding expressions for different trailing edge shapes (L3).
- Apply Kelvin circulation theorem to describe the generation of lift over an airfoil (L3).
- Describe the basic philosophy behind thin airfoil theory and vortex panel method (L2).
- Summarize important results of thin airfoil theory for a symmetric and cambered airfoil (L2).
- Estimate lift and moment coefficients using thin airfoil theory and compare them with experimental results (L3).
- Compare the advantages and limitations of thin airfoil theory and vortex panel method (L2).

UNIT V **10 hours**

Finite Wing Theory: Downwash, induced drag, Biot-Savart's law and Helmholtz's theorem. Prandtl's classical lifting line theory, Elliptic and general lift distribution over finite unswept wings, effect of aspect ratio, correlation of C_L distribution over other aspect ratios, flow past swept and delta wings, lifting surface theory, drag polar and ground effect.

Learning Outcomes

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

- Explain differences in flow characteristics over an airfoil and wing (L2).
- Apply Biot-Savart law to determine velocity induced at a point by straight vortex filament (L2).
- Explain Helmholtz's vortex theorems (L2).
- Describe basic philosophy behind Prandtl's lifting line theory (L2).
- Summarize important results of lifting line theory for an elliptic and general lift distribution (L2).
- Estimate aerodynamic characteristics of a finite wing using lifting line theory (L3).

- Explain the limitations of lifting line theory (L2).
- Summarize the flow characteristics over swept and delta wings (L2).
- Explain differences between Prandtl's lifting line theory and lifting surface theory (L2).
- Describe the effect of ground on aerodynamic characteristics of an aircraft (L2).

Course Outcomes:

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

- Apply the governing equations in both integral and differential form for different flows.
- Compute center of pressure, aerodynamic center, lift, drag and moment coefficients given appropriate information.
- Compute potential flow around two-dimensional bodies.
- Apply appropriate theoretical and numerical methods to estimate aerodynamic characteristics of an airfoil.
- Applying appropriate theoretical and numerical methods to estimate aerodynamic characteristics of a wing.

Text Book(s)

1. J. D. Anderson, Fundamentals of Aerodynamics, 5/e, McGraw Hill, 2010.
2. E. L. Houghton, P. W. Carpenter, S. H. Collicott, D. T. Valentine, Aerodynamics for Engineering Students, 6/e , Elsevier Science, 2012

References

1. L. J. Clancy, Aerodynamics, 1/e, Shroff Publications, 2006
2. J. J. Bertin and R. Cummings, Aerodynamics for Engineers, 6/e, Pearson, 2013.
3. B. W. McCormick, Aerodynamics, Aeronautics and Flight Mechanics, 2/e, John Wiley and Sons, 1995.
4. C. Y. Chow and A. M. Kuethe , Foundations of Aerodynamics, 5/e, Wiley India, 2009

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1

19EAE303: MECHANICS OF AEROSPACE STRUCTURES

L	T	P	C
3	1	0	4

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students to understand the basics principles of Mechanics of different components of Aerospace Structures. Understanding these principles will help them in the Design and Analysis of Aerospace Structures.

Course Objectives:

- To study and analyze structures using various energy methods.
- To familiarize different methods for statically indeterminate structures.
- To impart knowledge on the principles of the theory of elasticity.
- To educate the behavior of bending of thin plates under different load conditions.
- To identify the behavior of columns and struts with different end conditions.
- To understand the principles of buckling of thin plates.
- To learn the fundamental principles of mechanical vibrations.

UNIT I **12 hours**

Energy Methods: Unit load method for calculating displacement, strain energy method for uniaxial stress, pure bending and shearing stresses, Castigliano's theorem.

Statically Indeterminate Structures: Introduction, methods for indeterminate beams, superposition method, and moment distribution method, matrix methods for indeterminate trusses and frames.

Learning Outcomes:

After completion of this unit student will be able to

- Apply energy methods to solve problems. (L3)
- Understand different methods used for statically indeterminate structures (L2)
- Analyze statically indeterminate structures using different methods (L4)

UNIT II **8 hours**

Theory of Elasticity: Stress - Strain relations, equilibrium and compatibility conditions for elastic solids, 2D elasticity equations for plane stress, plane strain and generalized plane strain cases, stress functions; Airy's stress function, bending of end-loaded cantilever beams.

Learning Outcomes:

After completion of this unit student will be able to

- Explain the importance of equilibrium and compatibility conditions for elastic solids (L2)
- Distinguish between plane stress and plane strain conditions (L4)
- Solve 2-D elastic problems using stress functions (L3)

UNIT III **10 hours**

Bending of Thin Plates: Pure bending of thin plates, plates subjected to bending; Twisting and distributed transverse loads, combined bending and in-plane loading of a thin rectangular plate, bending of thin plates having a small initial curvature, energy methods for bending of thin plates.

Learning Outcomes:

After completion of this unit student will be able to

- Explain the behavior of bending of thin plates under different types of loadings (L2)
- Apply energy methods to solve bending of thin plate problems (L3)

UNIT IV

Buckling: **12 hours**

Columns and Struts: Elastic instability, Euler's buckling of columns - columns with one end free and the other fixed, both ends fixed, one end fixed and other hinged, column carrying eccentric load, empirical formulae.

Thin Plates: Buckling of thin plates - elastic buckling of isotropic flat plates in compression, elastic buckling of plates due to shear and bending stresses. Instability of stiffened panels, crippling stresses by Needham's and Gerard method.

Learning Outcomes:

After completion of this unit student will be able to

- Compare the behavior of columns with different end conditions (L2)
- Explain the behavior of column carrying eccentric load (L2)
- Explain the elastic buckling of isotropic flat plates under different load conditions (L2)
- Explain the instability of stiffened panels (L2)

UNIT V **10 hours**

Vibrations: Single degree of freedom systems, natural frequency, undamped and damped vibration, vibration of torsional system with single rotor, undamped and damped frequencies.

Learning Outcomes:

After completion of this unit student will be able to

- Explain the concept of mechanical vibrations. (L2)
- Distinguish between damped and undamped vibrations (L4)
- Solve simple problems on vibrations of single degree of freedom systems (L2)

Course Outcomes:

After the completion of this course student will be able to

- Solve problems on statically indeterminate structures using different methods
- Make use of principles of theory of elasticity to solve 2-D elastic solid problems
- Analyze thin plates under bending
- Analyze columns and thin plates under buckling.
- Solve simple problems on mechanical vibrations.

Text Book(s)

1. T. H. G. Megson, Aircraft Structures for Engineering Students, 5/e, Elsevier Publications, 2013.

References

1. Timoshenko, Strength of Materials Part - I and II, 3/e, CBS Publishers, 2011.
2. E. P. Popov, Mechanics of Solids, 2/e, Pearson Education, 2003.
3. I. H. Shames and J. M. Pitarres, Introduction to Solid Mechanics, 3/e, Prentice Hall of India, 2009.
4. F. P. Beer, E. R. Johnston, Jr. and J. T. Dewolf, Mechanics of Materials, 6/e, Tata McGraw Hill, 2013.
5. S. S. Rattan, Strength of Materials, 2/e, Tata McGraw Hill, 2011.

CO PO PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1

19EAE305: FLIGHT MECHANICS

L	T	P	C
3	0	0	3

Preamble:

This course is designed for aerospace engineering students. It introduces the fundamentals of mechanics of flight. This course is designed to acquaint the learners with governing equations of motion of flight, flow physics during mission profile and stability of the aircraft.

Course Objectives

- To introduce the science of predicting and controlling the motion of flight that results from Aerodynamic forces and moments.
- To familiarize the students about the complete picture of atmosphere and its physical properties.
- To analyze the flow physics of high lift devices.
- To Introduce basic concepts of stability and control.
- To describe the main principles of aircraft motion and the governing equation.

UNIT I **7 hours**

Principles of Flight: Physical properties and structure of the atmosphere, international standard atmosphere, temperature, pressure and density variations with altitude, measurement of speed: true, indicated and equivalent air speed; Streamlined and bluff bodies, various types of drag in airplanes, drag polar, methods of drag reduction of airplanes.

Learning Outcomes

Upon successful completion of the unit, the student will be able to

- Learn the influence of atmosphere, airplane weight and airplane configuration on aircraft performance (l1)
- Apply basic aerodynamic principles to analyze the aerodynamic characteristics (l3)
- Understand aerodynamic and control forces acting on aircraft (l2)

UNIT II **10 hours**

Aircraft Performance in Level, Climbing and Gliding Flight: Straight and level flight, thrust required and available, power required and available, effect of altitude on thrust and power, conditions for minimum drag and minimum power required, gliding and climbing flight, maximum rate of climb, numericals, Breguet range and endurance equation for jet and propeller engine aircraft, effect of tail and head wind on range and endurance.

Learning Outcomes

Upon successful completion of the unit, the student will be able to

- Learn airplane performance limitations such as airspeed, load factor (l1)
- Calculate and analyze airspeed-drag and power curve (l4)
- Calculate fuel consumption, flight range and endurance of an airplane (l3)

UNIT III **8 hours**

High Lift Devices: Introduction, trailing edge flap, plain flap, split flap, slotted flap, fowler flap, comparison of different types of flap, general comments on trailing edge flaps, leading edge slot, leading edge flap, boundary layer control, boundary layer blowing, boundary layer suction and jet flap.

Learning Outcomes

Upon successful completion of the unit, the student will be able to

- Learn different types of high lift devices and their performance (l1)
- Understand the flow physics of flaps slats and slots (l2)

UNIT IV **10 hours**

Accelerating Flight: Takeoff and landing performance, turning performance, horizontal and vertical turn, pull up and pull down, control in a turn, maximum turn rate, numerical, V-n diagram.

Learning Outcomes

Upon successful completion of the unit, the student will be able to

- Calculate and analyze the landing and take-off distance (**l4)**
- Understand the performance condition during turning flight **(l2)**
- Analyze velocity and load factor curve**(l3)**

UNIT V **9 hours**

Introduction to Stability and Control: Introduction, static stability, dynamic stability, aircraft control, axes of reference and notation, longitudinal stability, wing alone, wing and horizontal tail, factors affecting tail contribution, neutral point and static margin.

Learning Outcomes

Upon successful completion of the unit, the student will be able to

- Describe the influence of forces and moments on the static and dynamic stability of aircraft (l2)
- Apply the aircraft flight mechanics equations to analyze the flight stability performance of aircraft in different situations (l3)

Course Outcomes

After completion of the course the student will be able to

- Predict the influence of atmosphere and airplane configuration on aircraft performance.
- Understand the factors that influence aircraft design and limit aircraft performance.
- Apply knowledge of basic aerodynamics necessary for understanding mechanics of flight.
- Apply control system and maneuvering methodologies to solve flight control problems
- Identify limitations of the aircraft stability principles and equations as applied to aircraft.

Text Book(s)

1. J. D. Anderson, Introduction to Flight, 7/e, McGraw Hill, 2011.
2. E. L. Houghton, P. W. Carpenter, S. H. Collicott and D. T. Valentine, Aerodynamics for Engineering Students, 6/e , Elsevier, 2012.

References

1. L. J. Clancy, Aerodynamics, Shroff Publications, 2006.
2. J. J. Bertin and R. Cummings, Aerodynamics for Engineers, 6/e, Pearson, 2013.
3. A.W. Babister, Aircraft Stability and Response, Pergamon Press, 1980.
4. R. C. Nelson, Flight Stability and Automatic Control, 2/e, McGraw Hill, 1998.
5. M. V. Cook, Flight Dynamics Principles, 2/e, Elsevier Publications, 2012

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO1	**3**	**3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**2**	**1**
CO2	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
CO3	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**2**	**2**	**2**
CO4	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**2**	**2**	**2**
CO5	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**2**	**1**	**3**

19EAE321: Aircraft Propulsion Lab

L	T	P	C
0	0	2	1

Preamble: This laboratory course aims at imparting practical exposure of working of different subcomponents of a typical gas turbine engine. It provides broader scope to understand modulation of flow through different engine components.

Course objective

1) Teach physical working of turbo machinery components and related pressure calculations.

2) Give practical exposure on working of nozzle and its performance calculations

3) Expose students to concepts of free jet, wall jet and their practical influence on boundary flows

4) Explain actual working of gas turbine combustion and associated combustion mechanism

5) Help students understand mechanism on heat conduction and flame stabilization

List of Experiments:

1. Performance study of axial flow compressors
2. Performance study of centrifugal Compressors
3. Nozzles aerodynamics (pressure distribution, under and over expanded)
4. Nozzles performance (jet reaction, efficiency and choking)
5. Study of reaction turbine performance
6. Study of impulse turbine performance
7. Performance of gas turbine engine
8. Wall jet and wake study
9. Combustion process
10. Flame propagation and stability
11. Study of heat transfer by convection
12. Thermal conductivity of fuels.

Course outcomes

At the end of course students will be able to

- Exhibit knowledge on actual working of turbomachines, compressor and turbine for work and energy transfer
- take-up basic design assignment of supersonic nozzle for high speed applications
- Carryout performance evaluation of combustion chamber
- Appreciates development of free jet and wallet
- Ascertain heat energy transfer across different hot surfaces of engine components.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	2	1	1	2	1	2	1	3	1	1
CO2	3	2	2	1	1	2	1	1	2	1	2	1	3	1	1
CO3	3	2	2	1	1	2	1	1	2	1	2	1	3	1	1
CO4	3	2	2	1	1	2	1	1	2	1	2	1	3	1	1
CO5	3	2	2	1	1	2	1	1	2	1	2	1	3	1	1

Interdisciplinary Elective -I

19EEC373: FUNDAMENTALS OF GLOBAL POSITIONING SYSTEM

L	T	P	C
2	0	2	3

The course is structured to introduce students to the basic principles of positioning features. This course deals with topics on satellite constellation, data formats, positioning solution algorithm, different sources of errors and their mitigation techniques. Further this course exposes the student to other Global navigation systems such as Galileo and GLONASS. Application of GPS for different fields of Engineering is also introduced.

Course Objectives:

- To introduce the basic principles of Global Positioning System and other constellations.
- To make the student familiar with different error sources that affects the positioning accuracy.
- To familiarize about different reference frames and coordinate systems of positioning systems.
- To get acquainted about the GPS orbits and the satellite and Receiver position algorithm
- To explore different applications of GPS in engineering.

UNIT -I **8L**

Overview of GPS and other constellations: Basic concept, system architecture, space segment, user segment, GPS aided Geo-augmented navigation (GAGAN) architecture. GPS Signals and other constellations: signal structure, Galileo and GLONASS.

Learning Outcomes:

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

- understand the basic concept of Global Positioning and System architecture(L1).
- distinguish between the different segments of the architecture (L2).
- identify the necessity of augmented systems like GAGAN(L1).
- understand the Galileo and GLONASS constellation (L2).

UNIT - II **8L**

GPS Errors: GPS error sources – clock error, ionospheric error, tropospheric error, multipath, ionospheric error estimation using dual frequency GPS receiver, anti- spoofing (AS), selective availability(SA).

Learning Outcomes:

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

- understand the different types of error sources (L2).
- estimate the ionospheric and tropospheric error using real time data (L2).
- understand about anti- spoofing and selective availability(L2).

UNIT -III **8L**

GPS Coordinate Frames and Time References: Geodetic and geocentric coordinate systems, ECEF coordinate world geodetic 1984 (WGS 84), GPS time.

Learning Outcomes:

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

- describe different reference frames (L2).
- differentiate the different coordinate systems of GPS(L4).

- Interpret the GPS Time(L2).

UNIT - IV **8L**

GPS Orbits and Satellite Position Determination: GPS orbital parameters, description of receiver independent exchange format (RINEX), observation data and navigation message data parameters, GPS position determination.

Learning Outcomes:

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

- understand the satellite orbital parameters (L2).
- interpret the RINEX format (L2).
- identify orbital parameters from navigation message and observation data formats(L4).
- interpret the GPS position determination algorithm (L2).

UNIT -V **8L**

GIS and GPS Applications: Introduction to GIS, geodetic control surveys, engineering and monitoring, vehicle tracking, traffic control and road condition monitoring.

Learning Outcomes:

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

- explain the significance of GPS as a surveying tool (L2).
- discuss the usage of GPS in engineering and monitoring(L2).
- review the role of GPS in Traffic Control and road condition monitoring(L2).

Text Books:

1. B. Hoffman – Wellenhof, H. Liehtenegger, J. Collins, GPS: Theory and Practice, Springer – Wien, 2001.
2. Gottapu Sasibhushana Rao, Global Navigation Satellite Systems, Tata McGraw Hill Education, 2010.
3. Burrough.P.A, Principle of Geographical Information Systems for Land resources Assesment, OUP, Oxford, 1986.

References:

1. Parkinson. B, Spilker. J, Jr., GPS: Theory and Applications, Vol.II, AIAA, 1996.
2. James Ba, Yen Tsui, Fundamentals of GPS Receivers: A Software Approach, John Wiley and Sons, 2001.

Course outcomes:

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

- understand the basic principles of GPS and other constellations (L1).
- determine at least one /two errors with real time data (L3).
- explain the need of reference frames and coordinate systems in positioning systems(L3).
- describe the significance of orbital parameters in satellite systems (L2).
- interpret at least one engineering application of GPS(L3).

19EEC371: FUNDAMENTALS OF COMMUNICATION SYSTEMS

L	T	P	C
2	0	2	3

This course covers fundamental concepts of communication systems, which are essential for the understanding of advanced communication systems. Beginning with the basic communication system, the need for modulation, various analog and digital modulation techniques are covered. Further, this course will also focus on the basic concepts of various antenna and Radar systems, their working principles and applications.

Course Objectives:

- To familiarize with the need of modulation, AM, DSBSC and its applications.
- To explain the concept of angle modulation techniques and its practical applications.
- To demonstrate various pulse coding and the generation of digital modulation techniques.
- To explain the basics of antenna and its applications in HF/UHF/MW frequencies.
- To describe the working principles and applications of various RADAR Systems.

UNIT -I **9L**

Introduction to Communication Systems: Introduction to communication, elements of communication system, need of modulation, electromagnetic spectrum and typical applications. amplitude modulation techniques: elements of analog communication, theory of amplitude modulation (AM) technique, double sideband suppressed carrier (DSBSC) technique, generation of amplitude modulated Signal: generation of AM Signal, generation of DSBSC Signal.

Learning Outcomes:

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

- describe the elements of communication system (L1).
- explain the need of modulation, electromagnetic spectrum and applications (L2).
- analyze the generation of amplitude modulated signal and DSBSC signals (L5).

UNIT -II **8L**

Angle Modulation Techniques: Theory of angle modulation technique: frequency modulation, phase modulation, frequency spectrum of the FM wave, narrow band and wide band FM, stereophonic FM multiplex system, comparison of FM and AM.

Learning Outcomes:

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

- describe the theory of angle modulation technique (L1).
- compare frequency modulation, amplitude modulation and phase modulation (L2).
- differentiate narrow band and wide band FM (L4).
- analyze the stereophonic FM multiplex system (L4),

UNIT -III **8L**

Digital Pulse Modulation Techniques: pulse code modulation, delta modulation, digital modulation techniques: introduction, basic digital modulation schemes: amplitude shift keying (ASK), frequency shift keying (FSK) and phase shift keying (PSK).

Learning Outcomes:

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

- explain the digital pulse modulation techniques like pulse code modulation and delta modulation (L2).
- classify the basic digital modulation schemes (L3).
- demonstrate the generation of ASK, PSK, FSK signals (L3).

UNIT -IV **9L**

Antennas: Basic considerations, wire radiator in space, terms and definitions, directional high-frequency antennas: dipole arrays, folded dipole and applications UHF and microwave antennas: parabolic reflector antenna, horn antenna.

Learning Outcomes:

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

- explain the basic concepts of antenna fundamentals (L1).
- define the terms and definitions of antenna parameters (L1).
- illustrate the characteristics and applications of directional high-frequency antennas (L3).
- demonstrate the characteristics and applications of UHF and microwave antennas (L3).

UNIT -V **8L**

Radar Systems: Fundamentals, radar performance factors, basic pulsed radar systems, moving- target indication (MTI), CW doppler radar, frequency modulated CW radar.

Learning Outcomes:

After completion of this unit the student will be able to

- explain the fundamentals and performance factors of radar (L1).
- describe the principles of pulsed radar systems and moving- target indication (MTI) (L1).
- distinguish between CW Doppler radar and frequency modulated CW radar (L4).

Text Book:

1. George Kennedy, Bernard Davis and S R M Prasanna, Electronic Communication Systems, 5 Ed Mc Graw Hill Education (India) Private Limited, 2014.

References:

1. Taub H. and Schilling D., Principles of Communication Systems, Tata McGraw Hill, 2010.
2. Simon Haykins, Michel Mohar, Introduction to Analog and Digital Modulation, second edition, Wiley India, 2014.
3. P. Rama Krishna Rao, Analog Communications 1 Ed, Tata McGraw Hill, 2011.
4. Gottapu Sasibhushana Rao, Microwave and Radar Engineering, 1 Ed, Pearson Education, 2014.

Course Outcomes:

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

- summarize the need of modulation, AM, DSBSC and its applications (L2).
- describe the concept of angle modulation techniques and its practical applications(L1).
- demonstrate various pulse coding and the generation digital modulation techniques(L3).
- explain the basics of antenna and its applications in HF/UHF/MW frequencies(L2).
- describe the working principles and applications of various RADAR Systems(L2).

19EEI477: INDUSTRIAL AUTOMATION

L	T	P	C
2	0	2	3

To provide students with required knowledge in the field of automation and to introduce the advanced automation techniques like PLC, SCADA and DCS systems and Instrument protocols which are presently used in different Industries for Automation.

Course Objectives:

- To familiarize the role of automation in industries
- To explain the architecture and applications of PLC, SCADA and DCS
- To provide an understanding of instrumentation standard protocols
- To describe the concept and applications of DCS.
- To explore the importance and applications of automation in various modern industries.

UNIT I **8L**

Control Systems and Automation Principles: Evolution of instrumentation and control, role of automation in industries, benefits of automation, introduction to automation tools PLC, DCS, SCADA, hybrid DCS/PLC, automation strategy evolution, control system audit, performance criteria and safety systems.

Learning Outcomes:

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

- summarize the importance of instrumentation and control in industry (L2).
- describe various automation tools (L4).
- analyze the performance criteria of the system (L4).

UNIT II **9L**

Programmable logic Controllers (PLC): Introduction, architecture, definition of discrete state process control, PLC Vs PC, PLC Vs DCS, relay diagram, ladder diagram, PLC design, advanced applications of PLC and SCADA**:** PLC programming methods, PLC applications for batch process using SFC, analog control using PLC, PLC interface to SCADA/DCS using communication links (RS232, RS485) and protocols (Mod bus ASCII/RTU).

Learning Outcomes:

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

- explain the architecture of PLC and assemble it with SCADA/DCS (L2).
- distinguish between PLC & PC and PLC & DCS (L2).
- construct the ladder diagrams of PLC(L3).
- identify the advanced applications of PLC and SCADA(L1).
- list out PLC programming methods (L1).

UNIT III **8L**

Instrumentation Protocols: HART protocol introduction, frame structure, programming, implementation examples, benefits, advantages and limitations. Foundation field bus H1 introduction, structure, programming, FDS configuration, implementation examples, benefits, advantages and limitations, comparison with other field bus standards including device net, Profibus, control net, CAN, industrial Ethernet etc.

Learning Outcomes:

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

- explain the hart protocol and its programming (L2).
- list the advantages and limitations of HART protocol (L3).
- demonstrate the foundation field bus H1and its programming (L3).
- compare foundation field bus H1 with other field bus standards (L4).

UNIT IV **9L**

Distributed Digital Control Systems: DCS introduction, functions, advantages and limitations, DCS as an automation tool to support enterprise resources planning, DCS architecture of different makes, specifications, configuration and programming, functions including database management, reporting, alarm management, communication, third party interface, control, display etc. enhanced functions viz. advance process control, batch application, historical data management, OPC support, security and access control etc.

Learning Outcomes:

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

- describe distributed control system (L2).
- list the advantages and limitations of DCS (L3).
- formulate DCS as an automation tool for various functions (L5).
- illustrate DCS architecture of different makes (L3).

UNIT- V **8L**

Industrial Applications for Automation:–Power, water treatment, food and beverages, dairy, cement, steel, pharmaceuticals, automobile and building automation.

Learning Outcomes:

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

- analyze power plant industry (L4).
- develop water treatment and food &beverages plant using various automated tools (L3).
- explain the process of cement and steel plant automation (L3).
- adapt automated tools for automobile and building automation (L5).

Textbooks:

1. Popovik, Bhatkar, Distributed Computer Control for Industrial Automation, Marcel Dekkar Publications, 1990.
2. Webb and Reis, Programmable Logic Controllers: Principles and Applications, PHI, 5th Edition.
3. S.K.Singh, Computer Aided Process Control, PHI, 2004.

References:

1. Gary Dunning, Introduction to Programmable Logic Controllers, Thomson Learning, 3rd Edition.
2. N.E.Battikha, The Management of Control System: Justification and Technical Auditing, ISA, 1992.
3. Krishna Kant, Computer Based Process Control, PHI, 2nd Edition.

Course Outcomes:

After completion of this course, the students will able to

- explain the importance of automation in industries (L2).
- design and develop control systems for various real time industrial applications using PLC, SCADA and DCS (L5).
- apply different instrumentation protocols for industrial applications (L3).
- use DCS as an automation tool for various functions (L3).
- design and develop advanced Instrumentation systems in the Industrial & Automation field (L3).

19ECY373 NANOSCIENCE AND NANOTECHNOLOGY

L T P C
3 0 0 3

Preamble

This course enables the students to gain knowledge on various aspects of nanoscience and nanotechnology in understanding storage, safe handling and applications of nanomaterials to meet our demands.

COURSE OBJECTIVES

- To introduce students to the nano-world and types of materials.
- To familiarize with band structure and quantum mechanics.
- To acquaint students with various preparation methods of nanomaterials.
- To impart knowledge on the characterization by various techniques.
- To enable students in understanding storage, safe handling and applications of nanomaterials.

Unit- I **8 L**

INTRODUCTION TO NANO-WORLD

Concept of Size, Definition of Nanomaterial, Bulk vs Nanomaterials, Classification of Nanomaterials: Cluster, Colloid, Nanoparticles, Nanocrystal, Nanostructured material (3D-Particle, 2D-thin film, 1D-Wire, rod etc.), Quantum dot. Nanomaterials' Surface to volume ratio/fraction of atoms present at the surface with respect to the core calculation.

Learning outcomes

After completion of Unit-I, the student will be able to

- **list** the importance of nanomaterials. **(L-1)**
- **classify** the different types of materials. **(L-2)**
- **compare** nano structured materials. **(L-2)**
- **explain** the surface to volume ratio of nanomaterials. **(L-2)**

Unit- II **9L**

STRUCTURE AND BONDING

Molecular Orbital (MO) diagram, Highest Occupied Molecular Orbital (HOMO)-Lowest Unoccupied Molecular Orbital (LUMO), Band structure, Density of States (DOS). Size dependent properties (quantum effect): melting point, magnetism, Optical, electrical conductivity, Catalytic activity, Mechanical Property.

Learning outcomes

After completion of Unit-II, the student will be able to

- **list** the different types of molecular orbitals **(L-1)**
- **classify** HOMO & LUMO **(L-2)**
- **explain** the size dependent properties. **(L-2)**
- **illustrate** structure and bonding **(L-2)**

Unit- III **9 L**

SYNTHESIS OF NANOMATERIALS

Bottom Up and Top down Approach: Wet chemical synthesis, La Mer Diagram, Nucleation and growth control, Sol-gel technique, Microemulsion methodology, Hydrothermal Process, Chemical Vapour Deposition (CVD), Physical Vapour Deposition (PVD) and Lithography.

Learning outcomes

After completion of Unit-III, the student will be able to

- **list** the preparation of nanomaterials. **(L-1)**
- **illustrate** the concept of Bottom Up and Top down methods. **(L-2)**
- **explain** the details of Nucleation and growth control. **(L-2)**
- **apply** the physical and chemical methods for the synthesis of nanomaterials. **(L-3)**
- **compare** CVD and PVD. **(L-3)**

Unit- IV **9 L**

CHARACTERIZATION

Stepwise advancement, Sample preparation for each of the characterization techniques, Characterization techniques: UV-Visible Spectroscopy, Fluorescence Spectroscopy, Powder X-ray diffraction (PXRD). Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), Electron Microscopy – SEM, TEM. Engineering applications.

Learning outcomes

After completion of Unit-IV, the student will be able to

- **illustrate** the different types of characterization techniques. **(L-2)**
- **identify** the difference between PXRD & AFM. **(L-3)**
- **apply** SEM & TEM for surface topology. **(L-3)**
- **analyze** the composition of nanomaterials. **(L-4)**
- **distinguish** between AFM and STM. **(L-4)**

Unit- V **7 L**

STORAGE AND SAFE HANDLING OF NANOMATERIALS

Environmental implication of NPs, Application: Metal, Metal oxide, semiconductor and C-nanomaterials applied in medicinal, mechanical, electronic, engineering etc.

Learning outcomes

After completion of Unit-V, the student will be able to

- **identify** the procedures for storage of nanomaterials. **(L-3)**
- **analyze** safe handling of nanomaterials. **(L-4)**
- **classify** the different types of nanomaterials. **(L-4)**
- **justify** the environmental implication of nanoparticles **(L-5)**

COURSE OUTCOMES

After completion of course, the student will be able to

- **list** the importance of nanomaterials.
- **classify** HOMO & LUMO
- **apply** the physical and chemical methods for the synthesis of nanomaterials.
- **analyze** the composition of nanomaterials.
- **justify** the environmental implication of nanoparticles

Text books

1. Gunter Schmid, Nanoparticles- From theory to application, 2/e, Wiley-VCH (2004).
2. K J Klabunde, Nanoscale material in chemistry, 2/e, A John Wiley & Sons (2001).

References:

1. G. A. Ozin & A.C. Arsenault, Nano chemistry: A chemical Approach to Nanomaterials, (RSc), 2/e, Royal Society of Chemistry (2009).
2. Guozhong Cao, Nanostructures and Nanomaterials : Synthesis, Properties and Applications, 1/e, Imperial College Press (2004).
3. T. Pradeep, Nano: The Essentials Understanding nanoscience and nanotechnology, 1/e, Tata McGraw-Hill Publishing Company Limited (2007).

19ECS371: INTRODUCTION TO DATABASE MANAGEMENT SYSTEMS

L	T	P	C
2	0	2	3

This course provides fundamental and practical knowledge on database concepts by means of organizing the information, storing and retrieve the information in an efficient and a flexible way when data is stored in a well-structured relational model. This course ensures that every student will gain experience in creating data models and database design.

COURSE OBJECTIVES

- Relate the role of a database management system in an organization.
- Demonstrate basic database concepts, including the structure and operation of the relational data model.
- Construct simple and moderately advanced database queries using Structured Query Language (SQL).
- Explain and successfully apply logical database design principles, including E-R diagrams and database normalization.
- Demonstrate the concept of a database transaction and related database facilities, including concurrency control, and data object locking and protocols.

