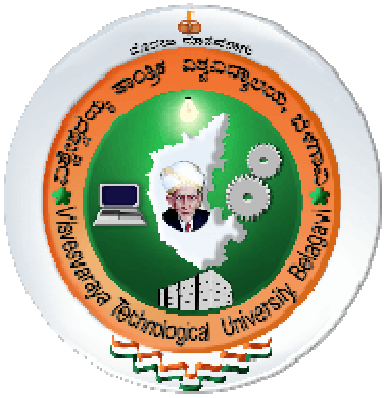
VISVESVARAYA TECHNOLOGICAL UNIVERSITY BELAGAVI



Scheme of Teaching and Examination and Syllabus

B.E. **AEROSPACE ENGINEERING**

III-VIII SEMESTER

(Effective from Academic year 2018-19)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
B.E. AEROSPACE ENGINEERING
(Effective from the academic year 2018 – 19)

III SEMESTER

Sl. No	Course and Course Code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	BSC	18MAT31	Transform calculus Fourier series and numerical technique	Mathematics	2	2	--	03	40	60	100	3
2	PCC	18AS32/ 18AE32	Aero-Thermodynamics	AS	3	2	--	03	40	60	100	4
3	PCC	18AS33/ 18AE33	Mechanics of Materials	AS	3	2	--	03	40	60	100	4
4	PCC	18AS34	Introduction To Aerospace Engineering	AS	3	0	--	03	40	60	100	3
5	PCC	18AS35/ 18AE35	Mechanics of Fluids	AS	3	0	--	03	40	60	100	3
6	PCC	18AS36	Aerospace Materials	AS	3	0	--	03	40	60	100	3
7	PCC	18ASL37	Measurements and Metrology Lab	AS	--	2	2	03	40	60	100	2
8	PCC	18ASL38	Material Testing Lab	AS	--	2	2	03	40	60	100	2
9	HSMC	18KVK39/49	Vyavaharika Kannada (Kannada for communication)/	HSMC	--	2	--	--	100	--	100	1
		18KAK39/49	Aadalitha Kannada (Kannada for Administration)									
		OR			OR							
		18CPC39	Constitution of India, Professional Ethics and Cyber Law		1	--	--	02	40	60		
					Examination is by objective type questions							
TOTAL					**17**	**10**	**04**	**24**	**420**	**480**	**900**	**25**
					OR	**OR**		**OR**	**OR**	**OR**		
					18	**12**		**26**	**360**	**540**		

Note: BSC: Basic Science, PCC: Professional Core, HSMC: Humanity and Social Science, NCMC: Non-credit mandatory course.

18KVK39 Vyavaharika Kannada (Kannada for communication) is for non-Kannada speaking, reading and writing students and 18KAK39 Aadalitha Kannada (Kannada for Administration) is for students who speak, read and write Kannada.

Course prescribed to lateral entry Diploma holders admitted to III semester of Engineering programs

10	NCMC	18MATDIP31	Additional Mathematics - I	Mathematics	02	01	--	03	40	60	100	0

(a)The mandatory non – credit courses Additional Mathematics I and II prescribed for III and IV semesters respectively, to the lateral entry Diploma holders admitted to III semester of BE/B. Tech programs, shall attend the classes during the respective semesters to complete all the formalities of the course and appear for the University examination. n case, any student fails to register for the said course/fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have secured F grade. In such a case, the students have to fulfill the requirements during subsequent semester/s to appear for SEE.
(b)These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree.

Courses prescribed to lateral entry B. Sc degree holders admitted to III semester of Engineering programs

Lateral entrant students from B.Sc. Stream, shall clear the non-credit courses Engineering Graphics and Elements of Civil Engineering and Mechanics of the First Year Engineering Programme. These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree.

AICTE Activity Points to be earned by students admitted to BE/B. Tech/B. Plan day college programme (For more details refer to Chapter 6,AICTE Activity Point Programme, Model Internship Guidelines):

Over and above the academic grades, every Day College regular student admitted to the 4 years Degree programme and every student entering 4 years Degree programme through lateral entry, shall earn 100 and 75 Activity Points respectively for the award of degree through AICTE Activity Point Programme. Students transferred from other Universities to fifth semester are required to earn 50 Activity Points from the year of entry to VTU. The Activity Points earned shall be reflected on the student's eighth semester Grade Card.

The activities can be can be spread over the years, anytime during the semester weekends and holidays, as per the liking and convenience of the student from the year of entry to the programme. However, minimum hours' requirement should be fulfilled. Activity Points (non-credit) have no effect on SGPA/CGPA and shall not be considered for vertical progression.