UNIT-I **12 hours**

Introduction to DBMS: Overview, File system vs DBMS, advantages of DBMS, storage data, queries, transaction management, DBMS structure, people who work with Databases.
Database Design: data models, the importance of data models.
E-R model: Entities, attributes and entity sets, relationship and relationship sets, mapping cardinalities, keys, features of ER model, conceptual database design with ER model

Learning outcomes

Students will be able to

- **interpret** the basic terminology of DBMS like data, database, database management systems**(L2)**
- **compare** DBMS over File Systems. **(L2)**
- **define** levels of abstraction with three tier architectures. **(L1)**
- **define** the role of DBA and other users of DBMS. **(L1)**
- **model** a given application using an ER diagram. **(L3)**

UNIT-II **10 hours**

Relational model: Integrity constraints over relations and enforcement, querying relational data, logical database design, views, destroying/altering tables and views.

Relational Algebra and Relational Calculus

Learning outcomes

Students will be able to

- **match** the integrity constraints from ER model to relational model. **(L1)**
- **translate** an ER Model to Relational Model and vice versa. **(L2)**
- **compare** the difference between views and physical tables and work with views**. (L2)**
- **construct** the given Query in Relational Algebra and Relational Calculus. **(L3)**

UNIT-III **12 hours**

Structured Query Language (SQL): Introduction to SQL, Basic SQL Queries: DML, DDL, DCL, TCL, Select Commands, Union, Intersection, Except, Nested Queries, Aggregate Operators, Null values, Relational set operators, SQL join operators

Learning outcomes

Students will be able to

- **create** and modify database using SQL query.**(L5)**
- **illustrate** different types of query forms (simple queries, nested queries, and aggregated queries) in SQL.**(L2)**

UNIT-IV **8 hours**

Schema Refinement and Normal Forms: Schema Refinement, Functional Dependencies, Reasoning about Functional Dependencies. Introduction to Normal Forms.

Learning outcomes

Students will be able to

- **make use of** about schema refinement process.**(L3)**
- **illustrate** knowledge about different types of normal forms and the importance of normalization. **(L2)**

UNIT-V **10 hours**

Transaction Management and Concurrency Control: Introduction to Transaction Management, ACID properties, Transactions and Schedules, Concurrent Execution of Transactions, Lock-Based Concurrency Control.

Concurrency Control: 2PL, Serializability and Recoverability, Introduction to Lock Management, Lock Conversions, Dealing with Deadlocks, Specialized Locking Techniques, Concurrency control without locking,

Learning outcomes

Students will be able to

- **interpret** the overview of transaction management in DBMS. **(L2)**
- **explain** the importance of concurrency and concurrency control mechanisms.**(L2)**
- **develop** knowledge about concurrency control with and without locks.**(L3)**
- **identify** knowledge about different types of crashes in DBMS.**(L3)**
- **apply** crash recovery techniques to recover from DBMS crashes. **(L3)**

COURSE OUTCOMES:

Upon completion of this course, students will be able to:

- build a database for a system Using E-R data model and Relational Data model(L3)
- construct logical database with all integrity constraints over relations.(L3)
- construct all types of SQL, relational algebra, relational calculus queries over relations and he/she can be able to create views on the existing relations.(l3)
- extend the characteristics of database transactions and how they affect database integrity and consistency.(L2)
- demonstrate the concurrency control mechanisms and crash recovery algorithms.(L2)

Text Books:

1. Database Management Systems, Raghu Ramakrishnan and Johannes Gehrke McGraw-Hill, 3rd Edition, 2014

Reference Books:

1. Database System Concepts, H.F.Korth and A.silberschatz McGraw-Hill, 6e, 2011

2. Fundamentals of Database Systems, Ramez Elmasri, Shamkant B. Navathe, Pearson Education, 7e, 2016
3. Fundamentals of Database Systems, Elmasri, Navathe, Somayajulu, Gupta, Pearson Education, 6e, 2010

19ECS373: OBJECT ORIENTED PROGRAMMING WITH C++

L	T	P	C
2	0	2	3

C++ is one of the most popular languages, contains object-orientation, a new programming concept, is used to create an object, in code, that has certain properties and methods or Units, the implementation of the Units helps to see the whole world in the form of objects. This course also helps in developing high quality software like system application software, drivers, client-server applications and embedded firmware.

Course Objectives:

- To introduce the difference between procedure-oriented programming and object-oriented programming.
- To familiarize the basic concept, applications of OOPS and practice of object-oriented analysis and design in the construction of robust, maintainable programs which satisfy their requirements.
- To identify and practice the object-oriented programming concepts and techniques, practice the use of C++ classes and class libraries, modify existing C++ classes, and develop C++ classes for simple applications.
- To explain the implementation of features of object-oriented programming to solve real world problems using Inheritance, data abstraction, encapsulation, and Polymorphism.
- To provide an understanding of the concept of file and handling function to perform file operations like accessing the data from file and store the data into file.

Unit I: **10 L**

Introduction to OOP: Procedure oriented programming, object-oriented programming, basic concepts of OOP, simple C++ program, namespace scope, structure of C++ Program, creating, compiling and linking a file.
Tokens: Keywords, identifiers, constants, basic data types, user defined data types, derived data types, dynamic initialization of variables, reference variables, operators in C++, scope resolution operator, member dereferencing operators, memory management operators.

Learning Outcomes::

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

- list the difference between procedure and object-oriented programming, applications of OOP (L1).
- explain basic concepts of object-oriented programming (L2).
- choose appropriate data type and operators in programs (L3).
- extend the concepts of C++ in developing efficient programs (L2).
- create, compile and run the C++ programs (L6).

Unit II: **8 L**

Control Structures:
Classes and Objects: Specifying a class, defining member functions, C++program with class, private member functions, arrays within class, memory allocation for objects, static data members, static member functions, arrays of objects.
Functions in C++: Main function, function prototyping, inline functions, default arguments.

Learning Outcomes:

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

- compare parameter passing techniques of C and C++ (L2).
- illustrate the concept of classes and objects (L3).

- develop real world applications by using appropriate concepts(L6).
- apply static members in programming (L3).
- compare inline functions with macros (L2).

Unit III: **8 L**

More about Functions: Function overloading, friendly functions: friend function, objects as function arguments.
Constructors & Destructors: Constructors, parameterized constructors, multiple constructors in a class, copy constructors, dynamic constructors, destructors.

Learning Outcomes:

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

- apply function overloading concept whenever required (L2).
- explain the need of friend function (L2).
- extend the concept of parameter passing techniques with objects (L2).
- define the different types of Constructors (L1).
- apply constructor and destructor in programming (L2).

Unit IV: **10 L**

Inheritance: Introduction to inheritance, single inheritance, making a private member inheritable (protected member), multi-level inheritance, multiple inheritance, hierarchical inheritance, hybrid inheritance.
Operator Overloading: Rules for overloading operators, overloading unary operators, overloading binary operators.
Pointers: Introduction to pointers, declaring and initializing pointers, pointers with arrays, arrays of pointers, 'this' pointer.

Learning Outcomes:

After completion of this unit, the student will be able to
- explain the need of reusability concept with inheritance (L2).
- summarize different types of inheritance (L2).
- extend the overloading concept on operators (L2).
- recall the basics of pointers from C language and extend to objects (L1).
- describe the need of this pointer (L2).

Unit V: **8 L**

Polymorphism and Virtual Functions: Compile-time polymorphism, run-time polymorphism, virtual functions.
Templates: Introduction, function templates, class templates.
Exception Handling: Introduction, exception handling mechanism, throwing mechanism, catching mechanism.

Learning Outcomes:

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

- compare and contrast compile time and run time polymorphism (L2).
- apply of virtual functions (L3).
- classify the various input and output operators into formatted and unformatted (L2).
- apply the concept of templates for generic programming (L3).

- show the handling of run time errors (L2).

Text Book(s):

1. E. Balagurusamy, Object Oriented Programming with C++, 6/e, McGraw Hill, 2013.

References:

1. SouravSahay, Object Oriented Programming with C++, 2/e, Oxford University Press, 2012.
2. Behrouz A. Forouzan and Richard F. Gilberg, Computer Science : A Structured Approach Using C++, 2/e, Cengage Learning, 2003.
3. Ashok N. Kamthane, Object Oriented Programming with ANSI and Turbo C++, 1/e, Pearson Education, 2006.

Course Outcomes:

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

- differentiate between procedure-oriented programming and object-oriented programming with emphasis on special features of C++ language (L2).
- differentiate the fundamental concepts of C and C++ (L2).
- identify the differences in C and C++ operators and their usage in C++ applications (L2).
- examine the working of Control structures in C++ programs (L3).
- define, declare and implement classes and objects (L1).
- develop applications with the help of functions, constructors and destructors (L6).
- interpret various Inheritance mechanisms, operator overloading, polymorphism and apply in applications (L3).
  - determine the concepts of Polymorphism, Virtual functions and Exception handling and be able to develop applications with them (L3).
  - construct applications using generic programming concepts (templates) (L6).

19ECS375: INTRODUCTION TO PROGRAMMING WITH JAVA

L	T	P	C
2	0	2	3

Java's unique architecture enables programmers to develop a single application that can run across multiple platforms seamlessly and reliably. In this hands-on course, students gain extensive experience with Java and its object-oriented features. Students learn to create robust console and GUI applications and store and retrieve data from relational databases.

Course objectives

- To make it understand the difference between programming languages C, C++ and Java.
- Learn various types of Inheritance mechanisms.
- Give exposure over various software packages applicability and usage of multithreading concepts.
- Applet creation and its graphical effects.
- Learn different components required for forms designing in AWT.

Unit I: 10L

Java Evolution and Overview of java Language: Fundamentals of OOP, Java evolution, overview of java language, java history, features of java, how java differs from C and C++, java and World Wide Web, web browser. Java Environment: Java Development kit (JDK), Application Programming Interface (API), java programming structure, java tokens, constants, variables, expressions, decision making statements and looping, java statements, overview of arrays and strings, machine neutral, Java Virtual Machine (JVM), Command Line Arguments. Arrays and Strings :One-dimensional arrays, creating an array, declaration of arrays, initialization of arrays, two-dimensional arrays, string arrays, string methods, string buffer class, vectors, wrapper classes. Basic I/O Streams: Scanner, buffered reader.

Learning Outcomes:

After completion of the unit, student will be able to

- identify the difference between c++ and Java (L2)
- identify the Environment that allows to write platform independent programs(L2)
- apply the methods of Strings to solve the string oriented problems.(L3)
- analyze the uses of wrapper classes in the design of solutions.(L4)
- contrast the difference between the usage of I/O Streams(L4)

Unit II: 11L

Classes, Objects and Methods: Introduction, defining a class, creating objects, accessing class members, constructors, methods overloading, static members. Inheritance: Defining a sub class, sub class constructor, multilevel variables, final classes, and finalize methods, abstract methods and classes, visibility control. Managing Errors and Exceptions: Introduction, types of errors: compile time and run time errors, exceptions, types of exceptions, syntax of exception handling code, multiple catch statements, using finally statement, throwing our own exceptions.

Learning Outcomes:

After completion of the unit, student will be able to

- define the user defined classes of the given problem to be solved.(L1)
- explain the behavior of each object in its scope.(L2)
- apply the concepts finalize, abstract and final over the methods and classes.(L3)
- analyze the exception handling mechanisms.(L4)
- develop a code with try and catch blocks.(L3)

Unit III: **9L**

Interfaces, Package & Multithreaded Programming: Introduction, defining interfaces, extending interfaces, implementing interfaces. Package: Creation, importing a package and user defined package. Threads: Introduction to threads, creating threads, extending the thread class, implementing the 'runnable' interface, life cycle of a thread, priority of a thread, synchronization, and deadlock.

Learning Outcomes:

After completion of the unit, student will be able to

- review the concepts of Inheritance for implementing new classes.(L2)
- extends the new classes from one or more classes.(L2)
- define the interfaces and packages.(L1)
- develop new packages for solving complex problems.(L3)
- analyze the flow of execution by decomposing into two or more.(L4)

Unit IV: **9L**

Applet Programming: Introduction, how applets differ from applications, building applet code, applet life cycle, about HTML, designing a web page, passing parameters to applets, getting input from the user.

Learning Outcomes:

After completion of the unit, the student will be able to

- define the new concept applet on internet programming.(L1)
- compare applet with application programs(L2)
- apply applet life cycle to the real problem to solve.(L3)
- test the parameterized applet.(L3)
- examine the behavior of applet using HTML code (L4)

Unit V: **8L**

Graphics Programming: Introduction, abstract window toolkit class hierarchy, frames, event-driven programming, layout managers, panels, canvases, drawing geometric figures. Introduction to Swings: Introduction to swings, overview of swing components-J button, J Check Box, J Radio Button, J Label, J Text Field, J Text Area, J List. Introduction to Networking: I net Address class, socket class, URL class.

Learning Outcomes:

After completion of the unit, the student will be able to

- choose awt to create GUI(L3)
- classify the various layouts (L3)
- develop the very user friendly GUIs(L3)
- contrast the between applet and Swings(L2)
- construct an Internet based application using networking concepts in java(L3)

Textbook(s):

1. Herbert Scheldt, The Java complete References, 9/e, TMH Publications,2014.

References:

1. Balagurusamy, Programming with JAVA, 2/e, TMH Publications,2014.
2. Y.DanielLiang, An Introduction to JAVA Programming, TMH Publications, 2009.
3. Kathy Sierra, Head First Java, 2/e, Shroff Publishers, 2012..

Course Outcomes:

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

- differentiate Java and C,C++ and basic environment required for implementing Java program.(L4)
- explain the concept of class and object and Ability to apply inheritance concepts(L2)
- illustrate concept of user defined exceptions(L4)
- demonstrate usage of a package and thread implementation in application development(L3)
- develop applets with various graphical aspects and Develop GUI forms using different AWT components(L3)

19EHS375: BUSINESS ETHICS AND CORPORATE GOVERNANCE

L	T	P	C
3	0	0	3

Ethics and responsibility in Business has received critical focus in the wake of the various corporate scams rocking the global economy. It is believed by many that in the own interest of business, importance be given to ethical functioning. Business decisions often concern complicated situations that are neither totally ethical nor totally unethical. The need for imparting sound ethics and a responsible mindset in the future leaders is considered as one of the important aspects of higher education. Decision making, when facing ethical dilemmas that arise in a wide range of contemporary business practices, is crucial, and is enabled through moral reasoning and understanding ethical norms of individual and organisation.

Course Objectives:

- To be able to rasp the various issues in the professional field from an ethical viewpoint
- To stimulate thoughts on ethical issues, and professional challenges encountered in business
- To create consciousness of the value system and its importance in business
- To enable students to recognize and manage ethical issues and to formulate their own standards of integrity and professionalism
- Would enable the student to take future decisions, in personal and professional life, with a clear understanding about the ethical implication of this on him, his firm, and the society at large.

Unit I: **7L**

Ethics and Values: Understanding of ethics and values and their formation; personal and professional ethics; moral overconfidence; moral disengagement – a basis for unethical behavior

Learning Outcomes:

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

- understand the basis for different ethical thinking (L2).
- interpret different ethical behaviors (L3).
- analyse behavior critically from the perspective of morality (L4).

Unit II: **9L**

Unit II: Corporate Culture and Ethics: Building an ethical corporate culture – the impact of business environment, Leadership, code of ethics, globalization; Ethical dilemmas, conflict of interest and resolutions; ethical decision making.

Learning Outcomes:

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

- analyse the impact of various factors on corporate culture (L4).
- identify ethical dilemmas (L2).
- construct an argument for an ethical decision making (L5).

Unit III: **8L**

Fairness in the workplace: Discrimination; harassment; working conditions - HSE, privacy, work-life balance; whistle blowing.

Learning Outcomes:

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

- identify various ethical issues relating to employee-employer (L2)
- debate on the rights and duties of an employee and employer (L4)
- justify his argument regarding workplace ethics (L6)

Unit IV: **8L**

Marketing and Ethics: Unethical issues in product, pricing, and advertising; issues due to globalization.

Learning Outcomes:

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

- identify ethical issues in business and customer relationship (L2).
- analyse the impact of unethicality in marketing (L4).
- evaluate the marketing strategies from an ethical point of view (L6).

Unit V: **8L**

Corporate Governance: Stakeholder theory; role of Board; Conflict of Interest, Insider Trading; Corporate Lobbying.

Learning Outcomes:

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

- understand the role of corporate governance in trust building of an organization (L2).
- identify various issues ethical issues an organization is susceptible to at the hands of the top management (L2).
- analyse the impact of conflict of interest on human behavior.

Text Book(s):

1. Richard T. DeGeorge, "Business Ethics", 7thEd., Pearson, New Delhi, 2011
2. Andrew Crane and Dirk Matten., Business Ethics. Oxford Publication, New Delhi: 2007.

References:

1. M.G. Velasquez, Business Ethics, Prentice Hall India Limited, New Delhi: 2007.
2. R.C. Sekhar., Ethical Choices in Business, Response Books, New Delhi: 2007.
3. Manikutty, S., "Being Ethical – Ethics as the foundation of Business", Random House India, Noida, 2011

Course Outcomes:

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

- identify various issues relating to ethics to ethics and (L3).
- analyse situations of ethical dilemmas and arrive at the right decision making (L4).
- distinguish between ethical and unethical actions in professional life (L4).
- choose the right path by evaluating the various choices available (L6).

SEMESTER – VI

19EAE302: AERODYNAMICS - II

L	T	P	C
3	1	2	5

Preamble

This course highlights syllabus related to high speed flows. It includes flow theories of normal, oblique and expansion shocks and flow linearization methods. Course find appealing and enhances interest in the area of high speed flows and gas dynamics

Course Objectives:

- Explain behavior of airflow both internal and external in a compressible flow regime with particular emphasis on supersonic flows.
- Train principles behind the formation of shocks and expansion fans in supersonic flows.
- Impart the knowledge of flow physics of nozzles and supersonic inlets.
- Familiarize approximation theory and linearization of potential flows.
- Encourage take up design of nozzles and supersonic airfoils

UNIT I **10 hours**

Isentropic Flows: Steady one dimensional isentropic flow: differential equations for 1D flow, isentropic flow with area variation, area-velocity relation and its application.

Normal Shock Theory: Normal shock concept, normal shock relations, stationary normal shocks.

Learning Outcomes

At the end of unit student will be able to

- Develop conceptual understanding of one-dimensional steady flow(L2)
- Deduce conservation equations from fundamental principles(L3)
- Learn applications of steady flow equations for one dimensional flow(L2)
- Appreciates the dynamics of high-speed flows(L2)
- Express interest in design of one-dimensional flow subsystems(L4)

UNIT II **10 hours**

Oblique Shocks and Shock Reflections: Oblique shocks, concept and theory, oblique shock relations, property variations, detached shocks, shock reflections, numerical examples and shock-shock interactions.

Expansion Theory: Expansions: 1D expansion wave, expansion fan, Prandtl-Meyer function, smooth expansions/compressions and numerical examples. Shock expansion theory: examples and its applications.

Learning Outcomes

At the end of unit student will be able to

- Develop knowledge on various types of shock and their properties(L1)
- Gain profound understanding of Mach number, shock and wedge angle significance(L2)
- Effectively differentiate oblique and expansion waves(L5)
- Put in sufficient applied numerical practice(L3)
- Analyze, interpret supersonic flow behavior for various objects(L6)

UNIT III **12 hours**

Nozzle Flows: Area-Mach number relations, geometric choking, convergent nozzles, divergent nozzles, convergent-divergent nozzles, numerical examples, multiple choking points, and effect of different pressure ratio across nozzle, under and over expanded nozzles.

Supersonic Inlets: Introduction, starting problem, convergent-divergent diffuser, divergent inlet, shock boundary layer problem, external deceleration and performance, flow stability problem with movable spikes.

Learning Outcomes

At the end of unit student will be able to

- Realize the significance of compressibility of high-speed flows(L2)
- Appreciates the aerodynamic performance of nozzles(L2)
- Exhibit knowledge on the design of different types of nozzles(L4)
- Develop understanding on supersonic inlets and their gas dynamic behavior (L2)
- Realize the complexities associated with high response of engine subsystems(L6)

UNIT IV **10 hours**

Linearized Potential flow Theory: Potential equation for 2-dimensional compressible flow, linearization of potential equation, perturbation potential, linearised pressure coefficient, linearised subsonic flow, Prandtl-Glauert rule, linearised supersonic flow, and Introduction to method of characteristics.

Learning Outcomes

At the end of unit student will be able to

- Appreciates linearization theory of potential flow of compressible regimes(L2)
- Exhibit enhanced interest in handling compressible nature of fluids over different aerodynamic objects(L6)
- Apply design knowledge of compressible flow to airfoil (L3)

UNIT V **10 hours**

Linearized Supersonic Flows: Critical Mach number, drag divergence Mach number, shock stall, supercritical airfoil sections, transonic area rule, swept wing, airfoils for supersonic flows, lift, drag, pitching moment and centre of pressure for supersonic profiles, wave drag, supersonic wings.

Learning Outcomes

At the end of unit student will be able to

- Improve knowledge of quantification of supersonic flows(L2)
- Exhibit increased interest in deducing critical high-speed flow response on different aerodynamic objects(L3)
- Compare exact and approximation theories in simplification of high-speed gas dynamic flows(L4)
- Exhibit design knowledge of supersonic wings and other high-speed components(L4)

Course Outcomes

At the end of course student will be able to

- Realize the significance of nature of high speeding flows and their relevance to mach number**(L2)**
- Exhibit knowledge of quantification of supersonic flow shock field concepts **(L4)**
- Ascertain, and design typical supersonic nozzle and inlet**(L6)**
- Understands the importance of linearization of potential flow and its quantification**(L2)**
- Exhibit knowledge of supersonic flow field complexities and quantification methods**(L4)**

Text Book(s)

1. E. Rathakrishnan, Gas Dynamics, 5/e, Prentice Hall of India, 2013.
2. J. D. Anderson, Modern Compressible flow, 3/e, McGraw Hill, 2012.

References

1. C. R Peterson and P. G. Hill, Mechanics and Thermodynamics of Propulsion, 2/e, Pearson, 2009.
2. H. W. Liepmann and A. Roshko, Elements of Gas Dynamics, Dover publications, 2007.
3. A. H. Shapiro, The Dynamics and Thermodynamics of Compressible Fluid Flow, volume I and II, 1/e, John Wiley, 1953.
4. P. H. Oosthuizen and W .E. Carscallen, Compressible Fluid Flow, 1/e, McGraw Hill, 1997.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	1	1	2	1	1	2	1	3	2	1
CO2	3	2	2	1	1	1	1	2	1	1	2	1	3	2	1
CO3	3	2	1	1	1	1	1	2	1	1	2	1	3	2	1
CO4	2	2	1	1	1	1	1	2	1	1	2	1	2	1	1
CO5	3	2	1	1	1	1	1	2	1	1	2	1	3	1	1

AERODYNAMICS LABORATORY

Preamble:

This course is designed for Aerospace Engineering undergraduate students. This course aims at imparting practical exposure on various techniques used to measure pressure, velocity, force and visualize the flow. Familiarity with these techniques helps in determining aerodynamic forces and moments.

Course objectives:

- introduce different types of wind tunnels.
- acquaint students with different pressure, velocity, and force measurement techniques.
- acquaint students with different flow visualization techniques.

List of Experiments:

1. Study of the pressure distribution over smooth and rough cylinder.
2. Study of the pressure distribution over symmetric and cambered airfoils.
3. Study of the characteristics of wings involving measurement of lift, drag, pitching moment.
4. Performance of an airfoil with flap, influence of flap angle on lift, drag and stall.
5. Aerodynamic characterization of different wing configurations.
6. Aerodynamic characterization of flapping wings.
7. Flow visualization studies in low-speed flow over airfoil with different angles of incidence.
8. Pressure distribution around a two- dimensional model in supersonic flow conditions, at different angles of attack.
9. Lift and drag coefficient for aerodynamic models in supersonic flow.
10. Shock waves and expansion patterns around a two - dimensional model in supersonic flow conditions. (Flow visualization with Schlieren apparatus.
11. Measurement of the velocity profile in the boundary layer at on rough and smooth plates
12. Measurement of the velocity profile in the boundary layer at various distances from the leading edge of the plate

Course Outcomes:

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

- classify and explain different types of wind tunnel and their components.
- explain the principle behind the different techniques used for measuring pressure, velocity, force and visualizing the flow.
- measure and analyse pressure/velocity distribution over bodies of practical interest such as cylinder, airfoil, wing and a flat plate
- use various flow visualization techniques to identify different flow structures in both subsonic and supersonic flows.
- measure and analyze lift, drag and moment coefficients.

19EAE304: ANALYSIS OF AEROSPACE STRUCTURES

L T P C
3 1 2 5

Preamble:
This course is intended to give insight on thin walled beams used in aerospace vehicles. Students will gain knowledge on the design of thin-walled beams and will be able to understand the behavior of beams which undergo different loading conditions in aircrafts.

Course Objectives:
- Provide concepts on bending stresses and deflections for beams.
- Train to compute shear stresses and twist angles in torsion for solid sections, closed thin-walled sections and open thin-walled sections.
- Focus on the application of structural idealization for different aircraft structures.
- Impart skills to design structural joints used in the aerospace domain.

UNIT I **10 hours**
Bending of Open and Closed Thin-Walled Beams: Symmetrical and unsymmetrical bending, resolution of bending moments, direct stress distribution, position of neutral axis, deflections due to bending and approximations for thin walled sections.

Learning Outcomes
At the end of the unit, student will be able to
- Differentiate between bending of symmetrical and unsymmetrical sections (l1)
- Estimate the stress distributions in thin walled sections (l3)
- Estimate the deflections due to bending (l3)

UNIT II **10 hours**
Shear of Open and Closed Thin-Walled Beams: General stress, strain and displacement relationships for open and single-cell closed section thin-walled beams, shear of open section beams, shear center, shear of closed section beams.

Learning Outcomes:
At the end of the unit, student will be able to
- Understand the concept of shear center in thin-walled section beams (l1)
- Estimate the shear in open and closed section beams (l3)
- Derive the stress, strain and displacement relationships for open and single-cell closed section thin-walled beams (l4)

UNIT III **11 hours**
Torsion of Circular Shafts: Shafts, torsion of shafts, torsion equation, hollow circular shafts, torsional rigidity, power transmitted by the shaft, importance of angle of twist and shear stresses in shafts, shafts in series, shafts in parallel, comparison of solid and hollow shafts, combined bending and torsion.

Torsion of Beams: Torsion of closed section, displacements associated with Bredt-Batho shear flow, torsion of open section beams, warping of cross section, conditions for zero warping.

Learning Outcomes:

At the end of the unit, student will be able to

- Understand the importance of angle of twist in beams (l1)
- Understand the concept of combined bending and torsion (l1)
- Estimate the displacements using bredt-batho theory (l3)
- Understand the concept of warping (l1)

UNIT IV **10 hours**

Structural Idealization: Idealization of panel, effect of idealization on the analysis of open and closed section beams. Deflection of open and closed section beams.

Sizing Procedures: Preliminary sizing, production stress analysis, formal stress reports, load path and free body diagrams; Margin of safety and stiffness requirements.

Learning Outcomes:

At the end of the unit, student will be able to

- Calculate the deflections in open and closed section beams using idealization (l3)
- Do stress analysis and draw free body diagrams (l4)
- Understand the importance of margin of safety in the structural aspect (l1)

UNIT V **9 hours**

Joints and Fittings: Introduction to bolted and riveted joints, standard parts, splices, eccentrically loaded connections, gusset joints, welded joints, bonded joints, lug analysis (bolt in shear), tension fittings (bolt in tension) and tension clips.

Learning Outcomes:

At the end of the unit, student will be able to

- Importance of bolts and riveted joints in aircraft structures (l1)
- Do shear analysis in joints (l3)
- Understand and apply the concept of different joints (l3)

Course Outcomes:

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

- Understand the fundamental principles relating to the bending analysis ofthin walled structures.(l1)
- Compute stresses, deflections and shear centers in asymmetric beams in bending. (l3)
- Analyze the circular and non-circular sections subjected to torsion (l4)
- Develop ability to size practical aerospace structures given representative loads (l4)
- Analyze different types of joints (l3)

Textbook(s)

1. T. H. G., Megson, Aircraft Structures for Engineering Students, 5/e, Elsevier, 2013.
2. M. C. Niu, Airframe Stress Analysis and Sizing, 3/e, 2011.

References

1. D. J. Peery, Aircraft Structures, 2/e, Dover publications, 2012.
2. B. K. Donaldson, Analysis of Aircraft Structures: An Introduction, 2/e, Cambridge University Press, 2012.
3. D. William, E. Arnold, An Introduction to the Theory of Aircraft Structures, Elsevier, 2013.
4. J. Cutler, Understanding Aircraft Structures, 3/e, Aditya Books, 2002.

AEROSPACE STRUCTURES LABORATORY

List of Experiments:

1. Maxwell's reciprocal theorem verification for beams with different end conditions.
2. Column instability test for different end conditions.
3. Shear tests on riveted joints.
4. Study the behavior of pressurized thin cylinder.
5. Shear centre in open sections beams.
6. Shear centre in closed sections beams.
7. Wagner tension field beam
8. Combined bending and torsion of a circular tube
9. Strength of structural under fatigue or cyclic loading.
10. Free vibration of a cantilever beam.
11. Forced vibration of beams.
12. Forced vibration of rotating unbalance

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO 1	3	2	1	1	1	1	2	1	1	1	1	2	3	2	1
CO 2	3	1	2	1	1	1	1	1	1	1	1	1	2	2	1
CO 3	2	3	2	1	1	1	1	1	1	1	1	1	3	1	1
CO 4	3	1	2	1	1	1	1	1	1	1	1	1	3	1	1
CO 5	3	2	1	1	1	1	1	1	1	1	1	1	2	1	1

Program Elective – I

19EAE342: INDUSTRIAL AERODYNAMICS

L	T	P	C
3	0	0	3

Preamble:

This course is intended for graduate students in the area of fluid dynamics, wind engineering, and Aerodynamics

Course Objectives:

- Familiarize the learner with non-aeronautical uses of aerodynamics such as road vehicle, building aerodynamics and problems of flow induced vibrations
- This course offers an introduction to industrial aerodynamics and wind engineering with the main characteristics of natural winds.
- Support the characteristics of velocity profiles and atmospheric turbulence are described along with the effects of upstream exposure.
- Developing wind speed and turbulence models for inhomogeneous upstream exposures are presented in comparison with atmospheric measurements and wind-tunnel simulations.
- Explain basic elements of wind-building interaction in the time-averaged mode for uniform and boundary layer flows are described, external and internal pressures and forces on buildings with emphasis on design significance are discussed.
- Demonstrate the patterns of air pollutant dispersion influenced by natural winds are presented.

UNIT I **8 hours**

Atmospheric Boundary Layer: Atmospheric circulation, local winds, terrain types, mean velocity profiles, power law and logarithm law. Wind speeds, turbulence profiles, roughness parameters and simulation techniques in wind tunnels.

Learning Outcomes:

At the end of the unit, the learners will be able to

- Basic understanding of the wind environment in atmosphere and flow structure in the atmospheric boundary layer. (l2)
- Understand the parameters of wind speeds (l2)
- Understand the simulation techniques in wind tunnels (l3)

UNIT II **9 hours**

Wind Energy Collectors: Horizontal and vertical axis machines, energy density of different rotors, power coefficient, Betz coefficient by momentum theory.

Learning Outcomes:

At the end of the unit, the learners will be able to:

- Gain knowledge on wing energy collectors like wind turbine machines. (l2)
- Comprehend the energy and energy types. (l2)
- Understand the production of electricity from wind energy. (l2)

UNIT III **10 hours**

Bluff Body Aerodynamics: Boundary layers and separation, two dimensional wake and vortex formation. Strouhal and Reynolds number, separation and reattachments, power requirements and drag coefficients of automobiles, effects of cut back angle, aerodynamics of trains.