In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
B.E. AEROSPACE ENGINEERING
(Effective from the academic year 2018 – 19)

IVSEMESTER

Sl. No.	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	BSC	18MAT41	Complex Analysis, Probability and statistical method	Mathematics	2	2	--	03	40	60	100	3
2	PCC	18AS42/ 18AE42	Aerodynamics - I	AS	3	2	--	03	40	60	100	4
3	PCC	18AS43	Aerospace Structures-I	AS	3	2	--	03	40	60	100	4
4	PCC	18AS44/ 18AE44	Mechanisms And Machine Theory	AS	3	0	--	03	40	60	100	3
5	PCC	18AS45	Introduction To Space Technology	AS	3	0	--	03	40	60	100	3
6	PCC	18AS46	Composite Materials	AS	3	0	--	03	40	60	100	3
7	PCC	18ASL47	Energy Conversion & Fluid Mechanics lab	AS	--	2	2	03	40	60	100	2
8	PCC	18ASL48/ 18AEL48	Computer Aided Aircraft Drawing Lab	AS	--	2	2	03	40	60	100	2
9	HSMC	18KVK39/49	Vyavaharika Kannada (Kannada for communication)/	HSMC	--	2	--	--	100	--	100	1
		18KAK39/49	Aadalitha Kannada (Kannada for Administration)									
		OR										
		18CPC49	Constitution of India, Professional Ethics and Cyber Law		1	--	--	02	40	60		
					Examination is by objective type questions							
TOTAL					**17**	**10**	**04**	**24**	**420**	**480**	**900**	**25**
					OR	**OR**		**OR**	**OR**	**OR**		
					18	**12**		**26**	**360**	**540**		

Note: BSC: Basic Science, PCC: Professional Core, HSMC: Humanity and Social Science, NCMC: Non-credit mandatory course.

18KVK39/49 Vyavaharika Kannada (Kannada for communication) is for non-Kannada speaking, reading and writing students and 18KAK39/49 Aadalitha Kannada (Kannada for Administration) is for students who speak, read and write Kannada.

Course prescribed to lateral entry Diploma holders admitted to III semester of Engineering programs

10	NCMC	18MATDIP41	Additional Mathematics – II	Mathematics	02	01	--	03	40	60	100	0

((a)The mandatory non – credit courses Additional Mathematics I and II prescribed for III and IV semesters respectively, to the lateral entry Diploma holders admitted to III semester of BE/B. Tech programs, shall attend the classes during the respective semesters to complete all the formalities of the course and appear for the University examination. In case, any student fails to register for the said course/fails to secure the minimum 40 % of the prescribed CIE marks, he/she shall be deemed to have secured F grade. In such a case, the students have to fulfill the requirements during subsequent semester/s to appear for SEE.
(b)These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree.

Courses prescribed to lateral entry B. Sc degree holders admitted to III semester of Engineering programs

Lateral entrant students from B.Sc. Stream, shall clear the non-credit courses Engineering Graphics and Elements of Civil Engineering and Mechanics of the First Year Engineering Programme. These Courses shall not be considered for vertical progression, but completion of the courses shall be mandatory for the award of degree.

AICTE activity Points: In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

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Scheme of Teaching and Examination 2018 – 19
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(Effective from the academic year 2018 – 19)

V SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18AS51/ 18AE51	Management and Entrepreneurship	AS	3	0	--	03	40	60	100	3
2	PCC	18AS52/ 18AE52	Aerodynamics - II	AS	3	2	--	03	40	60	100	4
3	PCC	18AS53	Aerospace Propulsion	AS	3	0	--	03	40	60	100	3
4	PCC	18AS54	Aerospace Structures –II	AS	3	--	--	03	40	60	100	3
5	PCC	18AS55/ 18AE55	Aircraft Systems & Instrumentation	AS	3	--	--	03	40	60	100	3
6	PCC	18AS56	Flight Mechanics	AS	3	--	--	03	40	60	100	3
7	PCC	18ASL57/ 18AEL57	Aerodynamics Lab	AS	--	2	2	03	40	60	100	2
8	PCC	18ASL58	Propulsion Lab	AS	--	2	2	03	40	60	100	2
9	HSMC	18CIV59	Environmental Studies	Civil/ Environmental [Paper setting: Civil Engineering Board]	1	--	--	02	40	60	100	1
TOTAL					**19**	**6**	**4**	**26**	**360**	**540**	**900**	**24**

Note: PCC: Professional Core, HSMC: Humanity and Social Science.