Learning Outcomes:

At the end of the unit, the learners will be able to:

- Understand and describe bluff body aerodynamics (l2)
- Understand the difference in aerodynamics of streamlined and bluff objects (l3)
- Understand the effect of reynolds number on bluff body aerodynamics (l2)
- Explain how vortex shedding occurs and the effect it may have on structures. (l3)

UNIT IV **8 hours**

Building Aerodynamics: Pressure distribution on low rise buildings, wind forces on buildings, environmental winds in city blocks and special problems of tall buildings. Building codes, ventilation and architectural aerodynamics.

Learning Outcomes:

At the end of the unit, the learners will be able to:

- Basic knowledge how to solve problems on wind loading of structures, cross-winds (l2)
- Understand the wind forces on buildings (l2)
- Understand how to write building codes and ventilation process(l3)
- Learn the process of architectural aerodynamics. (l3)

UNIT V **8 hours**

Flow Induced Vibrations: Effect of Reynolds number on wake formation of bluff shapes, vortex induced vibrations, vortex shedding, galloping - wind galloping of circular cables, oscillation of tall structure and launch vehicles under wind loads and stall flutter.

Learning Outcomes:

At the end of the unit, the learners will be able to:

- Solve the problems and be able to analyze vibrations during flow. (l3)
- Classify the mechanisms for flow-induced vibration and explain the qualitative (l2) differences between these mechanisms (l2)
- Explain the problems that coupling with a fluid (both quiescent and flowing) can pose for structural mechanics (l3)

Course Outcomes:

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

- To understand the concepts of industrial aerodynamics and wind engineering with the main characteristics of natural winds.(l2)
- To impart knowledge of external and internal pressures and forces on buildings and vehicles with emphasis on design significance (l3)
- use of aerodynamics for non- aerodynamics such as vehicle building.(l2)
- Solve the problems and be able to analyze vibrations during flow.(l3)
- Apply the problems on effect of Reynolds number on wake formations (l3)

Text Book(s)

1. M. Sovran, Aerodynamics and Drag Mechanisms of Bluff Bodies and Road Vehicles, Plenum press, 1978.
2. P. Sachs, Winds Forces in Engineering, Pergamon Press, 1978
3. R. D. Blevins, Flow Induced Vibrations, Van Nostrand, 1990.

References

1. R. S. Scorer, Environmental Aerodynamics, Ellis Harwood, 1978.
2. R. McAllen, F. Browand, J. Rose, The Aerodynamics of Heavy Vehicles: Trucks, Buses and Trains, Springer Berlin, 2004.
3. R. D. Blevins, Flow Induced Vibrations, Van Nostrand, 1990.
4. N. G. Calvert, Wind Power Principle, Charles Griffin and Co, 1997.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	2	1	2	1	2
CO2	2	3	1	1	1	1	1	1	1	1	1	1	3	1	1
CO3	3	2	1	1	1	1	1	1	1	1	2	1	2	1	2
CO4	2	3	1	1	1	1	1	1	1	1	2	1	2	1	1
CO5	3	2	1	1	1	1	1	1	1	1	1	1	1	1	2

19EAE344: COMBUSTION TECHNOLOGY

L	T	P	C
3	0	0	3

Preamble

This course highlights syllabus connected to combustion related aspects of typical engine. It focuses mainly on enhancing knowledge on combustion kinetics, study of different types of flames, combustion diagnostics methods and emission control.

Course Objectives:

- Explain different types of fuels used for combustion process of different heat engines
- Impart knowledge on basic thermodynamics of combustion and related kinetics
- Train concepts of premixed and non-premixed types of combustions
- Facilitate basic design of combustion process for typical combustor.
- Provide techniques of variety of combustion emissions and their quantification

UNIT I **8 hours**

Aviation Fuels: Properties and tests for petroleum products, motor gasoline, aviation gasoline, aviation turbine fuels, requirements of aviation turbine fuels of kerosene type and high flash point type, requirements for fuel oils.

Learning Outcomes

At the end of chapter student will be able to

- Develops awareness on various types fuels used for combustion and their properties(L1)
- Enhances knowledge on processes of petroleum products(L2)
- Understand different tests used for characterizing the fuels(L3)
- Assess the suitability of fuel, based on mission requirements(L4)
- Determine thermal properties of fuels(L6)

UNIT II **9hours**

Thermodynamics of Combustion: Combustion stoichiometry, methods of quantifying fuel and air content, heating values, adiabatic flame temperature, constant pressure process and calculation methods, elements of chemical kinetics, transport equations, mass and species conservation, momentum and energy conservation, normalization of equations.

Learning Outcomes

At the end of chapter student will be able to

- Understand combustion process related thermodynamics (L2)
- Deduces conversion of energy to thermal energy to appropriate numbers(L4)
- Appreciates different combustion process and quantification methods(L2)
- Enhances ability to understand and analyze chemical kinetics(L6)
- Apply and appreciate conservation methods for chemical combustion of fuels(L4)

UNIT III **9hours**

Premixed Flames: Physical process, flame speed and thickness, measurements, structure of premixed flames, dependence of flame speed and thickness on equivalence ratio, temperature and pressure, flammability limits and its effects by temperature, pressure, flame quenching, minimum energy for sustained ignition, overview of turbulent premixed flames.

Learning Outcomes

At the end of chapter student will be able to

- Appreciates the significance of premixing fuel and oxidizer (L2)
- Develop understanding on determination of flame properties(L2)
- Enhances ability to deduce flame characteristics from structure of flame(L6)
- Expose the significance of pressure and temperature in combustion(L4)
- Analyze turbulent premixed flame combustion(L4)

UNIT IV **10 hours**

Non Premixed Flames: Introduction, description of a candle flame, structure of non premixed laminar free jet flames, laminar jet flame height, empirical correlation of laminar flame height, Burke-Schumann jet diffusion flame, brief of turbulent jet flames, droplet vaporization, combustion, initial heating of droplet and its distribution.

Learning Outcomes

At the end of chapter student will be able to

- Compare and distinguish non premixed and premixed flames(L4)
- Gains knowledge on droplet vaporization and combustion(L2)
- Appreciates the formulations of empirical equations(L3)
- Determine non premixed flame properties(L4)
- Enhance learning on turbulent and non premixed flame (L2)

UNIT V **7 hours**

Emissions and Control: Negative effects of combustion products, pollution formation, parameters controlling formation of pollution, CO oxidation, mechanisms for NOx formation, controlling NOx formation, soot formation, relation between NOx and soot formation, oxides of sulphur, quantification of emissions.

Learning Outcomes

At the end of chapter student will be able to

- Develops understanding on negative effects of combustion(L2)
- Conduct thorough analysis of pollution formation(L6)
- Exhibit interest on quantification of emissions(L3)
- Design combustion process to possibly control formation of pollutants(L4)

Course Outcomes:

At the end of course student will be able to

Understand different properties and various tests conducted on aviation fuels(L2)

- Develop strong knowledge on thermodynamics of combustion processes(L4)
- Realizes the significance of premixed combustion and related characteristics(L3)
- Appreciate various ways of non premixed combustion processes for energy conversion(L3)
- Conduct detailed analysis of pollutants and their emission control(L4)

Text Book(s)

1. S. McAllister, Fundamentals of Combustion Processes, 2/e, Springer, 2011.
2. S. Turns, An Introduction to Combustion: Concepts and Applications, 3/e, McGraw Hill, 2011.

References

1. K. K. Kuo, Principles of Combustion, 2/e, John Wiley, 2005.
2. S. P. Sharma and C. Mohan, Fuels and Combustion, Tata McGraw Hill., 1984.
3. S. F. Parner, Propellant Chemistry, Reinhold Publishing Corporation, 1985.

4. C. K. Law, Combustion Physics, 1/e, Cambridge University Press, 2010

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	1	2	1	1	2	1	3	1	1
CO2	3	2	1	1	1	2	3	2	1	1	2	1	3	1	1
CO3	3	2	1	1	1	2	2	2	1	1	2	1	3	1	1
CO4	2	2	1	1	1	2	2	2	1	1	2	1	2	1	1
CO5	2	1	1	1	1	2	3	2	1	1	2	1	2	1	1

19EAE346: ADVANCED AEROSPACE STRUCTURES

L	T	P	C
3	0	0	3

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students to understand the advanced principles of Mechanics of different components of Aircraft Structures. Understanding these principles will help them in the Design and Analysis of Aerospace Structures.

Course Objectives:

- Provide basic concepts to size practical aerospace structures given representative loads and other parameters.
- Learn to compute stresses for different aerospace structural components.
- Develop skills to design simple aerospace structures to support mechanical loads.
- Develop a mind set to understand the advanced aircraft structures.

Unit I 8 hours

Stress Analysis of Wing Spars and Box Beams: Tapered beams of single web, open and closed section beams and beams having variable stinger areas.

Stress Analysis of Fuselages: Bending, shear and torsion of fuselage, cutouts in fuselages.

Learning outcomes:

After completion of this unit student will be able to

- o Analyze tapered beams of different sections
- o Analyze fuselages under bending, shear and torsion

Unit II **8 hours**

Stress Analysis of Wings: Bending, shear and torsion of wings, shear center, tapered wings, deflections and cut-outs in wings.

Stress Analysis of Fuselage Frames and Wing Ribs: Principles of stiffener/ web construction, fuselage frames, wing ribs.

Learning outcomes:

After completion of this unit student will be able to

- o Analyze wings under different loading conditions
- o Analyze fuselage frames and wing ribs

Unit III **10 hours**

Structural and Loading Discontinuities in Thin Walled Beams: Closed section beams: shear stress distribution of a closed section beam built in at one end under bending, shear and torsion loads, semi monocoque. Open section beams: I section beam subjected to torsion, torsion of beam of arbitrary section, torsion bending constant and shear lag.

Learning outcomes:

After completion of this unit student will be able to

- o Understand the effect of structural and loading discontinuities and analyse shear stress distribution in closed section beams with discontinuities
- o Distinguish between the shear stress distribution in open and closed section beams with discontinuities under different loading conditions

Unit IV **8 hours**

Fatigue: Safe life and fail-safe structures, designing against fatigue, fatigue strength of components, prediction of aircraft fatigue life, crack propagation.

Learning outcomes:
After completion of this unit student will be able to

- o Understand the basic principles of fatigue
- o Apply the principles to predict the fatigue strength and fatigue life

Unit V **8 hours**

Fracture Mechanics: Strength of cracked bodies, potential energy and surface energy; Griffith's theory, Irwin-Orwin extension of Griffith's theory to ductile materials, stress analysis of cracked bodies, effect of thickness on fracture toughness, stress intensity factors for typical geometries.

Learning outcomes:

After completion of this unit student will be able to

- o Understand the basic principles of fracture mechanics
- o Apply different theories for the analysis of components made of ductile materials
- o Explain the effect of thickness on different parameters

Course Outcomes:

After the completion of this course student will be able to

- perform the stress analysis of wing spars, box beams and fuselages subjected to mechanical loads. (L3)
- understand and analyze wings, wing ribs and fuselage frames (L2)
- understand the effect of structural and loading discontinuities on thin walled beams (L2)
- solve problems of fatigue damage and calculate fatigue-crack growth under aircraft spectrum loading.(L3)
- apply for principles of fracture mechanics to solve problems (L3)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	1	1	2	1	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	2	2	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1	2	2	1
CO4	3	2	1	1	1	1	1	1	1	1	1	1	2	1	1
CO5	3	2	1	1	1	1	1	1	1	1	1	1	2	2	1

Text Book(s)

1. T. H. G. Megson, Aircraft Structures for Engineering Students, 5/e, Elsevier, 2013.

2. J. F. Knott, Fundamentals of Fracture Mechanics, Butterworth and Co., 1983.

References

2. E. F. Bruhn, R. J. H. Bollard, Analysis and Design of Flight Vehicles Structures, Jacob Publishing, 1973.
3. B. K. Donaldson, Analysis of Aircraft Structures an Introduction, 2/e, Cambridge University Press, 2012.
4. D. William, E. Arnold, An Introduction to the Theory of Aircraft Structures, Elsevier, 2013.
5. E. H. Dowell, A Modern course in Aeroelasticity, 5/e, Springer International Publishing, 2014.

19EAE348: FLIGHT DYNAMICS

L	T	P	C
3	0	0	3

Preamble:

This course is designed for aerospace engineering students. It introduces the fundamentals of flight dynamics. This course is designed to acquaint the learners with different types of operating conditions and various controls and maneuvering dynamics.

Course Objectives

- To acquaint the students about the performance of airplanes under various operating conditions
- To familiarize them about the performance of control surfaces and their characteristics.
- To impart knowledge about the purpose of elevators and ailerons in various operating conditions.
- To learn the various maneuvering criteria and their stability.
- To familiarize the students with the concepts of dynamic stability in aircraft.

UNIT I **8 hours**

Stick Fixed Static Longitudinal Stability: Introduction to stability of airplane, wing alone configuration, wing and tail configuration, effect of tail on static stability, stick fixed longitudinal stability, effect of power, neutral point, center of gravity limits. In-flight measurement of stick fixed neutral point.

Learning Outcomes

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

- Describe the influence of forces and moments on the static and dynamic stability of aircraft (L2)
- Apply the aircraft flight mechanics equations to analyze the flight stability performance of aircraft in different situations (L3)
- Determine the practical approach of flight measurement of stick- fixed neutral point (L5)

UNIT II **8 hours**

Control Surfaces and Aerodynamic Balancing: Control surface hinge moments, floating and restoring tendencies, different types of tabs used on airplanes, mass balancing, frise aileron, the sealed nose balance, spoiler controls, aeroelastic effects.

Learning Outcomes

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

- Understand performance of various control surfaces and tab (L2)
- Demonstrate the advanced control concepts to design stabilization systems and autopilots (L3)
- Classify the aerodynamic balancing methods (L6)

UNIT III **8 hours**

Stick Free Static Longitudinal Stability: Effect of free elevator on airplane stability, elevator control force, stick force gradients, neutral point and controls free center of gravity limit. In-flight measurement of stick free neutral point.

Learning Outcomes

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

- Understand the stick free and trim condition (L2)

- Apply the practical approach of flight measurement of neutral point (L3)

UNIT IV **10 hours**

Maneuvering Flight, Directional and Lateral Control: Effect of acceleration on airplane balancing, elevator angle per g and stick force per g, maneuver margins. Asymmetric flight, weather cock stability, contribution of different parts of the airplane, rudder fixed and rudder free static directional stability, dihedral effect. Contribution of different parts of airplane controls in roll, aileron control power, cross coupling of lateral and directional effects.

Learning Outcomes

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

- Design tools for aircraft stability augmentation systems (L6)
- Demonstrate computational flight simulation systems based on the established dynamic models and airplane controls (L2)
- Linearized the non-linear equations of motion, and express them in state space form (L3)

UNIT V **11 hours**

Dynamic Stability: Introduction to dynamics, spring-mass system. Equations of motion without derivation, stability derivatives (a) longitudinal dynamic stability - solution of stability quadric, phugoid modes, Routh's criteria (b) lateral and directional dynamic stability and control - approximate analysis of roll subsidence spiral mode and Dutch roll.

Learning Outcomes

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

- Determine the physical and mathematical significance of aerodynamic derivatives (L2)
- Explain the natural modes of motion of a fixed wing aircraft (L2)
- Analyze the dynamic stability of aircraft based on a state space representation of its equations of motion. (L4)
- Derive transfer functions from the state space representation and hence calculate the response of fixed wing aircraft to control inputs. (L4)

Course Outcomes

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

- Apply the knowledge of performance characteristics under various operations.
- Implement the role of primary and secondary control surface in stability of aircraft.
- Apply the knowledge of elevator lock and unlock conditions.
- Implement the concept of various maneuvering conditions and their stability.
- Characterize and explain relevant flight and handling qualities and the disturbances acting on an aircraft.

Text Book(s)

1. B. N. Pamadi, Performance, Stability, Dynamics, and Control of Airplane; 2/e, AIAA, 2004.
2. T. R. Yechout, S. L. Morris, D. E. Bossert and W. F. Hallgren, Introduction to Aircraft Flight Mechanics, AIAA, 2009.

References

1. J. D. Anderson, Aircraft Performance and Design, 1/e, McGraw Hill, 2011.
2. J. J. Bertin and R. Cummings, Aerodynamics for Engineers, 6/e, Pearson, 2013.
3. A.W. Babister, Aircraft Stability and Response, Pergamon Press, 1980.
4. R. C. Nelson, Flight Stability and Automatic Control, 2/e, McGraw Hill, 199

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO2	2	2	2	1	1	0	1	1	1	1	1	1	2	1	1
CO3	2	2	2	1	2	1	1	1	0	1	1	1	2	1	1
CO4	2	2	1	1	1	0	1	1	1	1	0	0	2	3	0
CO5	3	2	1	1	1	2	1	1	0	1	1	1	2	2	0

19EAE350: AIRPORT PLANNING AND MANAGEMENT

L T P C
3 0 0 3

Preamble:
This course is designed for Aerospace Engineering undergraduate students. This course aims at basic understanding of airport operations, planning and management.

Course Objectives:
- Impart knowledge on administration and organization of airport systems.
- Familiarize with the components of the airport such as airfield, airspace and control, terminal and ground access.
- Understand the concepts of airport security and financial management.
- Focus on the economic role that airports play within local communities.
- Describe the different types of airfield pavements and their potential failures

UNIT I **8 hours**
Airports and airport systems: An introduction, organization and administration, a historical and legislative perspective.

Learning Outcomes:
After completion of this unit the student will be able to
- Identify federal regulations and advisory circulars that influence airport operations.(l3)
- Demonstrate the ownership characteristics of airports in the United States and internationally. (l2)
- Understand the public relations issues that are associated with airport management.(l2)
- Describe the development of national administrations that have regulated civil aviation throughout its history.(l1)
- Describe the various funding programs that have existed to support airports over the course of history.(l1)

Unit ii **9 hours**
The components of the airport: the airfield, airspace and air traffic control, airport terminals and ground access.

Learning outcomes:
After completion of this unit the student will be able to
- Identify the various facilities located on an airport's airfield.(l3)
- Interpret the specifications and types of airport runways.(l2)
- Understand the importance of runway orientation.(l2)
- Identify an airport's reference code.(l3)
- Be familiar with airfield lighting, signage, and markings.(l1)
- Describe the various navigational aids that exist on airfields.(l1)

UNIT III **9 hours**
Airport Operations and Financial Management: Airport operations management under FAR 139, airport security, airport financial management

Learning Outcomes:
After completion of this unit the student will be able to

- Understand the requirements under FAR Part 139 to operate airports serving commercial air carrier operations. (L2)
- Describe the different types of airfield pavements, their potential failures, and various types of maintenance programs. (L1)
- Identify the areas of concern with respect to safety inspection programs.(L3)
- Understand the difference between O&M and capital improvement expenses.(L2)
- Be familiar with the process of airport financial accounting.(L1)
- Explain the need for liability insurance at airports.(L2)

UNIT IV **9 hours**

Airport public administration and planning: The economic, political, and social role of airports, airport system and master planning.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand the important economic role airports play within local communities.(L2)
- Examine how airport activity stimulates economic growth in a metropolitan region.(l2)
- Appreciate the complex relationships between airport management and the airlines that serve their airports.(l2)
- Define the various measures used to determine the impact of noise around airports.(l1)
- Describe various noise abatement programs employed at airports.(l1)

UNIT V **7 hours**

Future of Airport management:

Airport capacity and delay, the future of airport management.

Learning Outcomes:

After completion of this unit the student will be able to

- Define the concepts of capacity, particularly as it relates to airport activity.(l1)
- Identify the factors of the airport environment that affect capacity and delay.(l3)
- Be familiar with the various runway configurations and their rules of operation that affect capacity.(l2)
- Describe the concept of lahso, as it relates to airport capacity.(l3)
- Estimate the capacity of an airfield on the basis of faa approximation charts.(l2)

Course Outcomes:

After successful completion of this course the students will be able to:

- Gain knowledge on the development of national administrations that have regulated civil aviation throughout its history.
- Identify various components of the airport and be familiar with airfield lighting.
- Be familiar with the process of airport financial accounting
- Appreciate the complex relationships between airport management and the airlines that serve their airports
- Understand the challenges for future airport management.

Text Book(s)

1. Seth Young and Alexander T. Wells, Airport Planning and Management, 7/e, McGraw Hill, 2019.
2. P.C.K. Ravindran, Airport Management, 1/e by, Asian Law House, 2013.

Reference(s):

1. Richard de Neufville and Amedeo Odoni, Airport Systems: Planning, Design and Management, 2/e, McGraw Hill, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1		1	1	1	1	1	1	1	1	2	1	1
CO2	2	2	1		1	1	1	1	1	1	1	1	2	1	1
CO3	2	1	1		1	1		1	1	1	2	1	2	1	1
CO4	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1
CO5	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1

Program Elective - II

19EAE352: BOUNDARY LAYER THEORY

L T P C
3 0 0 3

Preamble:
This course is designed for Aerospace Engineering undergraduate students. This course aims to introduce and explain the fundamental concepts of laminar and turbulent boundary layers.

Course Objectives:
- Provide an insight into development of boundary layer in various flow situations.
- Introduce Navier-Stokes equations and some of its exact solutions.
- Familiarize governing equations of laminar and turbulent flows.
- Familiarize exact and approximate methods to solve laminar boundary layer equations.
- Acquaint the basic concepts of compressible boundary layer.

UNIT I **8 hours**

Introduction: Description of flow along a solid surface, development of boundary layer along a flat plate, different measures of boundary layer thickness, boundary layer with pressure gradient, flow separation, boundary layer at inlet of pipe, flow through diffuser, flow over symmetrical and bluff bodies, form drag, and skin friction drag, dependence of drag coefficient on Reynolds number.

Learning Outcomes
After the completion of this unit the student will be able to
- Illustrate And Describe the Development of Boundary Layers In Various Internal And External Flow Situations (L2).
- Discuss The Characteristics of Laminar, Transitional and Turbulent Boundary Layer (L2).
- Describe Different Measures of Boundary Layer Thickness (L2).
- Explain The Reason for Boundary Layer Separation (L2).
- Discuss The Effect of Pressure Gradient On The Boundary Layer (L2).
- Explain The Variation of Drag Coefficient With Reynolds Number Over Bodies Of Practical Interest Such As Flat Plate, Airfoil, Cylinder, And Sphere (L2).

UNIT II **10 hours**

Navier-Stokes Equation: Relation between stress and strain system in a solid body (Hooke's law), relation between stress and strain rate system in liquids and gases (Stokes law), Navier-Stokes equations - general properties of Navier-Stokes equation.
Exact Solution of Navier-Stokes Equation: Two-dimensional flowthrough a straight channel, Hagen-Poiseuille flow, suddenly accelerated plane wall, flow near a rotating disk, and parallel flow past a sphere.

Learning Outcomes
After the completion of this unit the student will be able to
- Explain Stoke's Hypothesis (L2).
- Write Navier-Stokes Equation (L1).
- Interpret The Physical Meaning of Various Terms In Navier-Stokes Equation (L2).
- Describe The General Properties of Navier-Stokes Equation (L2).
- Apply Navier-Stokes Equation to Analyse Various Internal And External Flows (L3).

UNIT III **12 hours**

Laminar Boundary Layer: Simplified form of boundary layer equations, Blasius solution for flat plate, thermal boundary layer over an isothermal plate, Falkner-Skan wedge flow, momentum and energy integral equations for the boundary layers, one parameter integral methods: Pohlhausen method and Thwaites method. Application of integral methods to flow past a flat plate and a circular cylinder.

Learning Outcomes

After the completion of this unit the student will be able to

- Write The Governing Equations of Mass, Momentum and Energy Within the Boundary Layer (L1).
- List The Assumptions Made in Deriving the Governing Equations of Boundary Layer (L1).
- Develop A Similarity Solution for Velocity and Thermal Boundary Layer Over a Flat Plate (L3).
- Discuss Falkner-Skan Similarity Solutions (L2).
- Write The Energy and Momentum Integral Equations of The Laminar Boundary Layer (L1).
- Compare Exact and Approximate Solutions In Case Of A Flat Plate And Cylinder (L2).
- Estimate Boundary Layer Thickness, Skin Friction and Heat Transfer Rates Given Appropriate Information (L3).

UNIT IV **10 hours**

Turbulent Boundary Layer: Two-dimensional turbulent boundary layer equations, eddy viscosity, integral relations, turbulent boundary layer on a flat plate, velocity profiles: law of the wall, logarithmic law and law of the wake, turbulent flow in pipes and channels.

Learning Outcomes

After the completion of this unit the student will be able to

- Explain The Concept Of Reynolds Decomposition (L2).
- Write Reynolds Averaged Equations Of Motion (L1).
- Explain The Physical Meaning Of Different Terms In Reynolds Averaged Equations (L2).
- Modify Reynolds Averaged Equations To Obtain Boundary Layer Equations (L3).
- Discuss Differences Between Laminar And Turbulent Boundary Layer Equations (L2).
- Explain Why The Average Product Of Velocity Fluctuations Is Not Zero (L2).
- Explain The Concept Of Eddy Viscosity (L2).
- Compare The Integral Relations Of Laminar And Turbulent Boundary Layer (L2).
- Classify And Explain The Characteristics Of Different Regions In Turbulent Boundary Layer (L2).
- Compare The Turbulent Velocity Profiles In Pipes, Channels And Flat Plate (L2).
- Estimate Skin Friction Given Appropriate Information (L3).

UNIT V **6 hours**

Compressible Boundary Layer: Compressible boundary layer equation, recovery factor, similarity solutions, laminar supersonic cone rule and shock-boundary layer interaction.

Learning Outcomes

After the completion of this unit the student will be able to

- Discuss Differences Between Governing Equations Of Incompressible And Compressible Laminar Boundary Layer (L2).
- Write And Explain Crocco Busemann Relations (L1).
- Develop Similarity Solution For Compressible Laminar Flow Using Illingworth Transformation For A Flat Plate And Stagnation Point Flow (L3).
- Describe Supersonic Cone Rule For Laminar Compressible Flow (L2).

- Discuss Interaction Of Shock Waves With A Laminar Boundary Layer On A Flat Plate (L2).

Course Outcomes:

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

- Illustrate And Explain The Development Of Boundary Layers In Various Flow Situations.
- Apply Navier-Stokes Equation To Analyze Various Internal And External Flow Problems.
- Develop Similarity Solutions For Velocity And Thermal Boundary Layer Over A Flat Plate And Also Apply Integral Methods.
- Explain The Differences Between The Governing Equations Of Laminar And Turbulent Boundary Layers And Also Compare The Velocity Profiles In Pipes, Channel And Flat Plate In These Flows.
- Explain The Differences Between The Governing Equation Of Compressible And Incompressible Boundary Layer And The Interaction Of A Shock Wave With The Boundary Layer.

Text Book(s)

1. H. Schlichting, Boundary Layer Theory, 7/e., McGraw-Hill, 1979.
2. F. M. White, Viscous Fluid Flow, 2/e, McGraw Hill, New York, 1991.

References

1. A. J. Reynolds, Turbulent Flows in Engineering, John Wiley, 1980.
2. R. L. Panton., Incompressible Flow, John Wiley, 1984.
3. L. Rosenhead., Laminar boundary layers, Dover Publications, 1963.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1

19EAE354: AEROSPACE PROPULSION

L	T	P	C
3	0	0	3

Preamble

This course intends to train students on aspects connected to power plants that are used in rockets and missiles. It focuses mainly on the design of the rocket and thrust chamber. It also projects different aspects connected with fuels, fuel systems and nozzle aerodynamics. Course find appealing and enhances interest on rocket power plant engineering

Course Objectives:

- Explain principles of the several types of rocket power plants.
- Impart knowledge on performance evaluation of different types of rocket engines.
- Familiarize concepts of turbo pump, feed systems, nozzle and thrust chamber.
- Facilitate basic design of different typical rocket engines.
- Provide exposure to a variety of fuels used across different rocket engines.

UNIT I **8 hours**

Elements of Rocket Propulsion: Introduction to rocketry, classification and applications of rocket propulsion, Newton laws, rocket equation for gravity and drag free condition, vehicle velocity, mass ratio, mass fraction. Orbits, velocities, and space flight. Multi-staging of rocket and strap on boosters. Exhaust velocity, thrust at sea level and vacuum, energy and efficiency, total impulse, specific impulse, effect of propulsion system on vehicle performance.

Learning Outcomes

At the end of chapter student will be able to

- obtain basic understanding on principles of rocketry(L2)
- study and analysis the performance of various rockets(L3)
- show knowledge of orbits, launching of rockets, and related velocities(L4)
- exhibit skills of launch vehicle trajectory design and dynamics(L4)
- optimize payload design and vehicle mass distribution(L4)

UNIT II **9 hours**

Launch vehicle dynamics: Earth rotation and significance of Launch trajectory, Vertical and inclined motion under drag free earth's gravity field.

Rocket Nozzle dynamics: Aerothermodynamics of nozzle, review of thermodynamic relations, mass flow rate, Isentropic flow through nozzle and different types of expansions, design parameters. Performance measures of chemical rocket nozzle - thrust coefficient, specific impulse, engine parameters, thrust chamber pressure, temperature, characteristic and jet exhaust velocity. Nozzle configuration: Cone and bell-shaped nozzles. Nozzle alignment

Learning Outcomes

At the end of chapter student will be able to

- understand significance of inclined rocket motion under influence of earth's gravity(L2)
- exercise strong command on various parameters guiding nozzle thrust(L4)
- distinguish working of nozzle for various expansions (L4
- attempt the design and detailing of rocket nozzle(L4)
- characterize performance of typical rocket nozzle (L5)

UNIT III **9 hours**

Solid Propellant Rocket Motor: Rocket motor and components, applications, classification of motors, **propellant burning rate**-effect of temperature, pressure and burn rate modifiers, erosive burning, basic performance relations. **Grain** - propellant grain and grain configurations, grain stress and strain. **Propellants:** Solid propellants, classification, propellant characteristic, propellant ingredients and hazards. **Other propellants** - gas generator, smoke, smokeless and igniter propellants

Learning Outcomes

At the end of chapter student will be able to

- appreciate working of solid rocket motor(L2)
- understand combustion of grain and sensitivity associated ballistics (L1)
- analyze suitability of propellant pertaining to a mission(L4)
- gain knowledge on different types of rocket motors, solid propellants and grain design(L2)
- study the working of Solid propellant combustor (L3)

UNIT IV **10 hours**

Liquid Rocket Engines: Liquid rocket engines, propellants, **propellant feed systems** – gas and pressure feed, propellant tanks, tank pressurization, flow and pressure balance, **Liquid engines** – RCS & OMS. **Propellants:** Propellant properties, liquid oxidizers, liquid fuels, monopropellants, gaseous propellants, **Thrust chamber:** Injector, combustion chamber, and Combustion of liquid propellants.

Learning Outcomes

At the end of chapter student will be able to

- differentiate the working of solid and liquid rocket engines(L5)
- exhibit strong knowledge on various liquid engines and different fuels used(L3)
- exercise choice of feed systems, propellants, and structural materials suiting to specific need(L4)
- gain knowledge on combinations and combustion of various liquid propellants(L2)
- assess the significance of different subsystems of thrusters(L6)

UNIT V **12 hours**

Combustion Instabilities: Introduction to instabilities, Modes of instabilities, bulk mode in liquid engines and solid rockets motors, constant, increasing, and decaying amplitude, suppression and control of instability.

Electric propulsion systems: Electro-thermal: resisto jet and arc jet, magneto plasma dynamic (MPD) electric thruster, Electro-static types of Ion, hall, field emission thrusters

Learning Outcomes

At the end of chapter student will be able to

- gain basic understanding of causes for combustion related vibrations(L2)
- exhibit the knowledge of various combustion instabilities(L4)
- assess systems ability to control and suppress the instability (L6)
- show strong understanding on using electric energy source for thrusting devices(L4)
- appreciate the beauty and significance of these advanced electric propulsion concepts (L2)

Course Outcomes

At the end of course student will be able to

- Develops knowledge on working of rockets, missiles and space crafts (L6)
- Exhibit desire to design and develop solid motor rockets systems(L4)
- Exercises better choice across different engines and propellants(L3)
- Understand, interpret and assess the performance of different rocket systems combustion instabilities(L2)
- Appreciate the availability and usage of alternate advanced propulsion concepts(L5)

Text Book(s)

1. G. P. Sutton and D. M. Ross, Rocket Propulsion Elements, 8/e, John Wiley, 2010.
2. M. J. L. Turner, Rocket and Spacecraft Propulsion, 3/e, Springer Praxis, 2008

References

1. H. S. Mukunda, Understanding Aerospace Chemical Propulsion, 1/e, Interline Publishing, 2004.
2. K. Ramamurthi, Rocket Propulsion, 2/e, Mach Millan, 2012.
3. H. G. Ang, P. Sreekumar, High Energetic Polymers, 1/e, Wiley, 2011.
4. Champak Jyoti Bora, Fundamentals of Rocket and Spacecraft Propulsion, 1/e, Lulu Publications, 2014.
5. Kubota, Propellants and Explosives: Thermo Chemical Aspects of combustion, 2/e, Wiley, 2008

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	2	1	1	1	2	1	2	2	1
CO2	2	1	3	2	1	2	2	1	2	1	1	1	2	2	1
CO3	2	2	2	1	1	2	1	1	1	1	2	1	2	1	1
CO4	2	2	1	1	1	1	2	1	2	1	2	1	2	1	1
CO5	2	1	1	1	1	2	2	1	1	1	1	1	1	1	1

19EAE356 Vibrations and Acoustics

L	T	P	C
3	0	0	3

Preamble

This course is designed for aerospace engineering students. It introduces the fundamentals of vibration and acoustics. This course is designed to acquaint the learners with vibration theory involved in the mechanical system, dynamic behavior of the system and sound and wave propagation.

Course Objectives:

- To impart the fundamental concepts of vibration theory and dynamic modeling methods
- To acquaint to mathematically model real-world mechanical vibration problems
- To assess fluctuations and acoustic processes in nature in different forms.
- To understand the role of damping, stiffness and inertia in mechanical systems.
- Develops methods and understanding of analyzing vibrations in mechanical systems, which are closely related to acoustics engineering problems.

UNIT I **8 hours**

Free Vibration of Single Degree of Freedom Systems: Introduction, free vibration of an undamped translational system, free vibration of an undamped torsional system, stability conditions, Rayleigh's energy method, free vibration with viscous damping, Coulomb damping and hysteretic damping.

Learning Outcomes

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

- Describe the causes and effects of vibration in mechanical systems (L3)
- Understand the different types of vibration (L2)
- Develop schematic models for physical systems and formulate governing equations of motion (L6)

UNIT II **9 hours**

Harmonically Excited Vibrations: Introduction, equations of motion, response of undamped and damped systems under harmonic excitation, harmonic motion of the base and rotating unbalance.

Two Degree of Freedom System: Equations of motion for forced vibration, free vibration analysis of an undamped system, torsional system.

Learning Outcomes

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

- Analyze rotating and reciprocating systems and compute critical speeds. (l4)
- Apply newton's equation of motion and energy methods to model free and harmonically forced vibrations.(l3)

UNIT III **10 hours**

Multi Degree of Freedom Systems: Introduction, modeling of continuous systems as multi degree of freedom systems, Newton's second law to derive equations of motion, influence coefficients, generalized coordinates and generalized forces, Lagrange's equation to derive the equation of motion, Eigenvalue problem and solution.

Determination of Natural Frequencies and Mode Shapes: Introduction, Dunkerley's formula, Rayleigh's method.

Learning Outcomes

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

- Develop single- and multi-degree of freedom systems (L6)

- Perform and verify computer simulations employing time integration and modal analysis of discrete vibrating systems (L5)
- Determine the natural frequency and mode shapes of a given system (L4)

UNIT IV **8 hours**

Introduction to Acoustics: Introduction, derivation of the wave equation, traveling wave solutions, acoustic energy corollary, impedance and admittance, standing wave solutions.

Learning Outcomes

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

- Assess fluctuations and acoustic processes in nature in different forms (L5)
- Provide examples of variations and acoustic objects (L3)
- Analyze sound propagation and reflections in space (L4)

UNIT V **8 hours**

Propagation and Noise Reduction: Effect of area and temperature variation on wave propagation, wave equation in cylindrical coordinates and its applications, Rayleigh's criteria, noise reduction techniques.

Learning Outcomes

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

- Analyze sound propagation and reflections in space (L4)
- Understand the fluctuations in the interaction with acoustic audio distribution systems(L2)
- Evaluate different acoustic system designs and formulate the design of acoustic targets(L5)

Course Outcomes:

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

- Understand complex system behavior including interactions between components and with other systems.
- Develop schematic models for physical systems and formulate governing equations of motion
- Analyze rotating and reciprocating systems and compute critical speeds
- Develop models using appropriate tools such as computer software, laboratory equipment and other devices.
- Evaluate different acoustic system designs and formulate the design of acoustic targets.

Text Book(s)

1. S. S. Rao, Mechanical Vibrations, 4/e, Pearson Education Inc., 2009.
2. F. Fahy and P. Gardonio, Sound and Structural Vibration: Radiation, Transmission and Response, 2/e, 2007.

Reference

1. L. Meirovich, Elements of Vibration Analysis, 2/e, Tata McGraw Hill 2007.
2. L. E. Kinsler, A. R. Frey, A. B. Coppens and J. V. Sanders, Fundamentals of Acoustics, 4/e, Wiley, 2000.
3. L. Cremer, M. Heckl and B. A. T. Peterson, Structure Borne Sound, 3/e, Springer-Verlag, 2005
4. G. K. Grover, Mechanical Vibrations, 8/e, NemChand and Brothers, 2009

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	2	1	1	1	1	1	1	3	1	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	2	1	1
CO3	2	2	1	1	1	1	1	1	1	1	1	1	2	1	1
CO4	2	2	1	1	1	1	1	1	1	1	1	1	2	1	0
CO5	2	2	1	1	1	1	1	1	1	1	1	1	2	1	0

19EAE358: GUIDANCE AND CONTROL

L	T	P	C
3	0	0	3

Preamble:

This course work is designed specifically for the undergraduate students of Aerospace Engineering . It introduces aircraft guidance and control.

Course Objectives: To make the student to:

- Aware of the concept of navigation systems.
- Understand the operating principle of guidance law.
- Explore various augmentation systems.
- Study the concepts of longitudinal stability and lateral stability.
- Understand the mission requirements and its guidance.

UNIT I **6 hours**

Introduction: Introduction to navigation, guidance and control- mission requirements - definition and historical background.

Learning Outcomes

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

- Obtain the knowledge and overview of navigation, guidance and control. (l2)
- Understand the criteria for the navigation and control systems (l4)
- Know the flights control and management systems(l2)

UNIT II **10 hours**

Missile and Launch Vehicle Guidance: Operating principles and design of guidance laws, homing guidance laws - short range, medium range and beyond visual range missiles, launch vehicle implicit guidance schemes, explicit guidance, Q- guidance of missile.

Learning Outcomes

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

- Achieve deep knowledge of missile and launch vehicle guidance(l2)
- Possess knowledge of homing guiding laws and ranges.(l4)
- Understand the mission requirements and implicit schemes.(l4)

UNIT -III **6 hours**

Augmentation Systems: Need for automatic flight control systems, stability augmentation systems, control augmentation systems, gain scheduling concepts.

Learning Outcomes

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

- Achieve deep knowledge of flight augmentation systems and solutions for raised problems in flight control systems.(l2)
- Possess knowledge of aircraft stability augmentation systems, working mechanism and components (l4)
- Apply and understand gain scheduling concepts. (l5)

UNIT IV **10 hours**

Longitudinal Autopilot: 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 backstepping algorithm.

Learning Outcomes

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

- Have knowledge of various longitudinal autopilot and control systems .(l2)
- Understand the role of automatic flare control and flight path stabilization.(l3)
- Illustrate the requirements of air distribution systems, cabin pressurization systems (l2)

UNIT V **10 hours**

Lateral Autopilot: 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 backstepping algorithms.

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

- Understand the roles of lateral autopilot (l2)
- Have knowledge of various flight control systems.(l3)
- Understanding of stepping algorithms for lateral auto pilot.(l4)

Course Outcomes:

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

- Apply the principle of stability to various control augmentation systems
- Design the guidance laws for short, medium and long range missiles.
- Implement the application of back stepping algorithms in longitudinal and lateral control law design.
- Apply the algorithm for longitudinal and lateral autopilot.
- Learn the significance of fly-by-wire flight control systems using back step algorithms.

Text Book(s)

1. J. H. Blakelock, Automatic Control of Aircraft and Missiles, John Wiley, 1990.
2. B. L Stevens and F. L. Lewis, Aircraft Control and Simulation, John Wiley, 1992.

References

1. R. P. G. Collinson, Introduction to Avionics, Chapman and Hall, 1996.
2. P. Garnel and D. J. East, Guided Weapon Control Systems, Pergamon Press, 1977.
3. B. Etkin, Dynamics of Flight Stability and Control, John Wiley, 1972.
4. J. Strickland, Missile Flight Simulation, Lulu Inc, 2012.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO1	1	2	3	1	1	1	1	1	1	1	2	1	1	1	1
CO2	2	2	2	2	1	1	1	1	1	1	2	1	2	1	1
CO3	2	2	3	3	1	1	1	1	1	1	2	1	2	1	1
CO4	2	2	2	2	1	1	1	1	1	1	2	1	2	1	1
CO5	1	2	3	2	1	1	1	1	1	1	2	1	1	1	1

19EAE360: AIRCRAFT SYSTEMS AND INSTRUMENTS

L	T	P	C
3	0	0	3

Preamble: This course work is designed specifically for the undergraduate students of Aerospace Engineering as an elective. This course work is mainly aimed for the students, who are very interested in obtaining the knowledge of instrumentation and system components of the Aircraft. In the view of the outline, this course will provide knowledge to the students in the areas of control surfaces, Engine and fuel systems, Hydraulic and Pneumatic systems, Environmental Control Systems and Aircraft Instruments of flying machines.

Course Objectives:

- Introduction to various aircraft systems, integration and overview of the functions of the same.
- To impart knowledge of the hydraulic and pneumatic systems components
- To obtain knowledge of aircraft system and instrumentation's failures and analysis.

UNIT I **8 hours**

FLIGHT CONTROL SYSTEMS

Principles of flight control, flight control surfaces, flight control linkage systems, trim and feel, flight control actuation, fly by wire system, Airbus and Boeing implementations, interrelationship of flight control, guidance and vehicle management systems.

Learning Outcomes

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

- Obtain the knowledge and over view of flight instruments and components (l2)
- Understand the industrial design criteria for the flying machines (l4)
- Know the flights control and management systems(l2)

UNITII **10 hours**

ENGINE CONTROL AND FUEL SYSTEMS

Engine control problem, fuel flow control, air flow control, control system parameters, engine starting and ignition systems, lubricating systems for aircraft piston and jet/propeller engines.

Fuel systems: Characteristics of aircraft fuel systems, fuel systems components, fuel transfer pumps, fuel booster pumps, fuel transfer valves, and fuel quantity measurement systems - float type, capacitance type, fuel gauging probes, fuel system operating modes.

Learning Outcomes

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

- Achieve deep knowledge of flight power plant systems and solutions for raised problems in the same (l2)
- Possess knowledge of aircraft fuels systems, working mechanism and components (l4)
- Debug and cross checking in various components of power plant (l5)

UNITIII **10 hours**

HYDRAULIC & PNEUMATIC SYSTEMS

Hydraulic systems: Hydraulic circuit design, hydraulic actuation, hydraulic fluid, hydraulic pumps. Types of hydraulic systems, landing gear systems - retraction, steering, braking and anti skid **Pneumatic systems**: Basic working principle of pneumatic systems, pneumatic power system - components, use of pneumatic power in aircraft, sources of pneumatic power, the engine bleed air, engine bleed air control, uses of pneumatic power, wing and engine anti-ice, engine start, thrust reversers, hydraulic system, Pitot - static systems.

Learning Outcomes

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

- Know the definition and applications of hydraulic and pneumatic systems which are used in flying machines (l2)
- Acquire knowledge of various hydraulic systems and maintenance systems of the same (l2, l3)
- Exhibit knowledge on various pneumatic systems and uses of pneumatic power in flights controls (l2, l3)

UNIT IV **9 hours**

ENVIRONMENTAL CONTROL SYSTEMS

The need for a controlled environment in aircraft, Refrigeration systems - vapour cycle systems, boost - strap air cycle system, humidity control, aircraft anti-icing and de-icing systems, air distribution systems, cabin pressurization, g-tolerance, rain dispersal, anti-misting and demisting.

Learning Outcomes

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

- Have knowledge of various environmental conditions for flights, cycles and cooling systems (l2)
- Understand the role of humidity control, aircraft anti-icing and de-icing systems of aircrafts.(l3, l4)
- Illustrate the requirements of air distribution systems, cabin pressurization systems (l2)

UNITV **8 hours**

AIRCRAFT INSTRUMENTS

Flight instruments and navigation instruments, gyroscope, accelerometers, air speed indicators – TAS and EAS; Machmeters, altimeters, principles and operation, study of various types of engine instruments, tachometers, temperature gauges, pressure gauges – operation and principles.

Learning Outcomes

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

- Understand the roles of flight instruments and navigation instruments (l2)
- Have knowledge of various components of flights for navigation applications (l2, l3)
- Clear explanation of aircraft maintenance instruments and principal operations (l3, l4)

Course Outcomes

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

- Develop a mind set to implement instrumentation requirements and describe instrumentation elements, mechanism, error sources. (l3)
- Understand the aircraft classical and state of art control systems, engine control system fuel systems and its components for both civil and military aircrafts.(l2)
- Learn the significance of hydraulic system; pneumatic systems and emergency power sources used in aircraft.(l3)
- Increase the understanding of electrical systems (both a.c and d.c) utilizing as an auxiliary power sources in aircrafts. (l2)
- Develop effective skills for the operation of flight instruments incorporating gyroscopes, basic flight indicators, sensors and its operating principles. (l2)

Text Book(s)

1. A. Seabridge, I. Moir, Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, 2/e, John Wiley and Sons, 2008.
2. E. H. J. Pallett, Aircraft Instruments and Integrated Systems, 1/e, Pearson Education, 1992.
3. Mekinley, J.L. and R.D. Bent, "Aircraft Power Plants", McGraw Hill 1993

Reference Books

1. Moir, I. and Seabridge, A., Design and development of aircraft systems-an introduction, AIAA education series, AIAA,2004.
2. Aircraft systems by David A Lambro tata Mc Graw Hill. Ed;2009.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	2	1	1	1	1	1	1	1	2	1	1	1	1
CO2	1	2	2	2	1	1	1	1	1	1	2	1	1	1	1
CO3	2	2	3	3	1	1	1	1	1	1	3	1	2	1	1
CO4	2	2	2	2	1	1	1	1	1	1	2	1	2	1	1
CO5	2	1	3	1	1	1	1	1	1	1	2	1	2	1	1

19EAE392: COMPREHENSIVE SKILL DEVELOPMENT V

L T P A C
0 0 0 4 1

Course Objectives:

- To encourage the all-round development of students by focusing on soft skills, Coding & domain skills.
- To make the engineering students aware of the importance, the role and the content of soft skills, Coding and domain skills through instruction, knowledge acquisition, demonstration and practice.
- To develop and nurture the soft skills, coding and domain skills of the students through individual and group activities.
- To expose students to right attitudinal and behavioral aspects and to build the same through activities

Course Outcomes:

- On completion of the course, student will be able to– Effectively communicate through verbal/oral communication and improve the listening skills
- Write precise briefs or reports and technical documents, actively participate in group discussion / meetings / interviews and prepare & deliver presentations. Become a more effective individual through goal/target setting, self-motivation and practicing creative thinking.
- Students will be able to understand the problems and develop their competitive coding skills.
- Apply the skills in various domains and will be able to solve complex problems faced by the industry.
- Function effectively in multi-disciplinary and heterogeneous teams through the knowledge of team work, Inter-personal relationships, conflict management and leadership quality

Part-1 **- 2 Hours per week**

A. Verbal and Soft Skills:

Unit	Module/ Topics	Hrs
1.	Resume Writing & Acing Job Interviews	4
2.	Corporate Readiness 1	3
3.	Mock Tests with Solutions 1	5
4.	Company-Specific Tests with Solutions 1	3
	Total	**15**

B. Quantitative Aptitude and Reasoning

Unit	Module/ Topics	Hrs
1.	Combinatorics	4
2.	Crypt arithmetic & Modular Arithmetic	5
3.	Analogy & Classification of Numbers	3
4.	Puzzles	3
	Total	15

Unit	Module/ Topics	Hrs
1.	GRE-Oriented Advanced Concepts Discussion	4
2.	CAT-Oriented Advanced Concepts	4
3.	TCS, Infosys-Oriented Advanced Concepts	4
4.	Successful Test Cracking Techniques	3
	Total	15

Part-2 Domain Skills **-2 Hours per week**

Aerodynamics & CFD

- CFD using (coding & ANSYS) (case studies)
- Train the students on the concepts of domain discretization, equations discretization, grid generation and its types.
- Case -studies (Simulating 3D flow problems)
- Wind Tunnel Activities (Studies on building of a model, experimentation, and instrumentation)

Propulsion:

- Design and testing of a liquid rocket injector.
- Design and development of a gas turbine combustor.
- Design and development of compressors.
- Hand on training on CFX.

Flight Mechanics and Control:

- Hands on training on flight Simulation software
- Design and development of a table-top flight simulator.

Structures:

- Fabrication of composite laminates using hand lay-up and other methods.
- Applications of FEA's (using ANSYS)

Aircraft Design Practice:

- Design and fabrication of NACA Airfoils, Wings, Fuselage.
- Design and development of UAV's and MAV's
- Design and fabrication of a typical flight vehicle (using software, 3D printing)

Satellite Making:

- Orbital design using GMAT software.
- Estimation of Propulsion system
- Designing a satellite.

References:

1. https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules
2. https://confluence.cornell.edu/display/SIMULATION/ANSYS+Learning+Modules
3. https://aeromodellingtutor.in/

VII Semester

19EAE401: FLIGHT VEHICLE DESIGN

L	T	P	C
2	0	2	3

Preamble:

This course is designed for aerospace engineering students. It introduces the basic principles of aircraft design practice.

Course Objectives:

- Familiarize students with the important issues and methodologies of aircraft design.
- Instruct the process of aircraft synthesis as an outcome of the integration of the disciplines of aerodynamics, performance, stability and control, propulsion, structures and aero elasticity.
- Provide the ability to function as a member of a team in a design setting; including the ability to conduct a peer review of the other team members.
- Impart the students with Federal Aviation Regulations as a means for ensuring passenger safety.
- Explain, enhance and develop technical design skills.

UNIT I **7 hours**

Design Preliminaries: Aircraft design requirements, specifications, and role of users, aerodynamic and structural consideration, and importance of weight. Classification of airplanes, special features of modern airplane, air loads in flight.

Learning Outcomes

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

- Complete conceptual design of different types of aircraft. (l2)
- Choose the required decisions during the total design cycle of an aircraft including conceptual, preliminary and detail design. (l2)
- Discuss performance and stability analysis of different types of aircraft. (l3)

UNIT II **7 hours**

Airplane Weight Estimation: Weight estimation based on type of airplane, trends in wing loading, weight-estimation based on mission requirements, iterative approach. Basics of wing design: selection of airfoil selection, influencing factors.

Learning Outcomes

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

- Explain the hierarchical models in aircraft design as a multi-disciplinary design objective and utilize a system approach to design and operational performance; (l2)
- Discuss the design phases of an aircraft; (l2)
- Calculate total weight and weight fractures of an aircraft(l3)
- Understand the wing design and calculations. (l3)

UNIT III **8hours**

Fuselage and Empennage design: Volume considerations, aerodynamic considerations, drag estimation, spread sheet for fuselage design. Horizontal and vertical tail design: tail arrangement, horizontal and vertical tail sizing, tail plan form shape, airfoil section type, tail placement, spread sheet for tail design.

Learning Outcomes

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

- Evaluate sensitivity analysis of design parameters (l2)
- Perform and understand sizing of an aircraft(l3)
- Explain layout design of different aircraft (l2)

UNIT IV **7 hours**

Landing Gears: Different kinds of landing gears and associate darrangement for civil and military airplanes. Preliminary calculations for locating main and nose landing gears, landing gear arrangements, tire sizing, shock absorbers, castoring, wheel geometry, gear-retraction geometry, seaplanes and subsystems. Landing gear design and integration.

Learning Outcomes

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

- Preliminary calculations for position and location of landing gear (l2)
- Landing gear sizing and disposition (l2)
- Sizing to takeoff distance requirements (l4)
- Sizing to landing distance requirements (l3)
- Geometry of landing gear system or wheel geometry(l4)

UNIT V **6 hours**

Engine selection

Propulsion selection, number of engines, Engine ratings, turbojet engine sizing, propulsion system.

Learning Outcomes

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

- Understand fundamentals of aircraft engine configuration selection. (l3)
- Know how to choose engine/s and locate them. (l3)
- Understand the propulsion design system. (l2)

Course Outcomes:

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

- Explain the design requirements for an aircraft based on fundamental principles and statistical data.
- Evaluate the design specifications and discuss an aircraft design to meet the necessary requirements
- Apply engineering knowledge and applied skills to a design problem
- Analyze design issues considering aerodynamics, propulsion, structure, weights, stability, cost, and performance
- Design to a specified mission and generate a layout.

List of Experiments:

1. Comparative configuration study of different types of airplanes
2. Comparative study on specification and performance details of aircraft
3. Preliminary weight estimations, selection of main parameters,
4. Power plant selection, aerofoil selection, wing tail and control surfaces
5. Preparation of layouts of balance diagram and three view drawings
6. Aircraft conceptual sketch and its gross weight estimation algorithm
7. V- n diagram for the design study
8. Gust and maneuverability envelopes
9. Preliminary weight estimation (rubber sizing)
10. Load or induced drag estimation
11. Airfoil and geometry selection, determination of thrust to weight ratio, wing loading.
12. Balancing and maneuvering loads on tail plane, aileron and rudder loads.

Text Book(s)

1. D. P. Raymer, Aircraft Design: A conceptual approach, 5/e, AIAA 2013.
2. T. D. Stinton, The Design of Airplane, 2/e, AIAA, 2001.
3. J. D. Anderson,, Airplane Performance and Design, International Edition, Tata McGraw Hill, 1999.

References

1. L. M. Nicolai, G. E. Carichner, Fundamentals of Aircraft and Airship Design, AIAA Education Series, 2010.
2. J. Bertin, Aerodynamics for Engineers, 4/e, Pearson Education, 2002.
3. E. E. Scheler and L.G. Dunn, Airplane Structural Analysis and Design, John Wiley and Sons, 1963.

CO-PO-Mapping (Program Specific Outcomes (PSO's):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	3	1	1	1	1	1	1	1	1	1	3	1	1
CO2	2	2	2	2	1	1	1	1	1	1	1	1	2	1	1
CO3	3	1	2	2	1	1	1	1	1	1	1	1	3	1	1
CO4	2	2	2	2	1	1	1	1	1	1	1	1	2	1	1

CO5	2	1	2	1	1	1	1	1	2	1	1	1	2	1	1

19EHS405: OPERATIONS RESEARCH

L	T	P	C
3	0	0	3

Preamble:

This course is to aid decision making and improve efficiency of the system by applying advanced analytical methods. This course addresses a number of quantitative tools and techniques, and providing students with knowledge and skills needed to apply these tools and techniques for decision making in organizations.

Course Objectives:

- To introduce the basics of Operations research, formulation and solution of Linear Programming Problems using different methods
- To learn Formulation and solve problems of optimization problems in transportation and assignment of jobs.
- To explore different queuing
- to arrive at the optimal business strategy for a given situation.
- Introduce basic inventory models to optimize inventory costs and Project scheduling techniques – CPM & PERT models and sequencing techniques for optimal schedule of jobs on machines
- Impart Knowledge on replacement policies for estimation of economic life of equipment and the concept of game theory for optimum time and costs

UNIT I **10 hours**

Basics of Operations Research: History, definition, operations research models, phases of implementing operations research in practice.
Linear Programming: Introduction, formulation, graphical solution, simplex method, artificial variable techniques – Big M and two-phase methods, duality principle, dual simplex method.

Learning Outcomes:

After completion of unit, the students will be able to:

- Recognize the significance of Operations Research and mathematical modeling while analyzing the practical problems in industry (L1)
- Formulate the various linear Programming Models (L5)
- Evaluate the optimal solution to simple linear programming problems (L6)

UNIT II **8 hours**

Transportation Model: Formulation, initial feasible solution, optimal solution – MODI method, unbalanced transportation problems, degeneracy in transportation problems.
Assignment Model: Formulation, optimal solution, Hungarian method, traveling salesman problem.

Learning Outcomes:

After completion of unit, the students will be able to:

- Formulate the linear programming problem as a Transportation model (L5)
- Formulate the linear programming problem as an Assignment model (L5)
- Evaluate the optimal solution to Transportation Problems (L6)
- Evaluate the optimal solution to Assignment Problems (L6)

UNIT III **8 hours**

Queuing Models: Introduction, Kendall's notation, classification of queuing models, single server and multi-server models, Poisson arrival, exponential service, infinite population
Sequencing Models: Introduction, assumptions, processing n-jobs through two machines, n-jobs

through three machines, n-jobs through m-machines, and graphic solution for processing 2 jobs through n machines with different order of sequence.

Learning Outcomes:

After completion of unit, the students will be able to:

- Define the various queuing models (L1)
- Calculate Queue length & waiting time of a given queue system (L6)
- Evaluate the optimal sequence of the jobs on machines for minimum cycle time (L6)

UNIT IV **9 hours**

Replacement Models: Introduction, replacement of items that deteriorate with time - value of money unchanging and changing, simple probabilistic model for replacement of items that fail completely.
Game Theory: Introduction, game with pure strategies, game with mixed strategies, dominance principle, graphical method for 2xn and mx2 games, linear programming approach for game theory.

Learning Outcomes:

After completion of unit, the students will be able to:

- Analyze the replacement and maintenance costs of items under various replacement policies(L4)
- Evaluate the optimal replacement policy of items(L6)
- Analyze the players' strategies and thereby Evaluate optimal business strategies for the players (L4&L6)

UNIT V **9 hours**

Inventory Models: Introduction, inventory costs, Economic Order Quantity (EOQ) and Economic Batch Quantity (EBQ) models with and without shortages, inventory models with quantity discounts
Project Management: Introduction, phases of project management, network construction, numbering the events-Fulkerson's rule, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT)

Learning Outcomes:

After completion of unit, the students will be able to:

- Recognize the significance of Inventory models & Project Management in real world industrial scenarios (L1)
- Differentiate between the critical and non-critical activities of a given project (L4)
- Propose the optimal schedule of the activities involved in a project (L5)
- Evaluate the optimal order/batch quantity for minimum inventory cost (L6)

Course Outcomes:

After successful completion of this course, the students will be able to

- Recognize the scope of operations Research and develop the mathematical models for practical problems in industry so as to suggest the optimal resource allocation
- Formulate and solve transportation & assignment models for optimum resources
- Analyze the Queue system to Predict the Queue length & waiting time ; to propose the optimal sequence of performing jobs on machines for minimum cycle time
- Evaluate the best replacement policy of the equipment; to analyze the strategic interaction between rational decision-makers
- Design the inventory systems to minimize the costs; to plan and schedule the activities involved in a project

Text Books:

1. Gupta P K. & Hira D.S., Operation Research, 6/e, S Chand Publishers, 2006.
2. Paneerselvam R., Operations Research, 2/e Prentice Hall of India, 2010.

19EAE421: FINITE ELEMENT ANALYSIS AND COMPUTATIONAL FLUID DYNAMICS LAB

L	T	P	C
0	0	3	2

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students for the numerical simulation of fluid flows and to familiarize them about the use of the basic finite elements for structural applications using truss, beam, frame, and plane elements.

Course Objectives:

- To acquaint the student about the commercial Finite Element package ANSYS to build Finite Element models and solve a selected range of engineering problems.
- To familiarize them about the use of the basic finite elements for structural applications using truss, beam, frame, and plane elements.
- To access the computer program based on finite element method and model multi-dimensional heat transfer problems using ANSYS classical
- Train on the usage of CFD and FEA commercial packages.
- Impart the knowledge on code development for solving the governing equations of fluid flows and heat transfer.
- Analyze the CFD simulation output and compare with theoretical and experimental fluid dynamics results.

List of Experiments:

1. Introduction to anyone one of the suitable software employed in modeling and simulation of aerodynamic and structural problems
2. Numerical Solution for the following equations using finite difference and finite volume method (Code development).
   a. 1-D and 2-D Linear Convection equations using Lax – Fredrich and Lax Wendroff Techniques
   b. 1-D and 2-D Burger's Equations using Lax-Fredrich and Lax Wendroff Techniques
   c. One dimensional heat conduction equation using explicit and implicit methods.
3. Numerical Simulation of the following flow problems using commercial packages:
   a. Simulation of flow through a Converging - Diverging nozzle
   b. Simulation of Supersonic flow over a flat plate and a wedge
   c. Simulation of Boundary Layer over a Flat plate
   d. Grid Generation of Aerofoil NACA 0012
   e. Simulation of laminar flow through pipe
4. Analysis using 1-D element
   a. Stepped bar under axial load.
   b. Truss with transverse loads and thermal loads.
5. Analysis using plane stress: Stress concentration in rectangular plate with a hole
   a. With full geometry
   b. Half geometry
   c. Symmetric boundary condition with 16, 64, 256 elements and study of convergence
6. Axi-symmetric element
   a. Thick cylinder subjected to internal pressure.
7. Beams:
   a. Cantilever with concentrated loads, UDL with 16, 64,256 elements
      i. Cantilever with roller support at free end, uniformly distributed load.
      ii. Propped cantilever with uniformly distributed load

b. Simply supported beam
   i. Concentrated load, uniformly distributed load with 16, 64,256 elements
   ii. Simply supported beam with inverted L (Γ) bracket at the centre concentrated load at the tip of inverted L (Γ) bracket.