AICTE activity Points: In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

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Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
B.E. AEROSPACE ENGINEERING
(Effective from the academic year 2018 – 19)

VI SEMESTER

Sl. No.	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18AS61	Missiles And Launch Vehicles	AS	3	2	--	03	40	60	100	4
2	PCC	18AS62	Computational Fluid Dynamics	AS	3	0	--	03	40	60	100	3
3	PCC	18AS63/ 18AE63	Finite Element Method	AS	3	0	--	03	40	60	100	3
4	PEC	18AS64X	Professional Elective -1	AS	3	--	--	03	40	60	100	3
5	OEC	18AS65X	Open Elective -A	AS	3	--	--	03	40	60	100	3
6	PCC	18ASL66	Design, Modelling & Analysis Lab	AS	--	2	2	03	40	60	100	2
7	PCC	18ASL67	Aerospace Structures Lab	AS	--	2	2	03	40	60	100	2
8	MP	18ASMP68	Mini-project	AS	--	--	2	03	40	60	100	2
9	Internship	--	Internship	To be carried out during the vacation/s of VI and VII semesters and /or VII and VIII semesters.								
TOTAL					**15**	**6**	**6**	**24**	**320**	**480**	**800**	**22**

Note: PCC: Professional core, PEC: Professional Elective, OE: Open Elective, MP: Mini-project.

Professional Elective -1

Course code under18XX64X	Course Title
18AS641	Hypersonics
18 AS 642	Theory of Vibrations
18 AS 643	Introduction To Astrophysics And Space Environment
18 AS 644	Radar and Microwave Engineering

Open Elective -A

Students can select any one of the open electives offered by other Departments expect those that are offered by the parent Department (Please refer to the list of open electives under 18XX65X).Selection of an open elective shall not be allowed if,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of the Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.
- Registration to electives shall be documented under the guidance of Programme Coordinator/ Advisor/Mentor.

Mini-project work:

Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinary Mini-project can be assigned to an individual student or to a group having not more than 4 students.

CIE procedure for Mini-project:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the Mini-project work shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all the guides of the college.

The CIE marks awarded for the Mini-project, shall be based on the evaluation of project report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

SEE for Mini-project: (i) Single discipline: Contribution to the Mini-project and the performance of each group member shall be assessed individually in the semester end examination (SEE) conducted at the department. **(ii) Interdisciplinary:** Contribution to the Mini-project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belong to.

Internship: All the students admitted to III year of BE/B. Tech shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A University examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements.

AICTE activity Points: In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

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B.E. AEROSPACE ENGINEERING
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VII SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18AS71	Space Mechanics	AS	3	--	--	03	40	60	100	3
2	PCC	18AS72	Control Engineering	AS	3	--	--	03	40	60	100	3
3	PEC	18AS73X	Professional Elective - 2	AS	3	--	--	03	40	60	100	3
4	PEC	18AS74X	Professional Elective - 3	AS	3	--	--	03	40	60	100	3
5	OEC	18AS75X	Open Elective -B	AS	3	--	--	03	40	60	100	3
6	PCC	18ASL76	Space Simulation Lab	AS	--	2	2	03	40	60	100	2
	PCC	18ASL77	Avionics & Instrumentation Lab	AS	--	2	2	03	40	60	100	2
7	Project	18XXP78	Project Work Phase - 1	AS	--	--	2	--	100	--	100	2
8	Internship	--	Internship	(If not completed during the vacation of VI and VII semesters, it shall be carried out during the vacation of VII and VIII semesters)								
TOTAL					**15**	**4**	**4**	**18**	**340**	**360**	**700**	**21**

Note: PCC: Professional core, PEC: Professional Elective.

Professional Elective - 2

Course code under 18XX73X	Course Title
18AS731	Avionics Systems
18 AS 732	Space Vehicle Design
18 AS 733	Air and Missile Defense Systems
18 AS734/18AE734	Heat & Mass Transfer

Professional Electives - 3

Course code under 18XX74X	Course Title
18AS741	Satellite Communication
18AS742/18AE742	Wind Tunnel Techniques
18AS743/18AE743	Guidance, Navigation & Control
18AS744	Global Navigation Satellite Systems

Open Elective -B

Students can select any one of the open electives offered by other Departments expect those that are offered by the parent Department (Please refer to the list of open electives under 18XX75X).

Selection of an open elective shall not be allowed if,

- The candidate has studied the same course during the previous semesters of the programme.
- The syllabus content of open elective is similar to that of the Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters of the programme.
- Registration to electives shall be documented under the guidance of Programme Coordinator/ Advisor/Mentor.

Project work:
Based on the ability/abilities of the student/s and recommendations of the mentor, a single discipline or a multidisciplinaryproject can be assigned to an individual student or to a group having not more than 4 students. In extraordinary cases, like the funded projects requiring students from different disciplines, the project student strength can be 5 or 6.

CIE procedure for Project Work Phase - 1:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the project work phase -1, shall be based on the evaluation of the project work phase -1 Report (covering Literature Survey, Problem identification, Objectives and Methodology), project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the Project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable.

The CIE marks awarded for the project work phase -1, shall be based on the evaluation of project work phase -1 Report(covering Literature Survey, Problem identification, Objectives and Methodology), project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

Internship: All the students admitted to III year of BE/B. Tech shall have to undergo mandatory internship of 4 weeks during the vacation of VI and VII semesters and /or VII and VIII semesters. A University examination shall be conducted during VIII semester and the prescribed credit shall be included in VIII semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared fail and shall have to complete during subsequent University examination after satisfying the internship requirements.

AICTE activity Points: In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination 2018 – 19
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
B.E. AEROSPACE ENGINEERING
(Effective from the academic year 2018 – 19)

VIII SEMESTER

Sl. No	Course and Course code		Course Title	Teaching Department	Teaching Hours /Week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P					
1	PCC	18AS81	Spacecraft Systems	AS	3	--	--	03	40	60	100	3
2	PEC	18 AS82X	Professional Elective - 4	AS	3	--	--	03	40	60	100	3
3	Project	18 ASP83	Project Work Phase - 2	AS	--	--	2	03	40	60	100	8
4	Seminar	18 ASS84	Technical Seminar	AS	--	--	2	03	100	--	100	1
5	Internship	18 ASI85	Internship	Completed during the vacation/s of VI and VII semesters and /or VII and VIII semesters.)				03	40	60	100	3
TOTAL					**06**	--	**4**	**15**	**260**	**240**	**500**	**18**

Note: PCC: Professional Core, PEC: Professional Elective.

Professional Electives – 4

Course code under 18XX82X	Course Title
18AS821	Satellite Navigation Systems
18AS822	Cryogenics
18AS823	Robotics
18AS824	Optimization Techniques

Project Work

CIE procedure for Project Work Phase - 2:

(i) Single discipline: The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide.

The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

(ii) Interdisciplinary: Continuous Internal Evaluation shall be group wise at the college level with the participation of all guides of the college. Participation of external guide/s, if any, is desirable.

The CIE marks awarded for the project work phase -2, shall be based on the evaluation of project work phase -2 Report, project presentation skill and question and answer session in the ratio 50:25:25.The marks awarded for the project report shall be the same for all the batch mates.

SEE for Project Work Phase - 2:

(i) Single discipline: Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted at the department.

(ii) Interdisciplinary: Contribution to the project and the performance of each group member shall be assessed individually in semester end examination (SEE) conducted separately at the departments to which the student/s belong to.

Internship: Those, who have not pursued /completed the internship shall be declared as fail and have to complete during subsequent University examination after satisfying the internship requirements.

AICTE activity Points: In case students fail to earn the prescribed activity Points, Eighth semester Grade Card shall be issued only after earning the required activity Points. Students shall be admitted for the award of degree only after the release of the Eighth semester Grade Card.

Activity points of the students who have earned the prescribed AICTE activity Points shall be sent the University along with the CIE marks of 8th semester. In case of students who have not satisfied the AICTE activity Points at the end of eighth semester, the column under activity Points shall be marked NSAP (Not Satisfied Activity Points).

VISVESVARAYA TECHNOLOGICAL UNIVERSITY BELAGAVI

Scheme of Teaching and Examination and Syllabus
B.E. **AEROSPACE ENGINEERING**
III-VIII SEMESTER
(Effective from Academic year 2018-19)

B. E. COMMON TO ALL PROGRAMMES
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

TRANSFORM CALCULUS, FOURIER SERIES AND NUMERICAL TECHNIQUES

Course Code	**18MAT31**	CIE Marks	40
Teaching Hours/Week (L: T:P)	(2:2:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To have an insight into Fourier series, Fourier transforms, Laplace transforms, Difference equations and Z-transforms.
- To develop the proficiency in variational calculus and solving ODE's arising in engineering applications, using numerical methods.

Module-1

Laplace Transform: Definition and Laplace transforms of elementary functions (statements only). Laplace transforms of Periodic functions (statement only) and unit-step function – problems.
Inverse Laplace Transform: Definition and problems, Convolution theorem to find the inverse Laplace transforms (without Proof) and problems. Solution of linear differential equations using Laplace transforms.

Module-2

Fourier Series: Periodic functions, Dirichlet's condition. Fourier series of periodic functions period 2π and arbitrary period. Half range Fourier series. Practical harmonic analysis.

Module-3

Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Problems.
Difference Equations and Z-Transforms: Difference equations, basic definition, z-transform-definition, Standard z-transforms, Damping and shifting rules, initial value and final value theorems (without proof) and problems, Inverse z-transform and applications to solve difference equations.

Module-4

Numerical Solutions of Ordinary Differential Equations(ODE's):
Numerical solution of ODE's of first order and first degree- Taylor's series method, Modified Euler's method. Runge -Kutta method of fourth order, Milne's and Adam-Bash forth predictor and corrector method (No derivations of formulae)-Problems.