8. Natural frequency in a string fixed at the end.

List of Equipment/ Software Required:

- Internal server (or) Work station.
- Computers
- Modeling packages – ANSYS academic version
- Programming language – Matlab, Scilab

Course Outcomes:

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

- Develop proficiency in the application of the finite element method and CFD (modeling, analysis, and interpretation of results) to realistic engineering problems through the use of a major commercial package.
- Demonstrate the equations in finite element methods for 1D, 2D and 3D problems.
- Demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purposes.
- Analyse the CFD results and compare with available data, further discuss the findings.
- Develop the code for solving problems of fluid flow and heat transfer applications.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	1	1	1	1	1	1	1	3	1	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	1	2
CO3	2	2	1	1	1	1	0	1	1	1	1	1	3	1	2
CO4	2	2	1	1	1	1	1	1	1	1	1	1	2	1	2
CO5	3	2	1	1	1	1	0	1	1	1	1	1	3	1	2

Program Elective- III

19EAE441: WIND TUNNEL TECHNIQUES

L	T	P	C
3	0	0	3

Preamble:

This course is designed for Aerospace Engineering undergraduate students. This course aims to introduce fundamental aspects of wind tunnel testing.

Course Objectives:

- Introduce different types of wind tunnels.
- Acquaint different pressure, velocity and force measurement techniques.
- Familiarize different aspects of wind tunnel calibration.
- Acquaint different flow visualization techniques.
- Familiarize different aspects in testing of aircraft and its various components.

UNIT I **10 hours**

Wind Tunnels Testing: Review of dimensional analysis, similitude, classification of wind tunnels and testing, different flow regime testing - subsonic, transonic, supersonic and hypersonic speed regions, layouts: sizing and design parameters.

Learning Outcomes

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

- Classify wind tunnels based on the path followed by air and the maximum speed, (L1).
- Discuss the advantages and limitations of open return and closed return wind tunnels (L2).
- Illustrate and explain the general layout of different types of wind tunnels (L2).
- Describe the basic aspects of wind tunnel design (L2).

UNIT II **10 hours**

Wind Tunnel Measurements: Pressure and velocity measurements, force measurements, three component and six component balances, internal balances.

Learning Outcomes

After the completion of this unit the student will be able to

- List different ways of measuring pressure and velocity in a wind tunnel and explain the principle behind them (L2).
- Explain the basic principle behind three-component and six-component balances (L2).
- Classify and explain different types of external balances (L2).
- Explain the working of an internal balance (L2).

UNIT III **10 hours**

Calibration of Wind Tunnels: Test section speed, horizontal buoyancy, flow angularities, turbulence measurements, associated instrumentation, and calibration of supersonic tunnels.

Learning Outcomes

After the completion of this unit the student will be able to

- Discuss important parameters that need to be considered during the calibration of the wind tunnel (L2).

UNIT IV 10 hours

Flow Visualization: Smoke and tuft grid techniques, dye injection special techniques, optical methods of flow visualization.

Non-Intrusive Flow Diagnostics: Laser-doppler anemometry, particle image velocimetry, laser induced fluorescence.

Learning Outcomes

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

- Describe various intrusive and non-intrusive techniques used for visualizing flow in a wind tunnel (L2).
- Discuss the advantages and limitations of different visualization techniques (L2).

UNIT V **8 hours**

Aircraft and Component Testing: General test procedures, components, complete configuration, power effects, propeller aircraft, jet aircraft and V/STOL vehicles.

Learning Outcomes

After the completion of this unit the student will be able to

- Describe the general test procedure of an aircraft and its various components (L2).
- Discuss important parameters that are evaluated when testing the aircraft and its various components (L2).
- Determine aerodynamic characteristics given appropriate information (L3).

Course Outcomes:

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

- Classify and explain different types of wind tunnels and its components.
- Explain the principle behind the different techniques used for measuring pressure, velocity and force in a wind tunnel.
- Explain the various parameters that need to be considered during the calibration of the wind tunnel.
- Explain the principle behind the different intrusive and non-intrusive flow visualization techniques used in wind tunnels.
- Explain the general test procedure of an aircraft and its various components.

Text Book(s)

1. A. Pope and L Goin, High Speed Wind Tunnel Testing, John Wiley, 1985.
2. J. B. Barlow, W. H. Rae, A. Pope, Low Speed wind Tunnel Testing, 3/e, John Wiley, 2010.

References

1. P. Bradshaw, Experimental Fluid Mechanics, Pergamum Press, 1964.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1
CO2	3	2	1	1	2	1	1	1	1	1	1	1	2	1	1
CO3	2	1	1	1	1			1	1	1	1	1	2	1	1
CO4	3	2	1	1	2	1	1	1	1	1	1	1	2	1	1
CO5	3	1	1	1	1	1	1	1	1	1	1	1	2	1	1

19EAE443: THEORY OF CRYOGENICS

L	T	P	C
3	0	0	3

Preamble

This course highlights syllabus related to cryogen zing of propellants. It includes different theories of liquefaction, refrigeration, separation and purification. Course find appealing and enhances interest in the area of very low temperature liquid production

Course Objectives:

1. Explain the importance of cryogenics and very low temperature processes.
2. Train different principles behind gas liquefaction and refrigeration systems
3. Impart the knowledge of gas separation and purification process.
4. Familiarize different properties of materials at very low temperatures.
5. Provide exposure on challenges, design of cryogenic fluid process, materials and storage

UNIT I **8 hours**

Introduction: Properties of engineering materials at cryogenic temperatures, mechanical properties thermal properties, electric and magnetic properties, superconducting materials, thermoelectric materials, properties of cryogenic fluids, super fluidity of He3 and He4.

Learning Outcomes

At the end of unit student will be able to

- Understand properties of various applied cryogenic materials (L2)
- Exhibit interest in advanced material processes of superconducting and thermo electric (L3)
- Compare compatibility of materials and appropriate processes(L4)
- Gain knowledge of superfluidity of helium variants(L4)

UNIT II **9 hours**

Low Temperature Processes: Importance and applications, thermodynamic minimum work, cooling duty and COP, isobaric cooling minimum work, production of low temperatures, Joule-Thomson expansion, adiabatic reversible turbine expansion, discontinuous sudden expansion, Philips refrigerator, Gifford McMahan refrigerator, pulse tube refrigerator.

Learning Outcomes

At the end of unit student will be able to

- Learn importance of low temperature processes of different applications (L2)
- Exhibit interest on different refrigerators used for low temperature processes (L3)
- Appreciates thermodynamic working of different processes involved (L4)
- Apply principles for quantification of different parameters of refrigeration cycle (L4)

UNIT III **9 hours**

Gas Liquefaction and Refrigeration Systems: Thermodynamically ideal system for liquefaction, liquefaction for nitrogen, oxygen, and argon by Linde-Hampson process and simple Claude process. Neon, hydrogen, helium liquefaction by pre-cooled Linde-Hampson, Collins helium liquefaction process, natural gas by pure component refrigeration.

Learning Outcomes

At the end of unit student will be able to

- Learn concepts of gas liquefaction and refrigeration (L2)
- Apply knowledge of material liquefaction using different process (L3)

- Compare different method of refrigeration and liquefaction suitable to material (L4)
- Exhibit design knowledge refrigeration systems (L4)

UNIT IV **8 hours**

Gas Separation and Purification: Gas separation and purification, principles, cryogenic and non-cryogenic for air, hydrogen and helium separation systems.

Learning Outcomes

At the end of unit student will be able to

- Improve knowledge of gas separation and purification (L2)
- Exhibit increased interest in cryogenic separation systems (L3)
- Apply cryogenic principles for air, hydrogen and helium materials (L4)
- Design of purification processes for other materials (L4)

UNIT V **9 hours**

Cryogenics in Aerospace Applications: Challenges for cryogenic propellants, design concept for cryogenic propellant, boil off rate, storage and transportation of cryogenic fluids, storage vessel, thermal shields and insulation, effect of size shape on heat in-leak transfer and draining of liquid, transportation issues - nitrogen, helium and hydrogen.

Learning Outcomes

At the end of unit student will be able to

- Impart knowledge on different challenges of cryogenic propellants (L2)
- Exhibit interest in resolving issues of storage, evaporation and transportation (L3)
- Compare different parameters for preserving and storing of cryogenic propellants (L4)
- Exhibit design knowledge of cryogenic propellants (L4)

Course Outcomes

At the end of course student will be able to

- Understands properties of various materials that take part in cryogenisation process
- Realize the significance of low temperature processes
- Exhibit knowledge on gas liquefaction and refrigeration systems
- Apply principles of gas separation and purification for air, hydrogen and helium
- Appreciates challenges and design issues with regard to materials and processes

Text Book(s)

1. R. F. Barron, Cryogenic Systems, 2/e, McGraw Hill, 2008.
2. M. Mamata, Fundamentals of Cryogenic Engineering, 1/e, PHI, 2010.

References

1. T. M. Flynn, Cryogenic Engineering, 2/e , CRC press, 2005.
2. T. Flynn, Cryogenic Process Engineering, 1/e, Plenum press, 1989.
3. G. Haseldom, Cryogenic Fundamentals, 1/e, Academic Press, 1971.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO1	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**1**	**1**
CO2	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**1**	**1**
CO3	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**1**	**1**
CO4	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**1**	**1**
CO5	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**2**	**1**	**1**

19EAE445: INTRODUCTION TO FINITE ELEMENT ANALYSIS

L	T	P	C
3	0	0	3

Preamble:

This course is designed for aerospace engineering students. It introduces the basic principles of finite element procedure. This course is designed to acquaint the learners with finite element solutions to structural and thermal problems and deals with the realistic engineering problems.

Course Objectives:

- To impart the basic principles of finite element analysis procedure.
- To develop the ability to generate the governing FE equations for systems governed by partial differential equations.
- To familiarize and apply finite element solutions to structural, thermal, dynamic problem to develop the knowledge and skills needed to effectively evaluate finite element analyses performed by others.
- To develop proficiency in the application of the finite element method (modeling, analysis, and interpretation of results) to realistic engineering problems

UNIT I **8 hours**

Fundamental Concepts: Stresses and equilibrium, strain – displacement relations, stress-strain relations, plane stress, plane strain, temperature effects, potential energy and equilibrium. Rayleigh-Ritz method, Galerkin's method, Saint Venant's principle.

Learning Outcomes

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

- Understand the concepts behind variational methods and weighted residual methods in FEM (L2)
- Identify the application and characteristics of FEA elements (L3)
- Develop the ability to generate the governing FE equations for systems governed by partial differential equations (L5)

UNIT II **9 hours**

One-dimensional Problems: Finite element modeling, coordinates and shape functions. Potential energy approach. Galerkin's approach, assembly of the global stiffness matrix and load vector, treatment of boundary conditions, quadratic shape functions, temperature effects. Plane trusses, local and global co-ordinate system, direction cosines, element stiffness matrix, force terms, stress calculations.

Learning Outcomes

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

- Demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purposes (L3)
- Develop a basic understanding of the limitations of the FE method and understand the possible error sources in its use (L5)
- Formulate and Solve axially loaded bar Problem and analyze truss problem (L4)

UNIT III **8 hours**

Two-dimensional Problems using Constant Strain Triangles: Finite element modeling, constant strain triangle, problem modeling and boundary conditions, isoparametric representation, potential energy approach, element stiffness, force terms, stress calculations.

Axisymmetric Solids Subjected to Axisymmetric Loading: Axisymmetric formulation, axisymmetric triangular element, strain displacement relations, problem modeling and boundary conditions, stiffness matrix, body force terms.

Learning Outcomes

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

- Implement the formulation techniques to solve two-dimensional problems using triangle and quadrilateral elements (L5)
- Formulate and solve axi-symmetric problems and understand the formulation of three-dimensional elements (tetrahedral and brick elements). (L4)
- Classify the finite element modeling techniques (L3)

UNIT IV **9 hours**

Beams and Frames

Finite element formulation, load vector, boundary considerations, shears force and bending moment, plane frames. **Two-dimensional Isoparametric Elements and Numerical Integration:** Four-node quadrilateral element, shape functions, element stiffness matrix, element force vector. Numerical integration, Gauss quadrature, one dimension and two-dimensional integrals, stiffness integration, stress calculations.

Learning Outcomes

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

- Demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purposes (L3)
- Create models for beams and frames, plate structures, machine parts, and components.
- Understand the role and significance of shape functions in finite element formulations and use linear, quadratic, and cubic shape functions for interpolation (L2)

UNIT V **8 hours**

Scalar Field Problems: Steady state heat transfer, one dimensional heat conduction, one dimensional heat transfer in thin fins.

Dynamic Considerations: Formulation, solid body with distributed mass, element mass matrices, evaluation of eigenvalues and eigenvectors

Learning Outcomes

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

- Understand the application of FEA in heat transfer problem (L2)
- Apply the techniques, skills, and modern engineering tools necessary for engineering practice. (L3)

Course Outcomes:

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

- Understand the numerical methods involved in Finite Element Theory
- Apply the role and significance of shape functions in finite element formulations and use linear, quadratic, and cubic shape functions for interpolation
- Understand global, local, and natural coordinates and formulation of one-dimensional elements (truss and beam)
- Formulate two-dimensional elements, three dimensional and axisymmetric elements.
- Identify how the finite element method expands beyond the structural domain, for problems involving dynamics, heat transfer, and fluid flow.

Text Book(s)

1. Tirupathi R. Chandrupatla, Ashok D. Belegundu, Introduction to Finite Elements in Engineering, 3/e, Pearson Education, 2009.
2. Reddy. J.N., "An Introduction to the Finite Element Method", 3rd Edition, Tata McGraw-Hill, 2005

References

1. S.S.Rao, Finite Element Method in Engineering, Elsevier Butterworth-Heinmenn Publications, 2013.
2. J.N. Reddy, An Introduction to the Finite Element Method, 3/e, McGraw-Hill Publications, 2006.
3. Robert D. Cook, David S. Malkus, Michael E. Plesha, Rober J. Witt, Concepts and Applications of Finite Element Analysis, 4/e, Wiley India 2001.
4. Logan, D.L., "A first course in Finite Element Method", Thomson Asia Pvt. Ltd., 2002

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	2	1	3	2	2
CO2	2	2	2	1	1	0	1	1	1	1	2	1	2	1	2
CO3	2	2	2	1	2	1	1	1	0	1	2	1	2	1	2
CO4	2	2	1	1	1	0	1	1	1	1	2	0	2	3	2
CO5	3	2	1	1	1	2	1	1	0	1	2	1	2	2	2

19EAE447: SPACE TECHNOLOGY

L	T	P	C
3	0	0	3

Preamble:

This course is designed for aerospace engineering students. It introduces the basic introduction of Space Technology

Course Objectives

- Explain basic knowledge on fundamentals of Rocketry and space technology applications;
- Impart the awareness of the universality of use and multiplicity of space applications;
- Explain basic knowledge on space missions and national programs;
- Demonstrate and explain basic principles of rocket propulsion
- Focus and apply physical and mathematical methods used in analyzing engineering applications involving rocket

UNIT I **8 hours**

Fundamentals of Rocketry: Space mission, types, space environment, launch vehicle selection, types of orbits. Two-dimensional trajectories of rockets and missiles, multi-stage rockets, vehicle sizing, two stage, multi-stage rockets; Trade-off ratios, single stage to orbit, sounding rocket, aerospace plane, gravity turn trajectories.

Learning Outcomes:

At the completion of this unit, students will be able to:

- Understand of basic physics of rockets and space missions. (l2)
- Understand rocket propulsion systems for both launch and orbital control missions (l3)
- Understand the concept of two-dimensional trajectories of rockets and missiles. (l3)
- Understand the multistage of rockets and missiles. (l2)

UNIT II **8 hours**

Atmospheric Re-entry: Introduction, steep ballistic re-entry, ballistic orbital re-entry, skip re-entry, double dip reentry, aero braking, lifting body re-entry.

Learning Outcomes:

At the completion of this unit, students will be able to:

- Understand Reentry of space vehicle (L2)
- Get knowledge on different re-entry paths or maneuvers (L2)
- Understand the how to reduce the velocity of bodies while Re-entry of vehicles (L3)

UNIT III **8 hours**

Fundamentals of Orbit Mechanics: Orbit maneuvers, two body motion- circular, elliptic, hyperbolic, and parabolic orbits; Basic orbital elements, ground trace in-plane orbit changes, Hofmann transfer, bi-elliptical transfer, plane changes, combined maneuvers, propulsion for maneuvers.

Learning Outcomes:

At the completion of this unit, students will be able to:

- Understand and get the knowledge of fundamentals of mathematics and physics of Keplerian laws. (L3)
- Understand the orbital motions of planets (L2)
- Have knowledge on orbital transfer mechanics in the space environment. (L3)

UNIT IV **8 hours**

Satellite Attitude Dynamics: Torque free axi-symmetric rigid body, attitude control for spinning spacecraft, attitude control for non-spinning spacecraft, Yo-Yo mechanism, gravity - gradient satellite, dual spin spacecraft and attitude determination.

Learning Outcomes:

At the completion of this unit, students will be able to:

- Understand satellite attitude dynamics of axisymmetric rigid body (l2)
- Know the attitude control for spinning and non-spinning spacecraft. (l2)
- Understand the mechanisms of satellite attitude dynamics. (l3)

UNIT V **9 hours**

Space Mission Operations: Supporting ground systems, architecture and team interfaces, mission phases and core operations, team responsibilities, mission diversity, standard operations practices, impact point calculation, injection conditions, flight dispersions.

Learning Outcomes:

At the completion of this unit, students will be able to:

- Space mission operation like ground systems, architecture and team interfaces (l3)
- Understand standard operation of space mission (l2)
- Understand space impact point calculation, flight dispersions(l3)

Course Outcomes:

At the completion of this course, students will be able to:

- The candidate has broad knowledge on satellite orbits and multidisciplinary knowledge in space technology.
- Possess the basic knowledge on rocketry and related combustion
- Analyze and understand the spacecraft launch, space environment
- Exercise strong knowledge on working of spacecraft in different environment conditions.
- Good knowledge on space applications such as earth observation, navigation and communication.

Text Book(s)

1. W. E. Wiesel, Spaceflight Dynamics, 2/e, McGraw Hill, 2014.
2. F. J. Hale, Introduction to Space Flight, 1/e, Prentice Hall, 1993.

References

1. Cornelisse, H. F. R Schoyer and K. F. Wakker, Rocket Propulsion and Spaceflight Dynamics, Pitman, 1984.
2. V. L. Pisacane, Fundamentals of Space Systems, Oxford University Press, 2005.
3. J. Sellers, Understanding Space: An Introduction to Astronautics, McGraw Hill, 2000.
4. C. D. Brown, Spacecraft Mission Design, AIAA Education Series, 1998.
5. M. Rudolph, Elements of Space Technology for Aerospace Engineers, Academic Press, 1999.
6. C. Sivaram, Rocket Dynamics and Space Flight, 1/e, Ane Books Pvt. Limited, 2009.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3

CO1	3	1	2	1	1	1	1	1	1	1	1	1	3	1	1
CO2	2	2	2	1	1	1	1	1	1	1	1	1	2	1	1
CO3	2	2	3	2	1	1	1	1	1	1	1	1	2	1	1
CO4	2	2	2	2	1	1	1	1	1	1	1	1	2	1	1
CO5	2	1	2	1	1	1	1	1	2	1	1	1	2	1	1

19EAE449: INSTRUMENTATION AND CONTROL SYSTEMS

L	T	P	C
3	0	0	3

Preamble:

This course deals with the fundamentals of Instrumentation and control systems including Instrumentation systems and properties, relationships among the instrumentation and control systems, different techniques in control systems and application on instrumentation systems.

Course Objectives:

- Focuses on imparting the principles of measurements.
- Focuses on the working mechanism of various sensors and devices.
- Fundamentals of control systems.
- Understanding of electrical and mechanical systems transfer functions and modeling of
- systems
- Calculation of stability of various techniques of control systems.

UNIT-I **8 hours**

Introduction to Instrumentation – Process of measurement, Static performance characteristics, Dynamic performance characteristics, Transducer elements, Intermediate elements, Indicating and Recording of elements. Motion measurement: Relative motion measurement, Absolute motion measurement and calibration of motion measuring devices.

Learning Outcomes:

After completion of this unit the student will be able to

- understand the process of measurement (L2)
- understand the dynamic and static characteristics(L2)
- applying measurement techniques on motion measuring devices(L3)
- Calibrating of motion measuring devices (L3)

UNIT-II **8 hours**

Force measurement: Study and calibration of hydraulic load cell, pneumatic load cell and elastic force devices. Torque and power measurement: Transmission dynamometers, driving type dynamometers, Absorption dynamometers. Temperature measurement: Non-electrical methods, Electrical methods and Radiation methods. Vibration measurement: Velocity & Acceleration measurement, Vibration transducers, Signal conditioning, display and recording of elements, Vibration-meters and analyzers.

Learning Outcomes:

After completion of this unit the student will be able to

- Calibration of force measuring devices(L3)
- understand the torque measuring (L2)
- Understand the temperature measuring(L2)
- Study of velocity and acceleration measurement (L2)

- Calibrating of vibration measuring devices (L3)

UNIT-III **8 hours**

Control systems: Introduction, Open loop and Closed loop systems, Feedback control and its effects. Transfer function, block diagrams and signal flow graph: Impulse response and transfer functions of linear systems.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand the basics of control systems(l2)
- Understand the transfer function concept (l2)
- Calculating transfer function of block diagrams (l4)
- Calculating transfer function of block diagrams (l4)
- Understand the transfer functions of linear systems. (l2)

UNIT-IV **8 hours**

Mathematical modeling of physical systems: Equations of electrical networks, modeling of mechanical system elements, equations of mechanical systems. State-variable analysis of linear dynamic systems; Matrix representation of state equations, state transition matrix, state transition equation, relationship between state equations and high-order differential equations, relationship between state equations and transfer functions, characteristic equation, eigenvalues, and eigenvectors.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand the basics of electrical systems equations(l2)
- Understand the basics of mechanical systems equations (l2)
- Understand the state variable analysis and equations (l2)
- Calculating transfer function of electrica and mechanical systems (l4)
- Calculating relationship between state equations and transfer functions (l4)

UNIT-V **8 hours**

Time-domain analysis of control systems: Typical test signals for the response of control systems, Time-domain performance of control systems- stability of control systems, stability characteristic equation and state transition matrix, methods of determining stability of linear control systems, Routh-Hurwitz criterion. Introduction to Frequency-domain analysis of control systems, Bode plots and Nyquist plots.

Learning Outcomes:

After completion of this unit the student will be able to

- Understand the different test signals(l2)
- Understand the concept of stability of control systems (l2)
- Calculating stability of linear systems(l4)

- Calculating stability in frequency domain of systems (l4)
- Calculating state transition matrix (l4)

Course Outcomes:

After successful completion of this course the students will be able to:

- Explain the concepts of instrumentation and measurement systems and can differentiate relative motion and absolute motion.
- Measure different physical parameters like force , torque and temperature using gauges.
- Compute transfer functions of basic systems using sfg's and block diagrams.
- Compute transfer functions of electrical and mechanical systems.
- Compute stability of control systems in both time domain and in frequency domain.

Text Books:

1. Mechanical Measurements by R.S. Sirohi, H.C. Radhakrishnan; New Age International Ltd.
2. Automatic Control systems by Benjamin.C. Kuo, FaridGolnaraghi; Prentice Hall.

References:

1. Feedback Control of Dynamic Systems by Gene F. Franklin, J. David Powell, Abbas Emami-Naeini; Pearson Education.
2. Experimental Methods for Engineers, by J.P.Holman, McGraw-Hill.
3. Instrumentation Design Studies by E. Doeblin.
4. Mechanical and Industrial Measurements by R.K.Jain; Khanna Publishers.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1		2	1	1	1	1	1	1	1	2	2	3	1	1
CO2	1	1	3	1	1	1	1	1	1	2	1	1	3	1	1
CO3	1	2	2	2	1	2	1	1	1	1	1	1	3	2	1
CO4	1	1	2	2	1	1	1	1	1	1	1	1	2	2	1
CO5	1	2	1	3	1	1	1	1	1	1	1	2	3	2	1

Program Elective- IV

19EAE451: COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students for the basic understanding of numerical techniques to solve fluid and heat transfer problems.

Course Objectives:

- Familiarize widely used techniques in the numerical solution of fluid equations, issues that arise in the solution of such equations, and modern trends in CFD.
- Provide the essential numerical background for solving the partial differential equations governing the fluid flow
- Focus on various discretization methods and solving methodologies.
- Create confidence to solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers.
- To impart the knowledge which is base essential for application of CFD to engineering flow problems

UNIT I **7 hours**

Introduction: Applications of CFD in various branches of Engineering, models of fluid flow: finite control volume and infinitesimal fluid element.

Governing Equations: Derivation Of continuity, momentum and energy equations, physical boundary conditions, significance of conservation and non-conservation forms and their implication on CFD applications - strong and weak conservation forms - shock capturing and shock fitting approaches.

Learning Outcomes:

After completion of this unit the student will be able to

- Formulate the governing equation for a given fluid flow problem. (l6)
- Understand the significance of various forms of fluid flow equations (l2)
- Gain knowledge on implementation of various types of boundary conditions.(l3)

UNIT II **7 hours**

Mathematical Behavior of Partial Differential Equations and Their Impact on CFD: Classification of quasi-linear partial differential equations by Cramer's rule and Eigenvalue method; General behavior of different classes of partial differential equations and their importance in understanding physical and CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations; Domain of dependence and range of influence for hyperbolic equations – well posed problems.

Learning Outcomes:

After completion of this unit the student will be able to

- Classify a given partial differential equation. (l2)
- Interpret the mathematical behavior of a pde.(l5)
- Understand the conditions for the problem to be a well posed.(l2)

UNIT III **12 hours**

Basic Aspects of Discretization: Introduction to finite differences, finite difference approximation for first order, second order and mixed derivatives. Difference equations: explicit and implicit approaches, truncation and round-off errors, consistency, stability, accuracy, convergence, efficiency of numerical solutions; Von-Neumann stability analysis and physical significance of CFL stability condition.

Finite Volume Methods: Basis of finite volume method, conditions on the finite volume selections, cell-centered and cell-vertex approaches, definition of finite volume discretization, general formulation of a numerical scheme, two-dimensional finite volume methods with example.

Learning Outcomes:

After completion of this unit the student will be able to

- Write the finite difference approximations for the corresponding derivatives.(l2)
- Estimate the order of truncation error for particular numerical scheme.(l6)
- Perform stability analysis for a given numerical scheme (l5)
- Discretize the given pde using finite difference and finite volume techniques (l3).

UNIT IV **10 hours**

CFD Techniques: Lax-Fredrich's technique, Lax-Wendroff technique,Mac Cormack's technique, Crank-Nicholson technique, Relaxation technique, ADI technique, aspects of numerical dissipation and dispersion. Pressure correction technique: application to incompressible viscous flow; Need for staggered grid. Numerical procedures: SIMPLE, SIMPLER algorithms, boundary conditions for pressure correction method.

Learning Outcomes:

After completion of this unit the student will be able to

- Solve the fluid flow problems using the standard algorithms (L3)
- Understand the concept of numerical dissipation and dispersion (L1)
- Explain the difference between a standard grid and a staggered grid.(L2)

UNIT V **7 hours**

Grid Types and Characteristics: Need for grid generation, structured grids, cartesian grids, stretched (compressed) grids, body fitted structured grids, H-mesh, C-mesh, O-mesh, I-mesh, multi block grids, C-H mesh, H-O-H mesh, overset grids, adaptive grids. Unstructured grids, triangular cells, tetrahedral cells, hybrid grids, quadrilateral cells and hexahedral cells.

Learning Outcomes:

After completion of this unit the student will be able to

- Identify the advantages and limitations of a particular mesh chosen to solve a problem.(l3)
- Generate a structured and unstructured mesh (l3)
- Understand the applications of different types of grids (l2)

Course Outcomes:

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

- Formulate and solve computational problems arising in the flow of fluids.
- Assess the accuracy of a numerical solution by comparison to known solutions of simple test problems and by mesh refinement studies.
- Learn how cfd is used to predict aerodynamic behavior of internal and external flows.
- Familiar with the differential equations for flow phenomena and numerical methods for their solution
- Analyze different mathematical models and computational methods for flow simulations.

Text Book(s)

1. J. D. Anderson, Computational Fluid Dynamics: The Basics with Applications, 1/e, McGraw Hill, 2012.
2. R. H. Pletcher , J. C. Tannehill , D. A. Anderson, Computational Fluid Mechanics and Heat Transfer, 3/e, Taylor and Francis, 2011.

References

1. S. V. Patankar, Numerical Heat Transfer and Fluid Flow, 1/e, ANE Books, 1980.
2. C. Hirsch, Numerical Computation of Internal and External Flows: Fundamentals of Computational Fluid Dynamics, 2/e, Elsevier, 2007.
3. H. K. Versteeg, and W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2/e, Pearson Education, 2010.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	1	1	1	1	1	1	1	3	3	2
CO2	3	3	2	2	2	1	1	1	1	1	1	1	3	2	1
CO3	3	3	3	3	3	1	1	1	1	1	2	2	3	3	2
CO4	3	3	2	1	1	1	1	1	1	1	2	2	3	2	1
CO5	3	3	3	1	1	1	1	1	1	1	2	2	3	2	1

19EAE453: AERODYNAMICS OF TURBOMACHINERY

L	T	P	C
3	0	0	3

Preamble:

This course projects contents that include different types of turbomachinery aerodynamics. It focuses mainly on working of turbo machines and performance characterization and design philosophies. Course find appealing and enhances interest in the area of compressor and turbines

Course Objectives:

- Impart knowledge on principles of turbomachinery and various subsystems within.
- Train students on performance characterization of different turbo machines.
- Impart design knowledge of axial and centrifugal compressors and turbines.
- Familiarize analyzing various types of losses rotating machines could undergo.
- Explain fundamentals of matching different turbo machine components.

UNIT I **9 hours**

Axial Flow Compressors: Geometry structure of stage and related terminology, velocity triangles, flow behavior, thermodynamic cycle, single and multistage, degree of reaction, stage pressure ratio and other performance characteristics, compressor pressure curve. Losses - causes, primary and secondary losses, stall, surge. Efficiencies - polytropic, stage and adiabatic. Cascade aerodynamics - nomenclature, analysis of cascade forces, numericals and study of performance charts.

Learning Outcomes

At the end of unit student will be able to

- Understand rotating flow physics and its interpretation (L2)
- Appreciates the significance of velocity triangles and energy exchange, conversion processes (L4)
- Calculate and characterize the performance of axial flow compressors (L4)
- Quantify different types of losses of rotating machines (L3)
- Exhibit interest in enhancing deeper understanding of cascade flows (L5)

UNIT II **9 hours**

Centrifugal Compressors: Introduction, elements of centrifugal compressor, inlet and impeller slip factor, concept of rothalpy. Incidence and lag angles, forward lean, backward lean, velocity triangles, diffuser - vane and vaneless, volute casing centrifugal compressor characteristics, stage loses

Learning Outcomes

At the end of unit student will be able to

- Appreciates the difference between axial and centrifugal compressors (L4)
- Understand the significance of inducer at inlet and volute at the exit of compressor (L2)
- Exhibit design knowledge of different components of centrifugal compressors (L3)
- Characterize the performance of centrifugal compressors (L4)

UNIT III **9 hours**

Axial Flow Turbines: Velocity diagrams for rotors and stators,performance computations, degree of reaction, impulse and reaction turbines, flow losses and causes, efficiencies - total to total and total to static, blade spacing, blade and disk stress - centrifugal, bending and thermal. Typical blade profiles, study of performance charts. Limitations: Materials used for blades and disks, cooling - internal, external cooling. Numericals

Learning Outcomes

At the end of unit student will be able to

- Appreciates the difference between axial flow turbines and compressors (L4)
- Understand the significance of position of stators and its importance in axial flow machines (L2)
- Exhibit design knowledge of different types of axial flow turbine like impulse and reaction machines (L2)
- Get exposure on different types of turbine cooling techniques (L1)
- Understands the limitation of turbine working (L2)

UNIT IV **8 hours**

Radial Flow Turbines: Elements of radial turbines stage, stage velocity triangles, enthalpy - entropy diagrams, stage losses and efficiency, performance characteristics.

Learning Outcomes

At the end of unit student will be able to

- Appreciates the difference between axial and radial flow turbines (L4)
- Understand the significance of radial movement of flow in generation of shaft work (L2)
- Exhibit design capabilities of radial flow turbine and its aerodynamic components (L4)
- Characterize the performance of centrifugal compressors (L3)

UNIT V **8 hours**

Dimensional Analysis and Matching: Geometric similarity, dynamic similarity, Buckingham's PI theorem for turbo machines, compressor and turbine maps, choking of compressor and turbines, specific speed and its design role, turbine and compressor matching.

Learning Outcomes

At the end of unit student will be able to

- Appreciates the significance of matching mechanical and aerodynamic behavior of turbomachines (L4)
- Understand the role of performance maps, specific speeds and choking concept of turbomachine (L2)
- Exhibit knowledge of matching the performance of turbomachines in a typical engine (L4)
- Enhance understanding of similarity concepts (L2)

Course Outcomes

At the end of course student will be able to

- Appreciate working of axial flow compressor for fluid pressurization(L2)
- Understands and distinguishes the working and performance of centrifugal and axial compression systems(L4)
- Comprehend thermodynamic working of axial flow turbines(L3)
- Ascertain and design typical radial inflow turbine(L4)
- Determine best matching combinations across compressors and turbine (L4)

Text Book(s)

1. Baskharone, Principles of Turbomachinery in Air Breathing Engines, 2/e, Cambridge University Press, 2006.
2. R. D. Flack, Fundamentals of Jet Propulsion with Applications, 2/e, Cambridge University Press,

2010

References

1. E. Logan Jr., Turbomachinery: Basic Theory and Applications, 2/e, Taylor and Francis limited, 1993.
2. S. A. Korpela, Principles of Turbomachinery, 2/e, John Wiley, 2012.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	2	1	2	1	1	2	1	3	2	1
CO2	3	2	2	2	1	2	1	2	2	1	2	1	3	2	1
CO3	3	2	1	1	1	2	1	2	1	1	2	1	3	1	1
CO4	3	2	1	1	1	2	1	1	2	1	2	1	3	1	1
CO5	3	2	2	1	1	2	1	1	1	1	1	1	3	1	1

19EAE455: THEORY OF ELASTICITY

L	T	P	C
3	0	0	3

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students to understand the basics principles of Theory of Elasticity. Understanding these principles will help them in the Design and Analysis of Aerospace Structures.

Course Objectives:

- To familiarize notations and sign conventions for stress and strain
- To impart knowledge on basic equations of elasticity
- To help to understand plane stress and plane strain conditions
- To explain the elasticity problems using polar coordinates
- To focus on torsion of prismatic bars

UNIT I **4 hours**

Assumptions in Elasticity: Definitions, notations and sign conventions for stress and strain, equations of equilibrium.

Learning Outcomes:

After completion of this unit student will be able to

- Make use of proper sign conventions in the problems (L3)
- Explain about equations of equilibrium (L2)

UNIT II **12 hours**

Basic Equations of Elasticity: Strain-displacement relations, stress-strain relations, Lame's constant - cubical dilation, compressibility of material, bulk modulus, shear modulus, Compatibility equations for stresses and strains, principal stresses and principal strains, Mohr's circle, Saint Venant's principle.

Learning Outcomes:

After completion of this unit student will be able to

- Develop relations between stresses and strains in problems (L3)
- Explain different elastic constants (L2)
- Determine principal stresses and strains in a given problem (L5)
- Infer St. Venant's principle (L2)

UNIT III **8 hours**

Plane Stress and Plane Strain Problems: Airy's stress function, bi harmonic equations, polynomial solutions, simple two-dimensional problems in Cartesian coordinates like bending of cantilever and simply supported beams, etc.

Learning Outcomes:

After completion of this unit student will be able to

- Distinguish between plane stress and plane strain conditions (L4)
- Make use of Airy's stress functions and biharmonic equations (L3)
- Solve two-dimensional problems in Cartesian coordinates (L3)

UNIT IV **10 hours**

Polar Coordinates: Equations of equilibrium, strain-displacement relations, stress-strain relations, axi-symmetric problems, Kirsch, Michell's and Boussinesque problems.

Learning Outcomes:

After completion of this unit student will be able to

- Develop equations of elasticity in polar coordinates (L3)
- Apply these equations to solve axi-symmetric problems (L3)

UNIT V **8 hours**

Torsion of Prismatic Bars: Navier's theory, St. Venant's theory, Prandtl's theory on torsion, the semi- inverse method and applications to shafts of circular, elliptical, equilateral triangular and rectangular sections.

Learning Outcomes:

After completion of this unit student will be able to

- Distinguish the behavior of circular and prismatic bars under torsion (L4)
- Make use of different theories to solve problems on torsion of prismatic bars (L3)

Course Outcomes:

After the completion of this course student will be able to

- Make use of proper sign conventions in the problems (L3)
- Develop basic equations of elasticity (L3)
- Solve two dimensional problems in Cartesian coordinates (L3)
- Apply equations of elasticity in polar coordinates to solve axi-symmetric problems (L3)
- Analyse prismatic bars under torsion (L4)

Text Book(s)

1. S. Timoshenko and T. N. Goodier, Theory of Elasticity, 3/e, Tata McGrawHill, 2010.

References

1. E. Volterra and J. H. Caines, Advanced Strength of Materials, Prentice Hall, 1991.
2. C. T. Wang, Applied Elasticity, McGraw Hill, 1993.
3. R. B. Hetnaarski and J. Ignaczak, Mathematical Theory of Elasticity, CRCPress, 2011.
4. J. R. Barber, Elasticity, Springer, 2010.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2	1
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	1	1
CO5	3	3	1	1	1	1	2	1	1	2	1	1	3	2	1

19EAE457: SATELLITE ATTITUDE AND CONTROL

L	T	P	C
3	0	0	3

Preamble:

This course provides an introduction to the basic concepts of satellites and its control systems of space missions.

Course Objectives:

- Focus on developing mathematical models of spacecraft attitude dynamics
- Analyzing the response to external disturbances and control torques
- Demonstrate Multiplexing schemes and multiple access techniques
- Impart rigorously develops the concepts, mathematical procedures, and methods associated with defining, determining, and controlling the attitude of a spacecraft.
- Encourage the student will develop the theoretical background necessary to pursue advanced courses in the field of Spacecraft Attitude Dynamics.

UNIT I **6 hours**

Elements of Satellite Communication: Satellite systems, orbital description and orbital mechanics of LEO, MEO and GSO, placement of a satellite in a GSO, satellite, description of different communication subsystems, bandwidth allocation.

Learning Outcomes:

After completion of this unit students are able to

- Analyze keplerian motion and non-keplerian perturbation effects; (l4)
- Compute and analyze optimum impulsive maneuvers and orbit transfers; (l3)
- Demonstrate knowledge of preliminary (two-body) orbit determination techniques. (l2)

UNIT II **10 hours**

Transmission, Multiplexing, Multiple Access and Coding: Different Modulation and multiplexing schemes, multiple access techniques FDMA, TDMA, CDMA and DAMA, coding schemes, satellite packet communications.

Learning Outcomes:

After completion of this unit students are able to

- Understand about codes of satellite attitude dynamics for different techniques(l2)
- Understand multiple techniques of fdma,tdma, cdma and dama(l2)
- Learn to write coding schemes for transmission multiple access, (l3)

UNIT III **8 hours**

Attitude and Orbit Control System: Coordinate system, AOC requirements, environment effects, attitude stabilization, attitude sensors, actuators, design of control algorithms.

Learning Outcomes:

After completion of this unit students are able to

- Understand attitude control systems – 2-dimensional coordinate system of orbit (l2)
- Understand actuators, attitude sensors and attitude stabilization of satellite (l2)
- Understand environmental effects and its requirements aocs (l2)

UNIT IV **12 hours**

Propulsion Systems, Structures and Thermal Control: Systems trade-off, mono propellant systems, thermal consideration, system integration design factors, pre-flight test requirements, system reliability configuration design of spacecraft structure, structural elements, material selection. Environmental loads, vibrations, structural fabrication, orbital environments, average temperature in space, transient temperature evaluation, thermal control techniques, temperature calculation for a spacecraft, thermal design and analysis program structure, thermal design verification, active thermal control techniques.

Learning Outcomes:

After completion of this unit students are able to

- Learn about mono-propellants systems, thermal consideration of its systems (l3)
- Understand basic knowledge of spacecraft structures and its thermals control techniques (l2)
- Acquire knowledge on thermal design and analysis programs. (l2)

UNIT V **6 hours**

Telemetry Systems: Base band telemetry system, modulation, TT and CRF system, tele-command system, ground control systems.

Learning Outcomes:

After completion of this unit students are able to

- Understand telemetry system in space environment (l2)
- Get knowledge about tcs and gcs tracking systems (l3)
- Create basics ideas on writing programs for control systems (l3)

Course Outcomes:

After completion of this course students are able to

- Apply knowledge of math, science, and engineering to solve problems in the analysis of rigid body attitude motions of spacecraft. (l2)
- Evaluate and analyze spacecraft attitude control by developing mathematical models of spacecraft attitude dynamics in response to external disturbances and control torques. (l3)
- Design a system, component or process to meet desired needs. (l2)
- Use the techniques, skills, modern engineering tools necessary for engineering practice. (l2)
- Introduction to the trade-offs between various methods for attitude control and attitude determination. (l2)

Text Book(s)

1. K. V. B. Narayana, Satellite Architecture, 2/e, ISRO Satellite Center, 2011.
2. V. V. Beletsky and E. M. Levin, Dynamics of Space Tether Systems, 1/e, Amer Astronautical Society 1993.

References

1. P. C. Hughes, Spacecraft Attitude Dynamics, 1/e, Dover Publications, 2004.
2. V. A. Chobotov, Spacecraft Attitude Dynamics and Control, 1/e, Orbit Books,1991

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	3	1	1	1	1	1	1	1	3	1	2	1	1

CO2	2	2	2	1	1	1	1	1	1	1	2	1	1	1	1
CO3	2	1	2	1	1	1	1	1	1	1	1	1	3	2	1
CO4	2	2	1	1	2	1	1	1	1	1	2	1	1	1	1
CO5	2	1	2	1	2	1	1	1	1	1	1	1	2	1	1

19EAE459: HELICOPTER ENGINEERING

L	T	P	C
3	0	0	3

Preamble:

This course is intended to introduce helicopters to aerospace engineering students. This course will help students to gain knowledge on different types of helicopters and working principles and the design of helicopters considering various aspects.

Course Objectives:

- Familiarize different configurations of helicopters based on rotors.
- Explain the basic concepts of helicopter basic aerodynamics.
- Explain blade element theory of helicopter rotors and help to find aerodynamic force and moments generation using BET.
- Explain helicopter rotor using vertical and forward motion of helicopter.
- Explain the concept of auto rotation, gliding and powered flight of helicopters.

UNIT I **9 hours**

Elements of Helicopter Aerodynamics: Introduction, helicopters, configurations based on torque reaction, jet rotors and compound helicopters, methods of control, collective and cyclic pitch, lead-lag, flapping hinges and lift dissymmetry, helicopters - tandem and tail rotor configuration and their advantages and disadvantages, auto rotation of helicopter.

Learning Outcomes:

At the end of the unit, student will be able to

- Gain knowledge on different types of helicopters (l1)
- Understand the concept on methods of controls (l1)
- Learn about the advantages and disadvantages of different of types of helicopters and their applications (l1)

UNIT II **9 hours**

Momentum Theory and Wake Analysis: Momentum theory for hover, non-dimensionalization, figure of merit, axial flight, momentum theory of vertical climb, modeling the stream tube, descent, wind tunnel test results, complete induced velocity curve.

Blade Element Theory: Basic method - thrust grading, torque grading, non-uniform flow, ideal twist, blade mean lift coefficient, power approximations, tip loss, hover characteristics.

Learning Outcomes:

At the end of the unit, student will be able to

- Understand the hovering and apply the momentum theory for hovering (l3)
- Understand blade element theory (l2)
- Estimate power approximations and losses (l4)

UNIT III **8 hours**

Rotor Mechanism: The edgewise rotor, flapping motion, rotor control, equivalence of flapping and feathering, blade sailing, lagging motion, Coriolis acceleration, lag frequency, blade flexibility, ground resonance.

Rotor Aerodynamics: Descending forward flight, wake analysis, In-plane H-Force, torque and power, flapping coefficients.

Learning Outcomes:

At the end of the unit, student will be able to

- Understand the concepts ofrotor mechanism (l1)
- Estimate the flapping coefficients under different phases of flight. (l3)
- Estimate the power in forward flight (l4)
- Analyze the wake in forward flight. (l4)

UNIT IV **8 hours**

Configuration and Power Estimates: Tilt wing and vectored thrust, performance of VTOL and STOL aircraft in hover, transition and forward motion. Induced, profile and parasite power requirements in hover and forward flight, performance curves with effects of altitude, in-ground and out of ground effects of helicopter, preliminary ideas on helicopter's stability.

Learning Outcomes:

At the end of the unit, student will be able to

- Estimate the performance of vtol and stol aircrafts (l4)
- Plot the performance curves considering the effects of altitude (l4)
- Evaluate in-ground and out of ground effects of helicopter (l6)

UNIT V **8 hours**

Rotor Aerodynamic Design: Blade section design, blade tip shapes - rectangular, swept, and advanced planforms, tail rotors - propeller moment, precession, yaw agility, calculation of downwash, yaw acceleration, and parasite drag, rear fuselage upsweep and aerodynamic design process.

Learning Outcomes:

At the end of the unit, student will be able to

- Design the rotor blade considering aerodynamic parameters (l6)
- Understand the aerodynamic design process in rear fuselage of helicopter (l1)
- Calculate the drag of blade tip (l4)

Course Outcomes:

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

- Design helicopter blades using blade element theory for modern helicopters based on the requirement.
- Approximate the power calculations for hover, vertical and forward flight of a helicopter.
- Adapt the design of blades in different applications such as windmills for energy generation.
- Apply the knowledge of helicopter aerodynamics for autorotation and normal flying conditions.
- Exhibit the aerodynamic design process in rear fuselage of helicopter

Text Book(s)

1. J. Seddon and S. Newman, Basic Helicopter Aerodynamics, 3/e, John Wiley, 2011.
2. W. Johnson, Helicopter Theory, Dover Publications, 1994.

References

1. A. Gessow and G. C. Myers, Aerodynamics of Helicopter, Macmillan and Co., 1987.
2. B.W. McCormick, Aerodynamics of V/STOL Flight, Academics Press, 1987.
3. J. G. Leishman, Principles of Helicopter Aerodynamics, 2/e, Cambridge University Press, 2006.
4. L. Gupta, Helicopter Engineering, Himalayan Books, 1996

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1	1	2	1	0	1	1	2	0	2
CO2	3	2	1	0	1	2	2	1	2	2	0	2	1	2	0
CO3	2	2	2	2	1	2	1	2	1	1	1	1	3	2	2
CO4	3	1	1	1	1	2	2	2	2	2	1	2	2	1	2
CO5	3	2	2	1	1	0	1	1	1	1	2	1	3	1	2

Interdisciplinary Elective – II

19EEE471: RENEWABLE ENERGY SOURCES

L	T	P	C
3	0	0	3

UNIT I **8 hours**

General: Primary and conventional energy resources – study of availability, Energy consumption pattern and growth rate in India, Non-Conventional energy sources – availability, Economics and efficiency.

UNIT II **10 hours**

Solar Energy and applications: Solar radiation – Introduction to photovoltaic and thermoelectric conversion – principles of Solar energy collection – types of collectors. Characteristics and principles of different types of collectors and their efficiencies. Solar energy applications – water heaters, air heaters, Solar cooling, Solar drying, and power generation – solar tower concept (Solar plant) – Solar pump.

UNIT III **8 hours**

Wind Energy: Energy from the wind – General theory of windmills – types of wind mills – Elementary design principles – performance of wind machines – wind power – efficiency.

UNIT IV **8 hours**

Tidal Energy: Energy from tides and waves – working principles of tidal plants – tidal Power generations – Geothermal energy – principle of working of Geothermal power plants.

UNIT V **8 hours**

Bio-Energy: Energy from Bio-mass – Bioconversion processes. Bio-gas - its generation and utilization Bio-gas plants – various types – Industrial Wastes – Municipal waste – Burning – Plants – Energy from the Agricultural wastes – Applications.

Text Books:

1.G.D.Rai,Non-Conventional Energy Sources, Khanna publishers.
2.M.P.Agrawal,Future Sources of Electrical Power , 1st edition, S.Chand& Co., 1999.

Reference Books:

1. S.Rao,Energy Technology – Non-Conventional, Renewable & Conventional , Khanna publishers.

19EEE473: HYBRID ELECTRIC VEHICLES

L	T	P	C
3	0	0	3

Preamble: This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. The course will be useful for post-graduate students, teachers, practitioners and final year undergraduate students. This course goes deeper into the various aspects of hybrid and electric drive train such as their configuration, types of electric machines that can be used, energy storage devices, etc. Each topic will be developed in logical progression with up-to-date information.

Course Objectives:

The purpose of the course is to

- Study various basic concepts of hybrid and electric vehicles.
- Expose various basic conventional vehicle performance and various hybrid drive-train topologies.
- Familiarize various electric components used in hybrid and electric vehicles
- Expose various energy storage requirements in hybrid and electric Vehicles
- Interpret the energy management strategies used in hybrid and electric vehicles.

UNIT I **8 hours**

Basic concepts of Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.

UNIT II **10 hours**

Conventional Vehicles: Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.
Hybrid Electric Drive-Trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT III **8 hours**

Electric Propulsion Unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT IV **8 hours**

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

UNIT V **8 hours**

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Text Books:

1. Chrismi, M. AbulMasrur and David WenzhangGao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley, 2011.

2. Yang Sheng Xu, HuihuanQian, Jingyu Yan and Tin Cun Lam, Hybrid Electric Vehicle Design and Control: Intelligent Omnidirectional Hybrids, IET, 2014.

Reference Books:

1. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2004.

Course Outcomes:

Upon completion of the course, the students would be able to

- Compare the difference between hybrid and electric vehicles (L2)
- Identify different hybrid drive-train topologies. (L3)
- Estimate the various electric components used in hybrid and electric vehicles (L5)
- Assess various problems in hybridization of different energy storage devices. (L5)
- Predict various issues of energy management strategies. (L6)

19EEI472: MICRO ELECTRO-MECHANICAL SYSTEMS

L	T	P	C
3	0	0	3

Preamble: This course introduces the fundamentals and applications of MEM. The course emphasizes the working principles, fabrication technologies and packaging methods of MEMS and Microsystems. This course also deals with operating principles of Micro characterization techniques.

Course Objectives

- To understand the fundamentals and applications of MEMS and micro systems.
- To learn the working principles of micro sensors and actuators.
- To acquire knowledge on various micro fabrication technologies.
- To learn the fundamentals of Micro characterization methods.
- To understand different packaging methods used in MEMS and Microsystems.

UNIT I **8 hours**

Introduction: Need for miniaturization, Microsystems versus MEMS, micro fabrication, smart materials, structures and systems, integrated microsystems: micromechanical structures, micro sensors, micro actuators, applications of smart materials and microsystems. Applications of MEMS in automotive, health care, aerospace, industrial products, consumer products and telecommunications.

Learning Outcomes:

After completion of this unit the students will able to

- Get an overview of MEMS and microsystems (L1).
- State the need for miniaturization (L1).
- Describe the role of micro fabrication (L2).
- Differentiate the micro sensors and actuators (L4).
- Recognize the applications of MEMS in various fields (L1).

UNIT II **8 hours**

Microsensors and actuators: Silicon capacitive accelerometer, piezo resistive pressure sensor, conductometric gas sensor, electrostatic comb drive, a magnetic micro relay, portable blood analyzer, piezoelectric inkjet print head, micromirror array for video projection, micro-PCR systems, smart materials and systems.

Learning Outcomes:

After completion of this unit the students will able to

- Illustrate the working principles of various MEMS sensors (L1).
- Compare the differences between micro sensors and actuators (L2).
- Explain the operation of MEMS accelerometers, pressure sensors and gas sensors (L2).
- Summarizes the advantages and limitations of various MEMS sensors and actuators (L2).
- Lists the applications of various smart materials and systems (L1).

UNIT III **8 hours**

Micro fabrication technologies: Silicon as a material for micromachining, Thin-film deposition, lithography, doping, etching, silicon micromachining: bulk and surface, specialized materials for microsystems: polymers and ceramic materials, advanced processes for micro fabrication: wafer bonding techniques, dissolved wafer processes, LIGA process, HexSilprocess.

Learning Outcomes:

After completion of this unit the students will able to

- Identify the importance of silicon as a substrate material (L1).
- Get on overview on physical and chemical techniques for thin film deposition (L1).

- Distinguish dry and wet chemical etching techniques (L4).
- Compare bulk and surface micromachining processes (L2).
- Describe polymeric and ceramic materials and their processing (L2).

UNIT IV **8 hours**

Micro Characterization techniques: Scanning electron microscopy, X-ray Diffraction, X-ray photoelectron spectroscopy, Atomic force microscopy, UV-Visible spectroscopy, Fourier Transform Infrared spectroscopy, Transmission electron spectroscopy.

Learning Outcomes:

After completion of this unit the students will able to

- Understand the working principles of various characterization techniques (L1).
- Explain the advantages and limitations of different characterization techniques (L2).
- Recognize the techniques to characterize a material (L2).
- Summarize the features of various characterization techniques (L4).
- Differentiate the types of spectroscopy techniques (L4).

UNIT V **8 hours**

MEMs Packaging: Overview of Mechanical Packaging of Microelectronics, Micro-system Packaging, Interfaces in Micro-system Packaging, Essential Packaging Technologies, Three-Dimensional Packaging, Assembly of MEMS, Selection of Packaging Materials, Signal Mapping and Transduction, Design Case: Pressure Sensor Packaging.

Learning Outcomes:

After completion of this unit the students will able to

- Differentiate microelectronic packaging and microsystem packaging (L4).
- Describe different interfaces in microsystem packaging (L2).
- Summarizes the features of three-dimensional packaging (L4).
- Identify materials used for microsystem packaging (L1).
- Describes major steps involved in pressure sensor packaging (L2).

Course Outcomes:

After completion of this course the students will able to

- Understands the MEMS and Microsystem working principles (L1).
- Acquires knowledge on micro sensors and actuators (L2).
- Learn various MEMS fabrication methods (L1).
- Explain the working principles of various types of Micro characterization methods (L2).
- Understands different Microsystems packaging techniques (L1).

Text Books:

1. G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, Micro and Smart Systems, Wiley India, 2010.
2. Tai-Ran Hsu, “MEMS and Microsystems: Design and Manufacture”, Wiley, 2008.

References:

1. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systemsand MEMS: Design and Development Methodologies, John Wiley, 2006.
2. Mohamed GadelHak , The MEMS Handbook, University of Notre Dame,
3. M.-H. Bao, “Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes”, Elsevier, New York, 2000
4. M.J. Madou, "Fundamentals of Microfabrication",3rd Ed, CRC, 2011
5. Vinod Kumar Khanna, Nano sensors: Physical, Chemical and Biological, Series in Sensors, CRC press Taylor and Francis Group, 2012

19EEI371: SENSORS AND TECHNOLOGY

L	T	P	C
3	0	0	3

Preamble: The emphasis of this course is on the design and applications of various sensors for the measurement of physical parameters in an industry. This course covers the study of basic principles used in mechanical, thermal, magnetic, radiation and electro analytical sensors. This course introduced the latest advancement in sensor technologies like MEMS and NEMS.

Course Objectives:

- To study the basic fundamentals of sensors and their applications.
- To Familiarize the principles of different mechanical and electromechanical sensors
- To study the various types of thermal, magnetic and radiation sensors
- To acquaint with the different Electro analytical sensors
- To study the Advancement s in Sensor technology

UNIT I **8 hours**

Sensors Fundamentals and Applications: Basic Sensor Technology, Sensor Systems, Sensor classification,Sensor Characteristics, System Characteristics, Instrument Selection, Data Acquisition and Readout.

Learning Outcomes:
At the end of this unit the students will be able to

- understand the basic principles of sensor technology (L1).
- analyse the Sensor Performance Characteristics (L4).
- list out the instrument selection parameters (L3).
- illustrate the design of the Data Acquisition system (L1).
- describe the working of various readout devices (L1).

UNIT II **8 hours**

Mechanical & Electromechanical Sensors: Potentiometer, Strain gauges, Inductive sensors— Ferromagnetic type, Transformer type, Electromagnetic, Capacitive sensors— parallel plate, variable permittivity, electrostatic, piezoelectric**.**

Learning Outcomes:
At the end of this unit the students will be able to

- understand the principles and working of Inductive sensors (L1).
- describe the working of Electromagnetic sensors (L2).
- explain the working of LVDT (L2).
- discuss the basic principles behind the capacitive sensors (L1).
- illustrate the principle of piezoelectric sensor (L4).

UNIT III **10 hours**

Thermal, Magnetic and Radiation sensors: Thermal Sensors-resistance change type thermometric sensors, Thermo emf sensors and semiconducting sensors.
Magnetic sensors- Basic working principles, Magneto- strictive, Hall effect, Eddy current type, SQUID sensors.
Radiation sensors - Photo-detectors, Photo-emissive, Photomultiplier, scintillation detectors.

Learning Outcomes:

At the end of this unit the students will be able to

- describe the overview of basic types of sensors used to detect optical and near-infrared radiation (L2).
- illustrate the seebeck effect used in thermo emf sensors (L2).
- explain the working of resistance change type thermometric sensors (L2).
- deliver the working principles of a Magnetic sensor (L1).
- infer the basic operation of Radiation sensors (L3).

UNIT IV **8 hours**

Electro analytical sensors: Electrochemical cell, Polarization, Reference electrode-standard Hydrogen electrode, Measuring electrodes- Metal electrodes, Membrane electrodes, Electro-ceramics.

Learning Outcomes:

At the end of this unit the students will be able to

- working principle of Electrochemical cell (L2).
- design of Reference electrode-Standard Hydrogen electrode (L5).
- design of Metal electrodes (L4).
- analyze the Working of Membrane electrodes (L4).
- construct the designing of Electro-ceramics (L3).

UNIT V **8hours**

Advancement in Sensor technology: Introduction to smart sensors, Film sensors, Introduction to semiconductor IC technology and Micro Electro Mechanical System (MEMS), Nano- sensors. Bio-Sensors.

Learning Outcomes:

At the end of this unit the students will be able to

- understand the overview of smart sensors (L2).
- outline the concept of semiconductor IC technology (L4).
- implement the thin film sensors (L5).
- fabricate MEMS/NEMS sensors (L5).
- demonstrate the principle of Biosensor (L3).

Course Outcomes:

After completing the course, the student will be able to

- understand the basic sensor technology.
- list out the instrument selection parameters.
- describe the working of Electromagnetic sensors.
- illustrate the principle of piezoelectric sensor.
- describe the overview of basic types of sensors used to detect optical and near-infrared radiation.
- design of Reference Electrode-Standard Hydrogen electrode.
- understand the overview of smart sensors.
- implement the thin film sensors.
- fabricate MEMS/NEMS sensors .

Text Books:

1. Sensor Technology Handbook by Jon S. Wilson, Elsevier, 2005
2. Measurement Systems, Application and design, E.O. Doeblin, Tata McGraw Hill, 2004.

References:

1. A course in mechanical measurements and instrumentation,
2. Transducer Engineering, Ranganathan, Allied Publishers, Chennai.
3. Transducers and Instrumentation, D.V.S.Murthy, PHI, 1995.
4. Sensors and Transducers, D.Patranabis, PHI, 2004.
5. Principles of Industrial Instrumentation, Tata McGraw –Hill Education.

19EME332: HEAT AND MASS TRANSFER

L	T	P	C
3	0	0	3

Preamble:

This course focuses on the fundamental concepts and techniques of heat and mass transfer and emphasizes application of mathematical principles in heat transfer. The knowledge of Thermodynamics and Fluid mechanics are prerequisite in understanding the concepts fluid kinematics & boundary layer concepts with respect to heat and mass transfer. Further, this course gives a good understanding of industrial related problems such as phase change heat transfer and heat exchangers.

Course Objectives

- Impart the basic laws of conduction, convection and radiation heat transfer and their applications
- Familiarize the convective heat transfer concepts
- Explain basics of radiation heat transfer
- Make conversant with the heat transfer analysis related to thermal systems like heat exchangers, evaporator, and condenser.

UNIT I **9 hours**

Introduction: Basic modes of heat transfer- rate equations- generalized heat conduction equation - steady state heat conduction solution for plain and composite slabs - cylinders - critical thickness of insulation-

Learning Outcomes:

After completion of this unit, students will be able to

- identify the phenomenon related to different modes of heat transfer (L2)
- compare different types of conduction heat transfer(L2)
- apply concept of thermal resistance and its importance in practical problems(L3)

UNIT II **9 hours**

Fins: Heat conduction through fins of uniform cross section- fin effectiveness and efficiency.
Unsteady State Heat Transfer - Transient heat conduction- lumped system analysis and use of Heisler charts.

Learning Outcomes:

After completion of this unit, students will be able to

- compare different types of Fins(L2)
- apply concept transient heat conduction in practical problems(L3)

UNIT III **10 hours**

Convection: Basic concepts of convection–heat transfer coefficient - types of convection –forced convection and free convection. Dimensional analysis in convection
External Flow: Concepts of hydrodynamic and thermal boundary layer- use of empirical correlations for flow over plates and cylinders. Fluid friction – heat transfer analogy
Internal Flow: Use of empirical relations for convective heat transfer in horizontal pipe flow.
Free Convection -development of hydrodynamic and thermal boundary layer along a vertical plate – use of empirical relations for convective heat transfer on plates and cylinders in horizontal and vertical orientation

Learning Outcomes:

After completion of this unit, students will be able to

- apply the physical phenomenon of convective heat transfer(L3)
- calculate convective heat transfer using empirical relations for different cases (L6)
- use analogy between fluid friction and heat transfer to solve engineering problems.(L6)

UNIT IV **9 hours**

Boiling and Condensation: Different regimes of boiling- nucleate, transition and film boiling – condensation - filmwise and dropwise condensation.

Heat Exchangers: Types of heat exchangers- parallel flow- counter flow- cross flow heat exchangers- overall heat transfer coefficient- LMTD and NTU methods- fouling in heat exchangers

Learning Outcomes:

After completion of this unit, students will be able to

- identify different regimes of boiling in design of boilers(L1)
- interpret the basic modes of condensation heat transfer (L2)
- explain the working of different types of heat exchangers (L1)
- calculate the heat transfer in heat exchangers (L5)
- design a heat exchanger for a given application(L6)

UNIT V **9 hours**

Radiation: Radiation heat transfer – thermal radiation – laws of radiation - Black and Gray bodies – shape factor-radiation exchange between surfaces - Radiation shields - Greenhouse effect.