Module-5

Numerical Solution of Second Order ODE's: Runge-Kutta method and Milne's predictor and corrector method. (No derivations of formulae).
Calculus of Variations: Variation of function and functional, variational problems, Euler's equation, Geodesics, hanging chain, problems.

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

- CO1: Use Laplace transform and inverse Laplace transform in solving differential/ integral equation arising in network analysis, control systems and other fields of engineering.
- CO2: Demonstrate Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
- CO3: Make use of Fourier transform and Z-transform to illustrate discrete/continuous function arising in wave and heat propagation, signals and systems.
- CO4: Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numerical methods.
- CO5:Determine the externals of functionals using calculus of variations and solve problems arising in dynamics of rigid bodies and vibrational analysis.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.

- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2016
2	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	44th Edition, 2017
3	Engineering Mathematics	Srimanta Pal et al	Oxford University Press	3rd Edition, 2016
Reference Books				
1	Advanced Engineering Mathematics	C. Ray Wylie, Louis C. Barrett	McGraw-Hill Book Co	6th Edition, 1995
2	Introductory Methods of Numerical Analysis	S.S.Sastry	Prentice Hall of India	4th Edition 2010
3	Higher Engineering Mathematics	B.V. Ramana	McGraw-Hill	11th Edition,2010
4	A Textbook of Engineering Mathematics	N.P.Bali and Manish Goyal	Laxmi Publications	6th Edition, 2014
5	Advanced Engineering Mathematics	Chandrika Prasad and Reena Garg	Khanna Publishing,	2018

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/
4. VTU EDUSAT PROGRAMME - 20

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

Aero Thermodynamics

Course Code	**18AS32/18AE32**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Understand various concepts and definitions of thermodynamics.
- Comprehend the I-law and II-law of thermodynamics.
- Acquire the knowledge of various types of gas cycles

Module-1

Fundamental Concepts & Definitions:
Thermodynamics definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and Modules, intensive and extensive properties. Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium. Zeroth law of thermodynamics, Temperature; concepts, scales, fixed points and measurements.

Work and Heat:
Mechanics-definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention. Problems.

Module-2

First Law of Thermodynamics:
Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, modes of energy, pure substance; definition, two-property rule, Specific heat at constant volume, enthalpy, specific heat at constant pressure. Extension of the First law to control volume; steady state-steady flow energy equation, important applications, analysis of unsteady processes such as film and evacuation of vessels with and without heat transfer.

Module-3

Second Law of Thermodynamics:
Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle. Thermal reservoir. Direct heat engine; schematic representation and efficiency. Devices converting work to heat in a thermodynamic cycle; reversed heat engine, schematic representation, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Reversible and Irreversible processes; factors that make a process irreversible, reversible heat engines, Carnot cycle, Carnot principles.

Entropy: Clasius inequality; Statement, proof, application to a reversible cycle. Entropy; definition, a property, change of entropy, principle of increase in entropy, entropy as a quantitative test for irreversibility, calculation of entropy using Tds relations, entropy as a coordinate. Available and unavailable energy.

Module-4

Pure Substances & Ideal Gases: Mixture of ideal gases and real gases, ideal gas equation, compressibility factor use of charts. P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, Saturated liquid, mixture of saturated liquid and vapour, saturated vapour and superheated vapour states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and H-S diagrams, representation of various processes on these diagrams.

Thermodynamic relations
Maxwell's equations, Tds relations, ratio of heat capacities, evaluation of thermodynamic properties from an equation of state.

Module-5

Gas Power Cycles: Efficiency of air standard cycles, Carnot, Otto, Diesel cycles, P-V & T-S diagram, calculation of efficiency.

Vapour power cycle:

Simple Rankine cycle, Analysis and performance of Rankine Cycle, Ideal and practical regenerative Rankine cycles –Reheat and Regenerative Cycles, Binary vapour cycle.

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

- CO1: Apply the concepts and definitions of thermodynamics.
- CO2: Differentiate thermodynamic work and heat and apply I law and II law of thermodynamics to different process.
- CO3: Apply the principles of various gas cycles.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
		Textbooks		
1	Basic and Applied Thermodynamics	P K Nag	Tata McGraw Hill	2nd Ed , 2002
2.	Basic Engineering Thermodynamics	A Venkatesh	Universities Press, India	2007
		Reference Books		
1	Thermodynamics: An Engineering Approach	Yunus A. Cenegal and Michael A. Boles	Tata McGraw Hill	2002
2	Engineering Thermodynamics	J.B. Jones and G.A. Hawkins, John Wiley and Sons	Wiley	1986
3	Fundamentals of Classical Thermodynamics	G. J. Van Wylen and R.E. Sonntag	Wiley Eastern, Wiley	1985
4	An Introduction to Thermodynamics	Y.V.C. Rao	Wiley Eastern	1993
5	Basic Thermodynamics	B. K Venkanna, Swati B. Wadavadagi	PHI, New Delhi	2010

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

Mechanics of Materials

Course Code	**18AS33/18AE33**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Comprehend the basic concepts of strength of materials.
- Acquire the knowledge of stress, strain under different loadings.
- Understand the properties of materials.