Mass Transfer: Conservation laws and constitutive equations - Fick's law of diffusion, isothermal equi-mass - Equimolal diffusion- - diffusion of gases and liquids- mass transfer coefficient.

Learning Outcomes:

After completion of this unit, students will be able to

- apply the principles of radiation heat transfer(L3)
- design a radiation shield for given conditions (L6)
- examine the effect of greenhouse gases on atmosphere(L2)
- explain the basic mechanism of mass transfer(L2)
- differentiate between mass transfer due to convection and diffusion (L5)

Course Outcomes

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

- apply the concepts of different modes of heat transfer. (L3)
- apply knowledge of conduction heat transfer in the design of insulation of furnaces and pipes. (L3)
- analyse free and forced convection phenomena in external and internal flows. (L4)
- design of thermal shields using the concepts of black body and non-black body radiation. (L6)
- apply the basics of mass transfer for applications in diffusion of gases.(L3)

Text Book(s):

1. P.K. Nag, Heat Transfer, 3/e, Tata McGraw-Hill, 2011.
2. F. P. Incropera and D.P. Dewitt, Fundamentals of Heat and Mass Transfer, 6/e, John Wiley, 2007.

References:

1. J.P.Holman, Heat Transfer, 9/e, Tata McGraw-Hill,2008.
2. Cengel. A.Yunus, Heat Transfer- A Practical Approach, 4/e, Tata McGraw-Hill, 2007.
3. S.P. Sukhatme, A Textbook of Heat Transfer, Universities Press, 2005
4. Lienhard and Lienhard, A Heat and Mass Transfer, Cambridge Press, 2011.
5. C.P. Kothandaraman and S. Subramanyan, Heat and Mass Transfer databook, New Age Publications, 2014

19EME346: CAD/CAM

L	T	P	C
3	0	0	3

Preamble:

The concept of CAD/CAM is a computer aided design and manufacturing approach of using computers to control the entire production process from the beginning. The integration of all elements of the CAD/CAM environment allows individual processes to exchange information with each other and initiate actions. These activities encompass all functions necessary to translate customer needs into a final product. It includes computer aided design (CAD), computer aided manufacturing (CAM), CAPP, computer aided process planning, computer numerical control machine tools, robots, computer integrated production management system and a business system integrated by a common database.

Course Objectives

- Acquire fundamental understanding of the principles of CAD/CAM, including engineering drawing, geometric and surface modeling, and feature-based design.
- Use engineering mathematics related to geometry to understand CAD/CAM concepts.
- Apply computer aided manufacturing principles to perform manual and computer aided numerical control programming.
- Apply CAD/CAM concepts to product design and manufacturing
- Understand concept of Group Technology, FMS and CIM

UNIT I **10 hours**

Introduction: CAD/CAM/CIM, CAD/CAM input devices, CAD/CAM output devices, CAD/CAM software, Graphics standards and benefits of CAD. Transformations of geometry: Translation, scaling, rotation and mirroring. Homogeneous transformations, concatenation of transformations.

Learning Outcomes

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

- describe basic structure of CAD workstation, Memory types, input/output devices and display devices and computer graphics (L2).
- apply geometric transformations on the created wireframe, surface and solid models (L3).

UNIT II **8 hours**

Geometric Modeling of Curves: Bezier and B-spline curves in two dimensions and three dimensions; Geometric Modeling of Surfaces: Basic surfaces entities, sweep surfaces, surface of revolution, blends, intersections; Geometric Modeling of Solids: Solid entities, Boolean operations, B-rep of Solid Modeling, CSG approach of solid modeling.

Learning Outcomes

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

- use parametric 3D CAD software tools in the correct manner for making geometric part models, assemblies and automated drawings of mechanical components and assemblies (L3).
- acquire the knowledge of geometric modeling and Execute the steps required in CAD software for developing 2D and 3D models and perform transformations (L2).

UNIT III **8 hours**

Computer Aided Manufacturing (CAM): Introduction to Computer Numerical Control (CNC) and direct numerical control (DNC), structure of NC machine tools, designation of axes, drives and actuation systems, feedback devices, CNC tooling, automatic tool changers and work holding devices, Functions of CNC and DNC systems.

Learning Outcomes

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

- apply the concepts of machining for the purpose of selection of appropriate machining centers, machining parameters, select appropriate cutting tools for CNC milling and turning equipment, set-up, program, and operate CNC milling and CNC drilling (L3).
- create and validate NC part program data using manual data input (MDI) and automatically using standard commercial CAM package for manufacturing of required components using CNC milling or turning applications (L4).

UNIT IV **8 hours**

Robotics: Anatomy and configuration of robots, characteristics of robots, grippers, application of robots in manufacturing, robot programming languages.

Learning Outcomes

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

- understand robot configuration, structures, basic components, workspace and generations of robots (L2).
- understand the present & future applications of a robot (L1).

UNIT V **8 hours**

Group Technology: Introduction to group technology, part classification and coding systems: OPITZ, MICLASS. Computer aided process planning (CAPP): Introduction to CAPP, variant and generative methods of CAPP, advantages of CAPP, computer integrated manufacturing (CIM): Elements of CIM, CIM case studies.

Learning Outcomes

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

- Examine the importance of Group Technology, CAPP and CIM concepts (L4).

Course Outcomes

After completing the course, the student will be able to

- apply engineering knowledge, techniques, skills and modern tools to analyze problems in both design and manufacturing (L3).
- apply geometric transformation techniques in CAD (L4).
- develop mathematical models to represent curves, surfaces and solids (L4).
- develop manual and APT part programs for 2D complex profiles and test the programs through simulation (L3).
- demonstrate knowledge of industrial robots, CAPP, GIT and CIM systems (L2).

Text Book(s)

1. Mikell P. Groover and Emory W.Zimmers Jr, CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education Inc., 1984.
2. P.N.Rao, CAD / CAM Principles and Applications, 3/e, Tata McGraw Hill, 2014.

References

1. Ibrahim Zeid and Sivasubramanian, R., CAD/CAM Theory and Practice, 2/e, Tata McGraw Hill, 2009.
2. M.M.M. Sarcar, K. Mallikarjuna Rao, K. Lalit Narayan, Computer Aided Design and Manufacturing, 2/e, Printice Hall of India, 2012.

19EME348: ROBOTICS AND AUTOMATION

L	T	P	C
3	0	0	3

Preamble

In view of the meteoric industrial development Robotics and Automation are two closely related technologies which manifest high end requirements of integrated technologies and their application in industry. In this context Robotics and Automation in conjunction aims to impart the basics of Robot Kinematics, Robot Programming and its industrial applications followed by Automation, Flexible Manufacturing Systems, Automated Materials Handling and Storage Systems.

Course Objectives

- To familiarize the history and automation of robots and its applications.
- To enhance the students' knowledge about robot end effectors, sensors and their design as well as their applications.
- To give basic inputs related to Robot cell Design, Drives and Controls
- To impart computational skills related to kinematics and dynamics of robots
- To acquire knowledge about Robot Programming methods & Languages of robots.
- To develop the ability to analyze and design the articulated systems and their applications

UNIT I **9 hours**

Introduction: Historical robots, robots in science fiction, future trends of robots, definitions of robots, present application status.
Robot End Effectors: Classification of end effectors, drive systems for grippers, mechanical grippers, magnetic grippers, vacuum grippers, adhesive grippers, hooks, scoops and other miscellaneous devices, active and passive grippers.

Learning Outcomes:

After completing this unit, the student will be able to

- define robot systems (L1)
- explain the evolution of robotic systems(L2)
- classify and Interpret the functioning of end effectors (L2)

UNIT II **9 hours**

Robot Drives, Actuators and Control: Functions of drive systems, general types of control, pump classification, introduction to pneumatic systems, electrical drives, dc motors and transfer functions, stepper motor, drive mechanisms.

Learning Outcomes:

After completing this unit, the student will be able to

- enumerate the types of robot drive systems and controls (L1)
- describe the types of actuator mechanisms (L1)
- formulate the transfer function of electric systems (L5)
- interpret various types of drive mechanisms (L2)

UNIT III **7 hours**

Robot Kinematics: Forward and reverse kinematics of 3 degrees of freedom robot arm, forward and reverse kinematics of a 4 degree of freedom, arm manipulator in 3-D, homogeneous transformations.

Learning Outcomes:

After completing this unit, the student will be able to

- associate the relation between kinematic linkages and robot kinematics. (L2)
- analyze the manipulator kinematics with reference to degrees of freedom (L4)
- discover the Formulate the transfer function of electric systems (L5)
- solve numerical problems in transformations. (L3)

UNIT IV **9 hours**

Robot Sensors: Need for sensors, types of sensors, robot vision systems, robot tactile systems, robot proximity sensors, robot speech and hearing, speech synthesis, noise command systems, speech recognition systems.

Learning Outcomes:

After completing this unit, the student will be able to

- recognize the functionality of robot sensors in robotic systems (L2)
- classify different types of sensors with their application (L2)
- interpret the basic concepts of vision and tactile systems (L2)
- describe the fundamentals of speech systems in robotics (L1)

UNIT V **9 hours**

Robot Applications: Capabilities of robots, materials handling, machine, loading and unloading, machining and fettling, robot assembly, welding, future applications.

Learning Outcomes:

After completing this unit, the student will be able to

- give examples of the applications of robots in manufacturing industry (L2)
- interpret the applicability of robotic systems for future domains (L2)

Course Outcomes

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

1. understand the basic components of robots and the types of robots and robot grippers
2. comprehend and interpret various aspects relating to the designing of end effectors
3. analyze and demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational work-space characteristics
4. interpret basic safety guidelines for robotic applications.
5. describe and judge the use of robotics in industrial applications.

Text Book

1. S.R. Deb, Robotics Technology and Flexible Automation, TMH, 2010.

References:

1. Satya Ranjan, Robotics Technology and Flexible Automation, TMH, 2001.
2. James L.Fuller, Robotics: Introduction, Programming and Projects, Maxwell Macmillan, 2000

19ECS471: INTRODUCTION TO OPERATING SYSTEMS

L	T	P	C
2	0	2	3

Operating systems are an essential part of any computer system and equally important for computer science education. This course provides a clear description of the concepts that underlie operating systems.

Course Objectives

This course imparts knowledge on

- To introduce students with basic concepts of the operating system, its functions and services.
- To provide the basic concepts of process management and synchronization
- To familiarize the dead lock issues
- To understand the various memory management schemes.
- To give exposure over I/O systems and mass storage structures and Linux systems.

Unit I: **8 L**

Introduction: What Operating Systems Do, Computer System Organization, Computer-System Architecture, Operating System Structure, Operating system operations, Process Management, Memory Management, Storage management, Protection and security, Kernel data structures

Learning Outcomes:

After completion of this unit, student will be able to

- describe the basic organization of the computer systems.(L1)
- interpret the major components of operating systems.(L2)
- give an overview of the many types of computing environments.(L2)

Unit II: **8 L**

Operating system Structures: operating system services, User and operating system Interface, system calls, Types of System calls, system programs, operating system structure, system boot.

Process Management: Process concepts, process scheduling, Operations on processes, inter-process communication.

Learning Outcomes:

After completion of this unit, student will be able to

- describe the services an operating system provides to user's, processes, and other systems.(L1)
- explain the various ways of structuring an operating system.(L2)
- interpret the notion of a process- a program in execution and describe the various features of processes, including scheduling, creation and termination.(L3)
- analyze inter process communication using shared memory and message passing.(L4)

Unit III: **10 L**

CPU Scheduling: Scheduling-criteria, scheduling algorithms, Thread scheduling, Multiple processor scheduling, algorithm evaluation.

Process Synchronization: Critical section problem, Peterson's solution, synchronization hardware, Mutex locks, semaphores, classic problems of synchronization, monitors.

Learning Outcomes:

After completion of this unit, student will be able to

- identify CPU-scheduling and describe various CPU-scheduling algorithms.(L2)
- estimate evaluation criteria for selecting a CPU-scheduling algorithm for a particular system.(L2)
- identify critical section problem. (L2)
- find both hardware and software solutions to the critical section problem.(L1)
- classify several classical process synchronization problems.(L3)

Unit IV: **10 L**

Deadlock: System model, deadlock characterization, deadlock prevention, detection and avoidance, recovery from deadlock.

Memory Management: Swapping, contiguous memory allocation, paging, segmentation, structure of page the table.

Learning Outcomes:

After completion of this unit, student will be able to

- develop description of deadlocks.(L3)
- show a number of different methods for preventing or avoiding deadlocks.(L3)
- reproduce detailed description of various ways of organizing memory hardware.(L2)
- review various techniques of allocating memory to processes.(L2)

Unit V: **8 L**

Virtual memory: Demand paging, Copy-on-Write, page-replacement, allocation of frames, thrashing.

File Concepts: File concept, access Methods, directory and disk structure, protection.

Learning Outcomes:

After completion of this unit, student will be able to

- illustrate how paging works in contemporary computer systems.(L3)
- explain the concept of demand paging, page replacement algorithms, allocation of page frames.(L2)
- summarize briefly about file concepts.(L2)

Textbook(s):

1. Abraham Silberchatz, Peter B. Galvin, Greg Gagne, Operating System Concepts with Java, 9/e, John Wiley, 2016.

References:

1. Andrew S Tanenbaum, Modern Operating Systems, 2/e, Pearson/PHI, 2014.
2. Crowley, Operating System, A Design Approach, McGraw-Hill, 2012.
3. Stallings, Operating Systems - Internal and Design Principles, 5/e, 2013.
4. Pal Chaudhary, Operating system principles & Design, PHI Learning,1/e, 2013.
5. Deitel and Deitel, Operating System, Pearson Education, 2003.
6. D.M. Dhamdhere, Operating systems- A Concept based Approach-2/e, McGraw Hill, 2010.

Course Outcomes:

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

- illustrate the basic and overall view of operating system(L3)
- describe the structure of operating systems, applications, and services provided by operating systems(L2)
- analyze the concept of a process, process life cycle, process states and state transitions.(L4)
- implement various CPU scheduling strategies and process synchronization techniques.(L3)
- verify & resolve deadlock handling situation(L4)
- explain the importance of file structures in the data storage and manipulation.(L2)
- implement and practice various memory-management schemes.(L3)

19ECS475: INTRODUCTION TO WEB TECHNOLOGIES

L	T	P	C
2	0	2	3

This course enables the students to associate with developing websites for hosting via intranet or internet. The web development process includes web design, web content development, client-side scripting, server-side scripting. Web development is the coding or programming that enables website functionality as per the owner's requirements. It mainly deals with the non-design aspect of building websites, which includes coding and writing markup.

Course objectives

- On completion of this course, a student will be familiar with client server architecture and able to develop a web application using java technologies. Students will gain the skills and project- based experience needed for entry into web application and development careers.
- Employ fundamental computer theory to basic programming techniques.
- Use fundamental skills to maintain web server services required to host a website.
- Select and apply markup languages for processing, identifying, and presenting of information in web pages.
- Use scripting languages and web services to transfer data and add interactive components to web pages.

UNIT I **10 L**

HTML Programming: HTML elements, working with images, working with lists, Introduction to forms, working with frames, Introduction to cascading style sheets: inline, External, Internal, Style classes, multiple styles.

JavaScript Programming: Introducing JavaScript, Client-side Benefits of using JS over VB script, Embedding JavaScript in an HTML page, Handling Events, Using variables in JavaScript, Creating Objects in JavaScript, Using array in JavaScript, Using Operators, Working with control flow Statements, Working with Functions.

Learning Outcomes

After completion of this unit, student will be able to

- Analyze the uses of CSS in developing web technologies.(L4)
- determine the uses of HTML and its basic tags and their uses.(L3)
- Understand the way CSS helps us develop full-fledged graphic web pages.(L2)
- Illustrate how javascript is used in our day to day life.(L4)
- determine the basics of Elements in javascript(L3).

UNIT II **10 L**

PHP Programming: Introducing PHP: Creating and Running a PHP script, working with Variables and constants, Exploring data Types in PHP, Exploring operators in PHP, controlling program flow: Conditional statements, Looping statements, Break, continue and Exit statements.

Forms: Working with the <form> Tag and its elements, Text box, radio button, checkbox, Drop down box, processing a Web Form, Validating a form.

Learning Outcomes

After completion of this unit, student will be able to

- describe initial concepts of PHP.(L2)
- write conditional and looping statements to develop full-fledged PHP programmes.(L6)
- Understand Forms in PHP.(L2)
- explain Arrays in PHP.(L3)
- write functions and Iterators to create programs in PHP. (L6)

UNIT III **8 L**

Working with functions and arrays in PHP: User-defined functions, Built- in functions, recursive, variable and call back functions, Arrays and Types of Arrays, Traversing Arrays Using Loops and Array Iterators, Built In Array functions.

Introduction to XML: Describing DTD, Xml Schemas, Document Object Model(DOM), Extensible Style sheet Language Transformation(XSLT), Simple API for XML(SAX).

Learning Outcomes

After completion of this unit, student will be able to

- Analyze the syntaxes of XML.(L4)
- review the different XML schemas used to develop web technologies(L2)
- Understand other XML technologies like XLink, XPointer and XQuery.(L2)
- Connecting to a database using PHP and MySQL.(L4)
- Applying the concept of tables in Databases using PHP and MySQL.(L3)

UNIT IV **8 L**

Introduction to Servlets: java servlet, servlet api, Servlet object, Lifecycle of a servlet, Deploying first Servlet App, Initialization parameters, handling http request & responses, using cookies, session tracking and security issues.

Learning Outcomes

After completion of this unit, student will be able to

- explain servlets in JAVA and how servlets can be used to develop web pages.(L2)
- Review the Lifecycle of a Servlet.(L2)
- Understand the concept of cookies and session tracking(L2)

UNIT V **8 L**

Introduction to JSP: Understanding JSP: advantage over servlets, tag based Approach, JSP Lifecycle: Page translation stage, compilation stage, Loading and Initialization stage, Request handling stage, Destroying Stage, Creating simple JSP pages.

Learning Outcomes

After completion of this unit, student will be able to

- determine the uses of JSP in creating web applications.(L3)
- Understand the different stages of JSP Lifecycle.(L2)
- describe the concepts used in Programming Using JDBC.(L2)
- review the javax.sql.* package and how it is useful in JSP.(L2)
- Analyze the components of JSP and how it helps us to connect to a database.(L4)

Text book(s)

1. Web Technologies: HTML, JAVASCRIPT, PHP, JAVA, JSP, XML and AJAX, Black Book bykogent leanrning solutions, published by dreamtech.
2. Jason Hunter, William Crawford, Java Servlet Programming, 2/e, O'Reilly,2003

References

1. XML: The Complete Reference –(by Williamson Heather published by Osborne publications 1/e)(UNIT 3)
2. Robert W.Sebesta, Programming the World Wide Web, 4/e, PearsonEducation,2007.

Course Outcomes:

After completion of the course the student will be able to

- develop a dynamic webpage by the use of javascript and DHTML.(L6)
- write a well formed / valid XML document.(L6)
- connect a java program to a DBMS and perform insert, update and delete operations on DBMS table.(L4)
- write a server side java application called Servlet to catch form data sent from client, process it and store it on database.(L6)
- write a server side java application called JSP to catch form data sent from client and store it on database.(L6)

19EIE475: ENTREPRENEURSHIP DEVELOPMENT

L	T	P	C
3	0	0	3

Preamble: This course aims to provide entrepreneurial abilities because business conditions have changed significantly since the advent of new technologies and business started demanding from both CEOs and managers entrepreneurial abilities which are in line with latest and contemporary business models in the era of globalization and disruption. This course includes a description of various concepts like process of entrepreneurship, opportunity identification, business plan preparation, registration process of business enterprise, funds requirement for business and evaluation of business enterprise.

Course Objectives:

- To identify the concept and process of Entrepreneurship and its role in the society.
- To recognize opportunity identification, different business model and business plan preparation.
- To explain the entrepreneurship development programmes (EDP) and Central government policy initiatives for entrepreneurship development
- To identify the registration process of a business enterprise.
- To assess funds requirement and evaluation of business enterprise.

UNIT I **8 hours**

Introduction: Entrepreneur and Entrepreneurship; Description of an Entrepreneur; Traits of an Entrepreneur; evolution of Entrepreneurship; functions of an entrepreneur; Entrepreneurial mindset; Entrepreneurial Motivation; entrepreneurial process; entrepreneurial competencies; types of entrepreneurships; role of entrepreneurship in the economic development.

Learning Outcomes:

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

- identify the traits and functions of an entrepreneur(L2).
- recognize entrepreneurial process and entrepreneurial competencies(L3).
- demonstrate the role of entrepreneurship in economic development(L4).

UNIT II **8 hours**

Business Idea Generation and Business Opportunity Identification: Scanning the environment; finding the gaps for new business and new ways of business, Startup Culture and Incubation; Boot Camps; Mentoring the ideation process, validation of different ideas, Proto type Development; Business Model Development; need and importance of Business Plan preparation- process of Business Plan.

Learning Outcomes:

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

- list the gaps for new business and new ways of business(L1).
- identify startup culture and incubation and boot Camps(L2).
- recognize mentoring the ideation process, validation of different ideas(L2).
- apply prototype development and business model development(L3).
- demonstrate the need for and importance of business plan preparation- process of Business Plan(L3).

UNIT III **8 hours**

Entrepreneurship Development Programmes and Government Support to Entrepreneurs: Evolution of Entrepreneurship Development Programmes (EDP)-Phases of EDPs-Course content and curriculum of EDPs–Educational Institutions and Entrepreneurship Development Programmes;

Definition of Micro, Small and Medium Enterprises (MSME), growth and development of MSME's in India; Central Government Policy initiatives; District Industrial Centers and Industrial Estates.

Learning Outcomes:

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

- identify the phases of EDPs and curriculum of EDPs(L2).
- recognize growth and development of MSME's in India(L2).
- explain central government policy initiatives and district industrial centers(L2).

UNIT IV **8 hours**

Registration of Business Enterprises: Business Name registration; Trade Mark registration; Patent registration and legal formalities; Sole Proprietorship, Partnership, Limited Liability Partnership (LLP), Private Limited Company and Public Limited Company Registration process; benefits of registration of enterprises; process of obtaining licenses and permissions including export and import license; Income Tax and Goods and Service Tax (GST) registration process.

Learning Outcomes:

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

- interpret registration of business enterprises(L3).
- evaluate sole Proprietorship, Partnership, Limited Liability Partnership (LLP) (L6).
- Identify the process of obtaining licenses and permissions including export and import license(L2).

UNIT V **8 hours**

Funds Requirement and Evaluation of Business Enterprise: Own Capital v/s Loan Capital (equity and debt); Cost of the project; evaluation of different sources of funds - Projected Income and Turnover statements; Seed Capital, Angel Investment and Venture Capital; Institutional Financing to Entrepreneurs; Working Capital; Short term-Medium term and Long term financing to entrepreneurs by financial institutions and commercial banks.

Learning Outcomes:

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

- interpret the cost of the project, projected income and turn over statements (L3).
- evaluate different sources of funds(L6).
- Recognize Institutional Financing to Entrepreneurs financial institutions and commercial banks.(L2).
- Identify the process of obtaining licenses and permissions including export and import license(L2).

Case Analysis (not exceeding 200 words):

Any Software Company Business Plan- Any Automobile Company Business Plan- Any Ecommerce Business plan.

Course Outcomes:

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

- Interpret the concept and process of Entrepreneurship and its role in the society.(L3).
- Differentiate different business models and analyze business plan preparation. (L4).
- Appraise entrepreneurship development programs (EDP) and Central government policy initiatives for entrepreneurship development (L4).
- Conclude registration process of business enterprise (L6).
- Estimate funds requirement and interpret short term, medium term and long-term financing to entrepreneurs by financial institutions and commercial banks (L6).

Teaching and learning resources

1. Donald F. Kuratko, Entrepreneurship: Theory, Process, Practice, Cengage Learning, New Delhi, Latest Edition.
2. Robert Hisrich, M.J.Manimala, M.P.Peters and D. A.Shepherd "Entrepreneurship" MC Graw Hill Education, Latest Edition.
3. Bruce R Barringer, Preparing effective Business Plan-an Entrepreneurial Approach, New Delhi: Pearson Publication, Latest Edition.
4. Jeffrey A Timmons, New Venture Creation, New Delhi: Irwin publishers, Latest Edition.
5. Dr. S. S. Khanka "Entrepreneurship Development", S. Chand and Company Limited, New Delhi, Latest Edition.
6. PoornimaM.Charantimath,"EntrepreneurshipDevelopment-SmallBusiness Enterprises", Pearson, New Delhi, Latest Edition.
7. AryaKumar,"Entrepreneurship:CreatingandLeadinganEntrepreneurialOrganization" Pearson, New Delhi,Latest Edition.
8. Vasant Desai, Dynamics of Entrepreneurial Development and Management New Delhi: Himalaya Publishing House, Latest Edition.

Journals

1. Harvard Business Review
2. International Journal of Entrepreneurial Behavior And Research
3. International Journal of Small Business Management
4. International Journal of Entrepreneurship And Innovation Management

Daily English News Papers

1. The Mint
2. The Economic Times
3. Business Standard
4. Business Line

19EAE491: PROJECT PHASE – I

L	T	P	C
0	0	2	1

Course Objectives:

1. Learn practical and scientific aims focused on extending the student’s understanding and application.
2. Focus on developing and understanding of the nature and practices of the project, and the skills which they might need when working in the laboratory.
3. Learn the ideas, identify and understand assumptions, thesis and arguments that exist.

Course Outcomes: At the end of the course the student will be able to:

1. Demonstrate the experience of working with the industry's practices.
2. Develop team working skills, communication, organization and leadership.
3. Think for themselves, decision making, explanation, justification and evaluation.
4. Demonstrate organizational skills, planning, preparation and record keeping.
5. Identify the software and hardware tools to build the project.

COs	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO1 0	P O1 1	PO12	PSO1	PS O2	PSO3
CO1	3									2	3	3	3		
CO2			3		3		3			2				3	
CO3		3		3						3				3	
CO4						3		3		1					3
CO5									3	1					2

19EAE493: INTERNSHIP

L T P C

1

Course Objectives: To make the student to:

1. Expose to industrial practices such that they can correlate the theory learnt in classroom to the procedures adopted in the industry.

Course Outcomes: At the end of the course the student will be able to:

1. Appreciate how the theoretical knowledge they have learned is applied in the Industry.
2. Have an exposure and confidence by working alongside scientists and engineers.
3. Introduce to the trade-offs between various methods for attitude control and attitude determination.
4. expose students to industrial practices
5. Correlate the theory learnt in the classroom to the procedures adopted in industry.

COs	Programme Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3									2	3	3	3		
CO2			3		3		3			2				3	
CO3		3		3						3				3	
CO4						3		3		1					3
CO5									3	1					2

19EAE495: COMPREHENSIVE SKILL DEVELOPMENT VI

L	T	P	A	C
0	0	0	6	1

Course Objectives:

- To encourage the all-round development of students by focusing on soft skills, Coding & domain skills.
- To make the engineering students aware of the importance, the role and the content of soft skills, Coding and domain skills through instruction, knowledge acquisition, demonstration and practice.
- To develop and nurture the soft skills, coding and domain skills of the students through individual and group activities.
- To expose students to right attitudinal and behavioral aspects and to build the same through activities

Course Outcomes:

- On completion of the course, student will be able to– Effectively communicate through verbal/oral communication and improve the listening skills
- Write precise briefs or reports and technical documents, actively participate in group discussion / meetings / interviews and prepare & deliver presentations. Become a more effective individual through goal/target setting, self-motivation and practicing creative thinking.
- Students will be able to understand the problems and develop their competitive coding skills.
- Apply the skills in various domains and will be able to solve complex problems faced by the industry.
- Function effectively in multi-disciplinary and heterogeneous teams through the knowledge of team work, Inter-personal relationships, conflict management and leadership quality

Part-1 **- 2 Hours per week**

A. Verbal and Soft Skills:

Unit	Module/ Topics	Hrs
1.	Resume Writing & Acing Job Interviews	4
2.	Corporate Readiness 1	3
3.	Mock Tests with Solutions 1	5
4.	Company-Specific Tests with Solutions 1	3
	Total	**15**

B. Quantitative Aptitude and Reasoning

Unit	Module/ Topics	Hrs
1.	Combinatorics	4
2.	Crypt arithmetic & Modular Arithmetic	5
3.	Analogy & Classification of Numbers	3
4.	Puzzles	3
	Total	15

Unit	Module/ Topics	Hrs
1.	GRE-Oriented Advanced Concepts Discussion	4
2.	CAT-Oriented Advanced Concepts	4
3.	TCS, Infosys-Oriented Advanced Concepts	4
4.	Successful Test Cracking Techniques	3
	Total	15

Part-2 Domain Skills **-2 Hours per week**

Aerodynamics & CFD

- CFD using (coding & ANSYS) (case studies)
- Train the students on the concepts of domain discretization, equations discretization, grid generation and its types.
- Case -studies (Simulating 3D flow problems)
- Wind Tunnel Activities (Studies on building of a model, experimentation, and instrumentation)

Propulsion:

- Design and testing of a liquid rocket injector.
- Design and development of a gas turbine combustor.
- Design and development of compressors.
- Hand on training on CFX.

Flight Mechanics and Control:

- Hands on training on flight Simulation software
- Design and development of a table-top flight simulator.

Structures:

- Fabrication of composite laminates using hand lay-up and other methods.
- Applications of FEA's (using ANSYS)

Aircraft Design Practice:

- Design and fabrication of NACA Airfoils, Wings, Fuselage.
- Design and development of UAV's and MAV's
- Design and fabrication of a typical flight vehicle (using software, 3D printing)

Satellite Making:

- Orbital design using GMAT software.
- Estimation of Propulsion system
- Designing a satellite.

References:

4. https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules
5. https://confluence.cornell.edu/display/SIMULATION/ANSYS+Learning+Modules
6. https://aeromodellingtutor.in/

Program Elective – V

19EAE442: HYPERSONIC AERODYNAMICS

L	T	P	C
3	0	0	3

Preamble:

This course is designed for aerospace engineering students. It introduces the fundamentals on hypersonic flows and their characteristics. This course is designed to acquaint the learners with methods used for hypersonic flows and different experimental facilities available to understand the hypersonic flow behavior.

Course Objectives:

- Explain the flow behavior at hypersonic flows.
- Impart knowledge on the physics of shock-interactions under different conditions.
- Explain the theory used for predicting the flow characteristics at hypersonic speeds.
- Familiarize about the experimental test facilities available for hypersonic flows.
- Explain the concept of boundary layers in hypersonic flows.

UNIT I **8 hours**

Basics of Hypersonic Aerodynamics: Introduction to hypersonic aerodynamics, thin shock layers, entropy layers, low density and high-density flows, hypersonic flight paths, hypersonic flight similarity parameters, shock wave and expansion wave relations of inviscid hypersonic flows.

Learning Outcomes:

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

- Understand the characteristics of hypersonic flows (l1)
- Use the similarity parameters in hypersonic flight (l3)
- Derive the shock and expansion relations for hypersonic flows (l4)

UNIT II **9 hours**

Surface Inclination Methods for Hypersonic Inviscid Flows: Local surface inclination methods and modified Newtonian law. Newtonian theory, tangent wedge/ tangent cone and shock expansion methods, calculation of surface flow properties.