Module-1

Basics of linear elasticity: The concept of stress& strain, state of stress & Strain at a point, Equilibrium equations, The state of plane stress and plane strain. Compatibility equations, Constitutive Laws (Hooke's Law), Stress-strain curves for brittle and ductile materials, Allowable stress, Material selection for structural performance.

Simple & Compound Stresses: Extension / Shortening of a bar, bars with cross sections varying in steps, bars with continuously varying cross sections. Elongation due to self-weight. Volumetric strain, expression for volumetric strain, elastic constants, simple shear stress, shear strain, temperature stresses, Introduction to Plane stress, stresses on inclined sections, principal stresses & strains, Analytical & graphical method (Mohr's Circle) to find principal stresses & strains.

Module-2

Bending Moment and Shear Force in Beams: Introduction, Types of beams, loads and reactions, shear forces and bending moments, rate of loading, sign conventions, relationship between shear force and bending moments. Shear force and bending moment diagrams for different beams subjected to concentrated loads, uniformly distributed load, (UDL) uniformly varying load (UVL) and couple for different types of beams.

Euler-Bernoulli beam theory: The Euler-Bernoulli assumptions, Implications of the Euler-Bernoulli assumptions, the Euler-Bernoulli Beam theory derivation, Bending stress equation, Moment carrying capacity of a section. Shearing stresses in beams, shear stress across rectangular, circular, symmetrical I and T sections (Only Numerical).

Module-3

Module-4

Virtual work principles: Introduction, Equilibrium and work fundamentals, Principle of virtual work, Principle of virtual work applied to mechanical systems, Principle of virtual work applied to truss structures, Principle of virtual work applied to beams. Principle of complementary virtual work, internal virtual work in beams and solids.

Energy methods: Conservative forces, Principle of minimum total potential energy, Strain energy in springs, Strain energy in beams, Strain energy in solids, Applications to trusses, Development of a finite element formulation for trusses, Principle of minimum complementary, Energy theorems, Reciprocity theorems, Saint-Venant's principle.

Module-5

Mechanical Properties of materials:

Fracture: Type I, Type II and Type III.

Creep: Description of the phenomenon with examples. Three stages of creep, creep properties, stress relaxation.

Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, fatigue properties, fatigue testing and S-N diagram.

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

- CO1: Apply the basic concepts of strength of materials.
- CO2: Compute stress, strain under different loadings.
- CO3: Distinguish the properties of different materials.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.

- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Strength of Materials	S. S. Bhavaikatii	Vikas Publications House, New Delhi	2012
2	Strength of Materials	S. Ramamrutham	Dhanapath Rai Publishing Company	2012
Reference Books				
1	Introduction to Aircraft Structural Analysis	T. H. G Megson	Butterworth-Heinemann	2007
2	Mechanics of Materials	Beer. F. P. and Johnston. R	McGraw Hill Publishers	2006
3	Elements of Strength of Materials	Timoshenko and Young	East-West Press	1976
4	Structural Analysis	O. A. Bauchau and J. I. Craig	Springer Dordrecht Heidelberg London New York	

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

INTRODUCTION TO AEROSPACE ENGINEERING

Course Code	**18AS34**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand basic principles of aviation and the history of space vehicles.
- Acquire the basic knowledge of aircraft structures, aerodynamics, propulsion, materials and aircraft systems & instrumentation.
- Understand the basics of space propulsion, spacecrafts and their orbits.

Module-1

Introduction to Aircrafts: History of aviation, International Standard atmosphere, Atmosphere and its properties, Temperature, pressure and altitude relationships, Classification of aircrafts, V/STOL machines, Modern developments in Aviation like UAV.

Introduction to Space Flight: History of Space Flight & spacecraft technologies Difference between space and atmosphere, upper atmosphere, Introduction to basic orbital mechanics, types of Orbits (LEO, MEO, Geosynchronous and Geostationary, Polar orbits), Kepler's Laws of planetary motion.

Module-2

Basic principles of flight: Significance of speed of sound, Propagation of sound, Mach number, subsonic, transonic, supersonic, hypersonic flows, Bernoulli's theorem, Aerodynamic forces and moments on an Airfoil, Lift and drag components, lift curve, drag curve, types of drag, factors affecting lift and drag; Centre of pressure and its significance, Aerodynamic centre, Aspect ratio, Airfoil nomenclature, Basic characteristics of airfoils, NACA nomenclature, Simple problems on lift and drag.