Learning Outcomes:

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

- Understand the Newtonian theory used for hypersonic flows. (l1)
- Apply the knowledge of Newtonian theory in the design of various models in hypersonic flows. (l3)
- Apply the knowledge of shock-expansion methods for wedge/cone models and calculate the flow properties. (l3)

UNIT III **9 hours**

Approximate Methods for Inviscid Hypersonic Flows: Approximate methods hypersonic small disturbance equation and theory. Thin shock layer theory, blast wave theory, entropy effects, rotational method of characteristics, hypersonic shock wave shapes and correlations.

Learning Outcomes:

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

- Understand the concept of small disturbance theory used in hypersonic flows. (l1)

- Understand the concept of blast wave theory and shock layer theory. (l1)
- Differentiate the blast wave and shock wave concepts. (l4)
- Use the correlations used in hypersonic flows. (l5)

UNIT IV **9 hours**

Viscous Hypersonic Flow Theory: Navier-Stokes equations, boundary layer equations for hypersonic flow, hypersonic boundary layer theory and non-similar hypersonic boundary layers, hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating.

Learning Outcomes:

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

- Derive the navier-stokes equations used in high speed flows (l3)
- Understand the concept of hypersonic boundary layer(l1)
- Apply concepts about aerodynamic heating at high speed flows (l3)

UNIT V **10 hours**

Viscous Interactions in Hypersonic Flows: Strong and weak viscous interactions, hypersonic shockwaves and boundary layer interactions, role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

Shock Tube Based Experimental Facilities: Impulse facilities, hypersonic wind tunnels, shock tunnels, gun tunnels, and heat transfer measurements.

Learning Outcomes:

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

- Understand about shock-boundary layer interactions in hypersonic flows (l1)
- Apply the similarity parameters for hypersonic viscous flows. (l3)
- Learn about the different test facilities used to test various models in high speed flows (l1)
- Learn about application of heat transfer measurements in high speed experimental test facilities. (l3)

Course Outcomes:

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

- Apply the knowledge of hypersonic flow conditions for various configurations.
- Apply the knowledge of shock-boundary layer interactions in the design of supersonic combustion engines.
- Apply the knowledge of shock-shock interactions in the design of missile body or re-entry vehicle design.
- Design and test any model in shock tunnels in order to understand the high temperature effects in hypersonic flows.
- Obtain knowledge about the application of heat transfer measurements in high-speed experimental test facilities.

Text Book(s)

1. J. D. Anderson, Hypersonic and High Temperature Gas Dynamics, 2/e, McGraw Hill, 2002.
2. P. Curtis, The Shock tube, Kindle edition, Dream Engine Interactive limited, 2014.
3. J. J. Bertin, Hypersonic Aerothermodynamics, AIAA Education series, 1994.
4. Y. Burtschell, R. Brun, and D. Zeitoun, Shock Waves, 1/e, Springer Verlag, 1992.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	1	2	2	0	1	1	2	2	1	2
CO2	3	2	1	0	1	2	1	1	1	2	0	2	1	2	1
CO3	3	1	1	2	0	0	1	0	1	1	2	1	3	1	2
CO4	3	1	0	1	3	1	2	1	1	1	2	2	2	1	3
CO5	2	1	1	1	1	0	1	1	0	1	0	1	3	1	2

19EAE444: ROCKETS AND MISSILES

L	T	P	C
3	0	0	3

Preamble:

This course projects contents that involve the fundamentals of rocket and missile systems. It focuses mainly on rocket aerodynamic, typical engines used, trajectory design and rocket optimization. Course find appealing and enhances interest on rocketry

Course Objectives:

- Impart knowledge on aerodynamics of rocketry.
- Train students on rocket propulsion systems solid and liquid engines.
- Impart design knowledge of different types of trajectories.
- Explain fundamentals of multi-staging and optimization of rocket design.
- Familiarize different types of materials used for rockets and missile applications.

UNIT I **10 hours**

Aerodynamics of Rockets and Missiles: Airframe components of rockets and missiles, forces acting on a missile while passing through the atmosphere, classification of missiles, methods of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment and longitudinal moment of a rocket, lift and drag forces.

Learning Outcomes

At the end of unit student will be able to

- Gain sound knowledge on different components and their significance in rockets(L2)
- Appreciates working and aerodynamic forces and moments in sustaining the flight(L4)
- Calculate and characterize the basic static performance rocket(L3)
- Quantify different types aerodynamic loads on rockets(L3)

UNIT II **9 hours**

Solid Rocket Systems: Basic concepts and design, solid propellants, casing, nozzle and its performance.

Liquid Rocket Systems: Ignition system in rockets, types of igniters and igniter design considerations, injection system and propellant feed systems of liquid rockets and their design considerations, design considerations of liquid rocket thrust chambers, combustion mechanisms.

Learning Outcomes

At the end of unit student will be able to

- Understand anatomy of solid rocket motor(L2)
- Appreciates the significance of injection, ignition, and combustion systems(L4)
- Carryout basic design calculation of motor grain(L3)
- Quantify various types of design considerations of thrust chamber(L3)
- Exhibit interest in enhancing deeper understanding combustion mechanism(L4)

UNIT III **9 hours**

Rocket Motion in Free Space and Gravitational Field: One dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields, description of vertical, inclined and gravity turn trajectories, determination of range and altitude, simple approximations to burn out velocity and altitude, estimation of culmination time and altitude.

Learning Outcomes

At the end of unit student will be able to

Understand one- and two-dimensional rocket dynamics(L2)

- Appreciates the dynamics in gravity and free space environments(L4)
- Calculate kinematic and kinetic parameters that specify the trajectory(L3)
- Exhibit interest in studying different types of maneuvers and trajectory turns(L2)
- Develop trajectory design for a typical rocket(L4)

UNIT IV **8 hours**

Multi-Stage Rocket and Attitude Control

Nomenclature of the multi-stage rocket, ideal velocity of the multi-stage rocket, vertical ascent in a homogeneous gravitational field and in vacuum (burnout velocity, culmination altitude, vertical ascent of a two-stage rocket). Rocket thrust vector control, methods of thrust vector control, thrust magnitude control, and thrust termination.

Learning Outcomes

At the end of unit student will be able to

- Gain knowledge of multi staging of rocket and its significance (L2)
- Appreciates the priority of different mass ratios and burnout velocity (L4)
- Calculate and characterize multi-stage rocket performance (L3)
- Realize the role of thrust vector control and different methods of thrust vectoring(L2)
- Quantify different thrust vectoring terms to control and guide the vehicle(L3)

UNIT V **8 hours**

Separation Systems for Rockets and Missiles: Stage separation dynamics, separation techniques.
Materials for Rockets and Missiles: Criteria for selection of materials for rockets and missiles, choice of materials at cryogenic temperatures, extremely high temperatures, requirement of materials for thermal protection and pressure vessels.

Learning Outcomes

At the end of unit student will be able to

- Understand the importance of materials and their limitations(L2)
- Select different materials as demanded by situation(L5)
- Appreciates the working of high temperature materials(L4)
- Realize the role of thermal protection and materials for pressure vessels(L2)

Course Outcomes

At the end of Course student will be able to

- Appreciates working of aerodynamic forces and moments in sustaining the flight
- Realize suitability and capacity of matching propulsive engines
- Calculate kinematic and kinetic parameters that specify the trajectory
- Gain knowledge of multi staging of rocket and its design
- Select suitable high temperature materials

Text Book(s)

1. J. W. Cornelisse, H. F. R. Schoy, K. F. Wakker, Rocket propulsion and Space Dynamics, Pitman Publishing, 1979.
2. G. P. Sutton, Rocket Propulsion Elements, John Wiley, 2000.

References

1. Barrere et al, Rocket Propulsion, Elsevier, 1960.
2. M. J. L. Turner, Rocket and Spacecraft propulsion: Principles, Practice and New Developments, Springer Praxis, 2004.
3. N. Nielsen, Missile Aerodynamics, Mountain View, 1998.
4. S. S. Chin, Missile configuration Design, McGraw Hill, 1961.

5. E. R. Parker, Material for Missiles and Spacecraft, McGraw Hill, 1982.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO 2	PSO3
CO1	3	2	1	2	1	1	1	2	1	1	2	1	3	2	1
CO2	2	1	1	1	1	1	1	2	1	1	2	1	2	1	1
CO3	2	2	1	1	1	1	1	2	1	1	1	1	2	2	1
CO4	3	2	1	1	1	1	1	2	1	1	2	1	3	1	1
CO5	3	2	1	1	1	1	1	2	1	1	1	1	3	1	1

19EAE446: INTRODUCTION TO COMPOSITE MATERIALS

L	T	P	C
3	0	0	3

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students to understand the basics principles of Mechanics of Composite Materials. Understanding these principles will help them in the Design of Aerospace Structures.

Course Objectives:

- To familiarize the terminology and materials used for composite materials
- To impart knowledge on macro mechanical behavior of lamina
- To focus on micromechanics of lamina
- To support them to understand the stress strain behavior of different types of laminates
- To instruct the strength criteria of orthotropic lamina
- To explain the design of composite structures

UNIT I **8 hours**

Composite Materials: Composite materials terminology.
Classifications: Polymer matrix, metal matrix, ceramic matrix, carbon-carbon matrix composites.
Fabrication of Fibers: Glass fibers, carbon/graphite fibers, aramid fibers, boron fibers, banana and bamboo fibers.
Application of Composite Materials: Automotive, space, marine and aircraft application.

Learning Outcomes:

After completion of this unit student will be able to

- explain the terms related to composite materials (L2)
- classify the composite materials (L2)
- summarize the fabrication procedures of fibers (L2)

UNIT II **9 hours**

Macro Mechanical Behavior of Lamina: Hooke's Law, stiffness and compliance matrix for generally anisotropic materials, orthotropic materials, transversely isotropic materials and isotropic materials. Relations between engineering constants and elements of stiffness and compliance matrix. Stress strain relations for plane stress in a unidirectional orthotropic material and arbitrary oriented orthotropic material.

Learning Outcomes:

After completion of this unit student will be able to

- Outline the procedure to obtain stiffness and compliance matrices for different materials (L2)
- Develop stress strain relations for a unidirectional orthotropic material under plane stress (L3)
- Determine stress strain relations for an arbitrary oriented orthotropic material under plane stress (L5)

UNIT III **8 hours**

Micro Mechanical Behavior of Lamina: Introduction, Mechanics of materials approach to stiffness to determine Young's modulus, Poisson's ratio and rigidity modulus. Elasticity approach to stiffness by bounding techniques of elasticity.

Learning Outcomes:

After completion of this unit student will be able to

- Apply mechanics of materials approach to stiffness to determine elastic constants (L3)

- Explain elasticity approach to stiffness by bounding techniques of elasticity to determine elastic constants (L2)

UNIT IV **9 hours**

Macro Mechanical Behavior of Laminate:

Classical Lamination Theory: Lamina stress-strain behavior, stress and strain variation in a laminate, resultant laminate forces and moments.

Special Cases of Laminate Stiffness: Single-layered, symmetrical laminates, anti-symmetrical laminates, unsymmetrical laminates.

Learning Outcomes:

After completion of this unit student will be able to

- Make use of classical lamination theory to obtain forces and moments in a laminate (L3)
- Outline various special cases of laminates ((L2)

UNIT V **8 hours**

Performance of Composite Materials:

Strength Criteria of Orthotropic Lamina: Maximum stress failure criterion, maximum strain failure criterion, Tsai-Hill failure criterion, Hoffman failure criterion and Tsai-Wu failure criterion.

Design of Composite Structures: Elements of design, structural design process, design objectives and design drivers, design analysis stages. Material selection factors, fiber selection factors, matrix selection factors.

Learning Outcomes:

After completion of this unit student will be able to

- Determine strength of orthotropic lamina using different theories (L3)
- Explain the elements and process of design of composite structures (L2)
- Select proper materials for a given application (L3)

Course Outcomes:

After the completion of this course student will be able to

- Summarize on the terminology and classification of composite materials and outline The procedure for fabrication of fibers
- Develop relations for orthotropic materials under plane stress
- Apply various approaches to determine elastic constants of composite materials
- Analyze the macro mechanical behavior of laminates
- Make use of various strength criteria in the design of composite structures

Text Book(s)

1. R M Jones, Mechanics of Composite Materials, 2/e, Taylor and Francis, 1999.

References

1. Nicholas J. Pagano, Reddy J.N, Mechanics of Composite Materials, Kluwer Academic Publishers, 1994.
2. Agarwal. B. D, Boatman. L. J, Chandrasekhar K, Analysis and Performance of Fiber Composites, 3/e, John Wiley and Sons, 2006.
3. Malik P.K, Fiber Reinforced Composites, 3/e, CRC Press, 2013.
4. Aurar K Kaw, Mechanics of Composite Materials, 2/e, Taylor and Francis,2013.

CO PO PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	0	0	2	2	1	1	2	0	2	0	0	1
CO2	3	2	2	1	1	1	0	1	2	2	1	2	2	2	1
CO3	3	2	2	1	1	1	0	1	2	2	1	2	2	2	1
CO4	3	2	2	1	1	1	0	1	2	2	1	2	2	2	1
CO5	3	2	3	2	1	1	0	1	2	2	1	2	2	3	1

19EAE448: AVIONICS

L	T	P	C
3	0	0	3

Preamble:

This course work is mainly aimed for the students, who are very interested in obtaining the knowledge of Avionics and avionics systems. From the outline of this course, it can be observed that, after completion of this course work, students are able to obtain knowledge in the areas of basics and working with of Avionic systems, overview of flight desks and cockpits, radio navigation systems, Autopilots configurations and, needs and operations of surveillance systems which are also green areas of research works in aircraft research and manufacturing organizations.

Course Objectives:

- Introduce the students to functioning and principle of operation of various avionics systems namely, flight sensors installed on a modern passenger and fighter aircraft.
- Introduce the students to guidance, landing, the concepts of autopilots and surveillance systems of UAVs, and MAV's,
- To introduce various digital electronic principles and working operations of digital circuits.
- To integrate the digital electronics with cockpit equipment
- To understand the various principles in flight disk and cockpit panels.
- To study the communication and navigation equipment

UNIT I **8 hours**

Introduction to Avionics: Importance and role of avionics, basic principles of avionics, typical avionics subsystem in civil/ military aircraft and space vehicles need for avionics in civil and military aircraft and space systems, importance of illities, integrated avionics and weapon systems, traffic collision avoidance system - TCAS-I and TCAS-II, ground proximity warning system.

Learning Outcomes

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

- Understand the role of avionics, and c principles of avionics in flying machines (L2)
- Knowledge of avionics subsystem in civil/ military aircraft and space vehicles (L2, L3)
- Explanation about the integrated avionics, weapon systems TCAS-I and TCAS-II(L2, L6)

UNIT II **8 hours**

Flight Decks and Cockpits: Control and display technologies: CRT, LED, LCD, EL, plasma panel, touch screen, direct voice input (DVI). Civil and military cockpits: MFDS, MFK, HUD, HMD, HOTAS

Learning Outcomes

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

- Understand the concepts of Control and display technologies (L2)
- Knowledge and working principal of plasma panel, touch screen, direct voice input (DVI) (L2, L4).

UNIT III **10 hours**

Radio Navigation Systems: Aircraft audio systems, basic audio transmitter and receiver principles, types of frequency bands - HF, VHF, UHF, SHF, automatic direction finder (ADF) - transmitter and receiver principles

operation.

Ranging and Landing Systems: Very high frequency Omnidirectional range(VOR), transmitter receiver principles of operation, distance measuring equipment (DME), transmitter and receiver principles of operation, instrument landing system (ILS), localizer and glideslope.

Learning Outcomes

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

- Understand the concepts of Aircraft audio systems, working of basic audio transmitter and various frequency band width (L2)
- Knowledge and working principle of (ADF) - transmitter and receiver principles of operation. (L2, L3).
- Importance of Ranging and Landing Systems of the flying machines.(L2)
- Know about the various distance measuring systems in avionics. (L2)

UNIT IV **8 hours**

Fly-By-Wire Flight Control and Navigation Systems: FBW flight control features, basic concept, advantages of FBW control, fly-by-wire control laws, redundancy and failure Survival.
Navigation Systems: Types, inertial navigation, GPS basic principles, integration of GPS and INS, differential GPS.

Learning Outcomes

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

- Understand the basic concepts of FBW flight control features (L2)
- Deep knowledge of fly-by-wire control laws, redundancy and failure Survival. (L2, L3).
- Get to know about the various types of navigation systems. (L2)

UNIT V **10 hours**

Surveillance and Auto Flight Systems: Basic principles, height control, heading control, ILS/MLS coupled control, automatic landing, and speed control and auto-throttle control system.
Flight Management Systems: Introduction, radio navigation tuning, navigation, flight planning, performance prediction and flight path optimization, control of vertical flight path profile. Integrated data transfer methodology by use of MILS – STD – 1553/ ARINC – 429.

Learning Outcomes

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

- Understand the basic concepts Basic principles, height control, heading control, ILS/MLS coupled control (L2)
- Deep knowledge of Automatic landing, speed control and auto-throttle control system.(L2)
- Flight Management Systems which can help to control features such as maneuvering, integrated data management systems.(L2, L6)

Course Outcomes

Upon completion of the course, students will be able to:

- Describe the hardware required for aircraft
- Explain the communication and navigation techniques used in aircrafts
- Discuss about the autopilot and cockpit display related concepts
- Apply the algorithm for an aircraft actuation system, servo-components, inertial sensors, modelling, design and testing of sensors.
- Deploy these skills effectively in the solution of problems in avionics engineering.

Text Book(s)

1. R. P. G Collinson, Introduction to Avionics System, 3/e, Springer, 2011.
2. C. R. Spitzer, Digital Avionics Systems: Principles and Practice, 2/e, TheBlackburn Press, 2001.

References

1. D. H. Middleton, E. Longman, Avionics systems, Longman Group, 1989.
2. I. Moir, A. Seabridge, M. Jukes, Civil Avionics Systems, 2/e, John Wiley,2013.
3. R. P. G. Collinson, Introduction to Avionics, 3/e, Springer, 2011.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1	1	1	1	1	3	1	2	1	1
CO2	1	2	2	2	1	1	1	1	1	1	2	1	1	1	1
CO3	2	2	3	2	1	1	1	1	1	1	2	1	2	1	1
CO4	2	1	2	2	2	1	1	1	1	1	1	1	2	1	1
CO5	1	2	1	3	2	1	1	1	1	1	2	1	1	1	1

19EAE450: OPTIMIZATION METHODS

L	T	P	C
3	0	0	3

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students to understand the basic principles of Optimization. This is useful for obtaining the best result under given circumstances in design, construction and maintenance of aerospace engineering system.

Course Objectives:

1. Introduce the basic concepts of optimization to students
2. Make the students to use calculus for optimization
3. Explain different methods to solve linear programming problems
4. Make the students to learn the principles of dynamic programming
5. Explain advanced optimization methods

UNIT I **8 hours**

Introduction and Basic Concepts - Historical Development; Engineering applications of Optimization; Art of Modeling. Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems. Classification of optimization problems. Optimization techniques – classical and advanced techniques.

Learning outcomes:

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

- Understand the basic concepts of optimization
- Classify the optimization problems

UNIT II **10 hours**

Optimization using Calculus - Stationary points; Functions of single and two variables; Global Optimum. Convexity and concavity of functions of one and two variables. Optimization of function of one variable and multiple variables; Gradient vectors; Optimization of function of multiple variables subject to equality constraints; Lagrangian function. Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation; Kuhn-Tucker Conditions.

Learning outcomes:

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

- Understand the use of calculus for optimization
- Apply calculus for solving optimization problems

UNIT III **10 hours**

Linear Programming - Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations. Graphical method for two variable optimization problem; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems. Revised simplex method; Duality in LP;Primaldual relations; Dual Simplex method; Sensitivity or post optimality analysis. Other algorithms for solving LP problems – Karmarkar's projective scaling method.

Learning outcomes:

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

- Understand linear programming problem
- Apply different methods to solve linear programming problems

UNIT IV **10 hours**

Dynamic Programming – Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality. Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming (DP). Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP.

Learning outcomes:

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

- Understand the concept of dynamic programming
- Solve optimization problems using dynamic programming

UNIT V **10 hours**

Integer Programming - Integer linear programming; Concept of cutting plane method. Mixed integer programming; Solution algorithms.

Advanced Topics in Optimization - Piecewise linear approximation of a nonlinear function. Multi objective optimization – Weighted and constrained methods; Multi level optimization. Direct and indirect search methods. Evolutionary algorithms for optimization and search.

Learning outcomes:

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

- Understand inter programming for optimization
- Explain few advanced topics in optimization

Course Outcomes

Upon completion of the course, students will be able to:

- Understand the basic principles and classification of optimization problems (L2)
- Apply calculus for solving optimization problems (L3)
- Apply different methods to solve linear programming problems (L3)
- Solve optimization problems using dynamic programming (L3)
- Explain a few advanced methods in optimization (L2)

Text book

1. S.S. Rao,"Engineering Optimization: Theory and Practice", New Age International P)Ltd., New Delhi, 2000.

References

1. G. Hadley,"Linear programming", Narosa Publishing House, New Delhi, 1990.

2. H.A. Taha,"Operations Research:An Introduction", 5th Edition, Macmillan, New York, 1992.

3. K. Deb,"Optimization for Engineering DesignAlgorithms and Examples",Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.

Program Elective – VI

19EAE452: FLAPPING WING AERODYNAMICS

L	T	P	C
3	0	0	3

Preamble:

This course is designed for aerospace engineering students. It introduces the fundamentals of flapping wing aerodynamics. This course is designed to acquaint the learners with aerodynamics of birds, insects and low Reynolds number flyers which is useful for understanding the mechanism of Bio-inspired MAVs and UAVs.

Course Objectives

- To impart the various aspects of aerodynamics of natural flyers such as birds, bats, and micro aerial vehicles.
- To familiarize the role of structural flexibility of low Reynolds number wing aerodynamics.
- To acquaint the flight stability for flapping wings and also the passive control.
- To exhibit the insight into low Reynolds number flight science while providing guidelines for vehicle development

UNIT I **6 hours**

Introduction: Flapping flight in nature, scaling, geometrical similarity,wing span, wing area, wing loading, aspect ratio, wing - beat frequency. Mechanics of gliding, forward and hovering flight - gliding and soaring, powered flight flapping - power implication of flapping wings - upper and lower limit, drag and power.

Learning Outcomes

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

- Apply flow similarity, non-dimensional coefficients such as the lift and drag coefficient, and non-dimensional parameters such as Reynolds number in aerodynamic modeling of flapping wings (L3)
- Contribute substantially as an individual to the design and execution of a computational and experimental aerodynamic analysis of flapping wings (L4)

UNIT II **8 hours**

Rigid Fixed-Wing Aerodynamics: Laminar separation and transition to turbulence - Navier-Stokes equation and the transition model, the eN method, factors affecting low Reynolds number aerodynamics, effect of free stream turbulence, effects of unsteady free stream. 3D wing aerodynamics - unsteady phenomena at high angle of attack, aspect ratio and tip vortices, wing tip effect, unsteady tip vortices.

Learning Outcomes

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

- Differentiate the characteristics of rigid fixed and flexible wing (L4)
- Understand the unsteady aerodynamics of flexible 3-d wings (L2)

UNIT III **9 hours**

Rigid Flapping Wing Aerodynamics: Flapping wing and body kinematics,governing equations and non-dimensional parameters - Reynolds number, Strouhal number and reduced frequency. Unsteady aerodynamics mechanism in flapping wings - leading edge vortices, rapid pitch up, wake capture, tip vortices, clap and fling mechanism, modeling of biological flyer in a rigid - wing frame, Reynolds number effects on the LEV’s and span wise flow in Howkmoth, fruit fly in hovering flight.

Learning Outcomes

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

- Understand the rigid wing aerodynamics (L2)
- Analyze the flow physics of flapping wing mavs (L4)
- Make use of different non dimensional performance parameter for low Reynolds number flyers (L3)

UNIT IV **9 hours**

Flow Physics at Low Reynolds Numbers: Flow physics in 'O' regime, effects of kinematics on hovering airfoil performance, effects of wind gust on hovering aerodynamics. Flow around a flat plate in shallow and deep stall, airfoil shape effects; appropriate analysis for non-stationary airfoil, force prediction for pitching and plunging. Simplified aerodynamics models and scaling of the forces.

Learning Outcomes

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

- Differentiate the aerodynamic flow behavior of rigid, flexible and hovering wings(L4)
- Classify the scaling and aerodynamic models for low Reynolds number flyers (L3)

UNIT V **9 hours**

Flexible Wing Aerodynamics: Introduction, governing equations for wing structures, linear beam model, linear membrane model, hyper elastic membrane model, flat plate and shell models, flapping flexible wings, non-dimensional wing tip deformation parameters, scaling and lift generation of hovering flexible wing of insect size, power input efficiency.

Learning Outcomes

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

- Understand the governing equations of motion for different flexible wing model (L2)
- Categorize the plunging and pitching motion of the insects (L3)
- Calculate the efficiency and power input of flexible wing birds (L4)

Course Outcomes:

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

- Apply the knowledge of low Reynolds numbers for natural flyers and manmade flyers.
- Demonstrate the aerodynamics of fixed, rigid and flapping wings
- Analyze the implications of laminar-turbulent transition, multiple time scale,
- Exhibit aerofoil shapes and Time-dependent structural and fluid dynamics of flapping wing body.
- Differentiate the aerodynamic flow behavior of rigid, flexible and hovering wings

Text Book(s)

1. W. Shyy, H. Aono, C. K. Kang, H. Liu, An Introduction to Flapping Wing Aerodynamics, Cambridge University Press, 2015.

References

1. Muller and Thomas, Fixed and Flapping Wing Aerodynamics for Micro Air Vehicle Applications, AIAA, 2002.
2. J. E. Toomey, Proquest, Numerical and Experimental Studies of flexibility in Flapping Wing Aerodynamics, Umi Dissertation Publishing, 2011.
3. Wei Shyy, Yongsheng Lian, Jian Tang, Dragos vileru, HaoLiu, Aerodynamics of low Reynolds number flyers, Cambridge Aerospace Series, 2008

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	1	1	1	1	2	1	3	1	2
CO2	3	2	1	1	1	1	1	1	1	1	2	1	2	1	2
CO3	2	2	1	1	1	1		1	1	1	1	1	3	1	1
CO4	2	2	1	1	1	1	1	1	1	1	2	1	2	1	2
CO5	2	2	1	1	1	1	1	1	1	1	1	1	2	1	1

19EAE454: EXPERIMENTAL TECHNIQUES

L	T	P	C
3	0	0	3

Preamble:

This course is designed for Aerospace Engineering undergraduate students. It is designed for the students to understand the basics principles of Measurements, Instrumentation and Experimental Methods of Stress Analysis. Understanding these principles will help them in the Design, Analysis and Testing of Aerospace Structures.

Course Objectives:

- To explain different principles of measurement.
- To familiarize various instruments required for measurement
- To focus on electrical resistance strain gauges
- To impart knowledge on optical methods for stress analysis
- To help the students to understand Non-destructive testing techniques.

UNIT I **9 hours**

Measurements and Extensometers: Principles of measurements, accuracy, sensitivity and range of measurements, extensometers – type sand uses of acoustic, mechanical, electrical, electronic, optical and laser, basic electrical components, Kirchhoff 's circuit laws, resistance thermometers, thermocouples, dynamic response of temperature sensors, flow velocity, flow rates in closed systems by pressure variation measurements.

Learning Outcomes:

After completion of this unit student will be able to

- Classify the types of measurement (L2)
- Explain the function of basic electrical components involved in measurement (L2)
- Summarize the temperature sensors and their response (L2)

UNIT II **8 hours**

Instrumentation for Engineering Measurements: Applications of electronic instrument systems, engineering analysis, experimental error, general characteristics of recording instruments, voltmeters for slowly and rapidly varying signals, eddy-current sensors, signal conditioning circuits, data acquisition system.

Learning Outcomes:

After completion of this unit student will be able to

- Compare various electronic instrument systems (L2)
- Summarize general characteristics of recording instruments (L2)
- Select proper electronic instrument for a particular application (L3)

UNIT III **8 hours**

Strain Measurement Methods and Strain Gauges: Introduction to strain measurements and strain gauges, electrical resistance strain gages, strain gage circuits and instrumentation, strain sensitivity of a strain gage, bridge sensitivity, Rosettes, strain gauge alloys, carriers and adhesives, performance of strain gauge system, temperature compensation, two-wire and three-wire circuits, strain gauge selection, bonding of a strain gauge, soldering, accounting for transverse sensitivity effects.

Learning Outcomes:

After completion of this unit student will be able to

- Explain the construction and working of electrical resistance strain gauges (L2)
- Select appropriate strain gauge for a given application (L3)
- Build strain gauge circuits (L3)

UNIT IV **8 hours**

Optical methods of Stress analysis: Introduction to optics, photoelasticity, applied photoelasticity, two dimensional and three dimensional photoelasticity, interferometry and holography, Moiré method, Moiré interferometry, polariscope - circular and plane, speckle methods -subjective, objective, digital image correlation, optical methods for determining fracture parameters.

Learning Outcomes:

After completion of this unit student will be able to

- Explain the usage of photoelasticity for stress analysis (L2)
- Compare the function of different polariscopes (L2)
- Outline the interferometry and holography technique (L2)
- Apply the optical methods for determining fracture parameters (L3)

UNIT V **9 hours**

Coatings and Non-Destructive Testing: Introduction to brittle coatings, coating materials, selection of coating thickness, industrial application of photoelastic coatings, calibration of photoelastic coatings, introduction to brittle coatings, analysis of brittle coatings.

Non-Destructive Testing: Fundamentals of non-destructive testing, radiography, ultrasonics, holography, laser holography magnetic particle inspection, fluorescent penetrant technique, eddy current testing, acoustic emission technique, X-ray applications, ultrasonic C-scan, thermograph, fiber-optic sensors.

Learning Outcomes:

After completion of this unit student will be able to

- Select proper brittle coating material and thickness of coating based on application (L3)
- Explain the calibration procedure of photo elastic coatings (L2)
- Identify the relative advantages and disadvantages of various Non-destructive testing techniques (L3)
- Choose proper Non-destructive testing technique based on the requirement (L2)

Course Outcomes:

After the completion of this course student will be able to

- Summarize the function of basic electrical components involved in measurement
- Select proper electronic and recording instruments for a given application
- Build strain gauge circuits and use them for strain measurements
- Apply the optical methods for determining fracture parameters
- Choose and make use of proper Non-destructive testing technique based on the requirement

Text Book(s)

1. J. W. Dally, W. F. Riley, K. G. McConnell, Instrumentation For Engineering measurements, 2/e, John Wiley and Sons, 1984.
2. P. Fordham, Non-Destructive Testing Techniques, Business PublicationsLimited, 1988.

References

1. J. W. Dally and M. F. Riley, Experimental Stress Analysis, 3/e, McGraw Hill,1988.
3. L. S. Srinath, M. R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, And K.Ramachandra, Experimental Stress Analysis, Tata McGraw Hill, 1984.
4. M. Hetenyi, Handbook of Experimental Stress Analysis, John Wiley and Sons,1980.
5. G. S. Holister, Experimental Stress Analysis, Principles and Methods,Cambridge University Press, 1987.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	0	1	0	0	1	1	1	0	2	1	2	1
CO2	2	1	1	1	2	1	0	1	1	1	0	2	2	2	1
CO3	2	2	2	1	2	1	0	1	1	1	1	2	2	1	1
CO4	2	2	2	2	2	1	1	1	1	1	1	2	2	3	1
CO5	2	2	2	2	2	1	1	1	1	1	1	2	2	3	1