Module-3

Aircraft Propulsion : Introduction, Classification, Piston Engine & its application, Brayton cycle, Principle of operation of Turboprop, turbojet and turbofan engines, Introduction to ramjets and scramjets; performance characteristics,

Rocket Propulsion: Principles of operation of rocket, Classification of Rockets, Types of rockets and typical applications, Introduction to Space Exploration.

Module-4

Aircraft Structures and Materials: Introduction, General types of construction, Monocoque, Semi-Monocoque and Geodesic structures, Typical wing and fuselage structure; Metallic and non-metallic materials for aircraft application. Aluminum alloy, titanium, stainless steel and composite materials for aerospace applications.

Module-5

Aircraft Instruments: Instrument Displays, Introduction to Navigation Instruments, Basic Air data systems & Probes, Mach meter, Air speed indicator, Vertical speed indicator, Altimeter, Gyro based instruments.

Aircraft Systems : Introduction to Hydraulic and pneumatic systems, Air Conditioning and Cockpit pressurization system, Generation and distribution of Electricity on board the airplane, Aircraft Fuel System, Fire Protection, Ice and Rain Protection System.

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

1. CO1: Apply the basic knowledge & principles of aviation & spaceflight.
2. CO2: Apply the concepts of fundaments of flight, basics of aircraft structures, aircraft & rocket propulsion and aircraft materials during the development of an aircraft.
3. CO3: Appreciate the complexities involved during development of flight vehicles

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.

- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to Flight	John D. Anderson	McGraw-Hill Education	8th edition, 2015
2	Fundamentals of Flight Vol-I to Vol-IV	Lalit Gupta and O P Sharma	Himalayan Books	2006
Reference Books				
1	Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration	Ian Moir, Allan Seabridge	John Wiley & Sons	3rd edition, 2011
2	Rocket Propulsion Elements	Sutton G.P	John Wiley, New York	9th edition,2016
3	Flight without formulae	A.C. Kermode	Pearson Education India	5th edition,1989
4	Flight stability and automatic control	Nelson R.C	McGraw-Hill	2nd edition,1998

B. E. AEROSPACE ENGINEERING
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SEMESTER - III

Mechanics of Fluids

Course Code	**18AS35/18AE35**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic fluid properties.
- Understand the governing laws of fluid flow.
- Acquire the knowledge of types of fluid flows.

Module-1

Basic Considerations:
Introduction, Dimensions- Modules and physical quantities, Continuum view of gases and liquids, Pressure and Temperature scales, Physical properties of fluids.

Fluid Statics:
Pressure distribution in a static fluid, Pressure and its measurement, hydrostatic forces on plane and curved surfaces, buoyancy, illustration by examples.

Module-2

Fluids in motion:
Methods of describing fluid motion, types of fluid flow, continuity equation in 3 dimensions, velocity potential function and stream function. Types of motion, Source sink, doublet, plotting of stream lines and potential lines Numerical problems.

Fluid Kinematics:
Kinematics of fluid motion and the constitutive equations, Integral (global) form of conservation equations (mass, momentum, energy) and applications, Differential form of conservation equations (continuity, Navier-Stokes equations, energy equation).

Module-3

Fluid Dynamics:
Equations of motion: Euler's and Bernoulli's equation of motion for ideal and real fluids. Momentum equation, Fluid flow measurements. Numerical problems.

Dimensional analysis and similarity:
Dimensional homogeneity, methods of dimensional analysis, model analysis, types of similarity and similitude. Dimensionless numbers. Model laws. Numerical problems.

Module-4

Flow past Immersed bodies:
Introduction to boundary layer, boundary layer thickness, karman's integral momentum theory, drag on a flat plate for laminar and turbulent flow, Drag on immersed bodies. Expression for drag and lift. Kutta – joukowsky theorem; Fundamentals of aerofoil theory Numerical problems.

Module-5

Compressible flow and Boundary Layers theory:
Steady, one-dimensional gas dynamics, Propagation of pressure waves in a compressible medium, velocity of sound, Mach number, Mach cone, Stagnation properties, Bernoulli's eqn for isentropic flow, normal shock waves. Numerical Problem; Laminar and turbulent boundary layers.

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

- CO1: Evaluate the effect of fluid properties.
- CO2: Apply the governing laws of fluid flow.
- CO3: Classify different types of fluid flows.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fluid Mechanics and Hydraulics Machines	Bansal, R.K	Laxmi Publications (P) Ltd., New Delhi	2015
2	Fluid Mechanics	Rathakrishnan. E	Prentice-Hall of India Pvt. Ltd	2010
Reference Books				
1	Fluid Mechanics and Applications	Yunus A. Cengel & John M Cimbala	McGraw Hill Education;	3rd edition,2013
2	Hydraulic Fluid Mechanics and Fluid Machines	Ramamritham. S	Dhanpat Rai& Sons, Delhi	1988
3	Engineering Fluid Mechanics	Kumar. K.L	Eurasia Publishing House (P) Ltd., New Delhi	VII Ed.,1995
4	Fluid Mechanics	Streeter. V. L., and Wylie, E.B	McGraw Hill	1983

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

AEROSPACE MATERIALS

Course Code	**18AS36**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Acquire knowledge of different aerospace materials & their properties.
- Understand the Heat Treatment processes of aircraft metals and alloys
- Characteristics and Applications of Aluminum alloys, Ceramics, Composites and High Temperature Materials.

Module-1

Mechanical Behaviour of Engineering Materials: Introduction to aerospace materials and their classification, Linear and non-linear elastic properties-Stress and Strain Curves-Yielding and strain Hardening, Toughness-Modules of resilience- Bauchinger's effect-Effect of notches-Testing and flaw detection of materials and components, knowledge of various material testing machines

Module-2

Non-ferrous materials in aircraft construction: Aluminium and its alloys: Types and identification. Properties-Castings-Heat treatment processes –Surface treatments.
Magnesium and its alloys: Cast and Wrought alloys-Aircraft application, features specification, fabrication problems, Special treatments.
Titanium and its alloys: Applications, machining, forming, welding and heat treatment, Copper Alloys.
Wood and fabric in aircraft construction and specifications- Glues Use of glass, plastics & rubber in aircraft, Introduction to glass & carbon composite.

Module-3

Ferrous materials in aircraft construction: Steels: Plain and low carbon steels, various low alloy steels, aircraft steel specifications, corrosion and heat resistant steels, structural applications.
Maraging Steels: Properties and Applications.
Super Alloys: Use -Nickel base-Cobalt base- Iron base -Forging and Casting of Super alloys-Welding, Heat treatment.

Module-4

Ceramics and Composites: Introduction, modern ceramic materials, cermets, glass ceramic, production of semi-fabricated forms, Carbon/Carbon composites, Fabrication processes and its aerospace applications involved in metal matrix composites, polymer composites.

Module-5

High Temperature Materials Characterization: Classification, production and characteristics, Methods and testing, Determination of mechanical and thermal properties of materials at elevated temperatures, Application of these materials in Thermal protection systems of Aerospace vehicles, High temperature material characterization.

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

1. CO1: Apply the knowledge about the mechanical behaviour of different aircraft & aerospace materials.
2. CO2: Explain the applications of Aluminum alloys, Ceramics and Composites Materials.
3. CO3: Evaluate the importance of high temperature materials and their characterization.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft Material and Processes	Titterton G F Lienhard V	English Book Store, New Delhi	5th Ed.,1998
2	Advanced Aerospace Materials	H Buhl	Springer, Berlin	1992
Reference Books				
1	Aerospace material	Balram Gupta	S Chand & Co	2009
2	Materials for Missiles and Space	ParkerER	Mc Graw-Hill	1963
3.	The Materials of Aircraft Construction	HillFT	Pitman London	1937
4.	Handbook of Aircraft materials	C G Krishnadas Nair	Interline publishers	1993

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

MEASUREMENTS AND METROLOGY LAB

Course Code	**18ASL37**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Learn the concepts of mechanical measurements and metrology
- Use the concept of accuracy, error and calibration
- Use the basic metrological instruments

Sl. No.	Experiments
1	Calibration of Pressure Gauge
2	Calibration of Thermocouple
3	Calibration of LVDT
4	Calibration of Load cell
5	Determination of modulus of elasticity of a mild steel specimen using strain gauges.
6	Comparison and measurements using vernier caliper and micrometer
7	Measurement of vibration parameters using vibration setup.
8	Measurements using Optical Projector / Toolmaker Microscope.
9	Measurement of angle using Sine Center / Sine bar / bevel protractor
10	Measurement of alignment using Autocollimator / Roller set
11	Measurement of Screw threads Parameters using Two-wire or Three-wire method.
12	Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
13	Measurement of gear tooth profile using gear tooth vernier /Gear tooth micrometer
14	Calibration of Micrometer using slip gauges.

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

1. CO1: Identify and classify different measuring tools related to experiments.
2. CO2: Identify, define, and explain accuracy, precision, and some additional terminology.
3. CO3: Conduct, Analyze, interpret, and present measurement data from measurements experiments.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

MATERIAL TESTING LAB

Course Code	**18ASL38**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Understand the relations among materials and their properties.
- Understand the formation, properties and significance of the alloys through different experiments.
- Understand the types, advantages and applications of various NDT methods.

Sl. No	Experiments
1	Hardness Testing – Vicker's, Brinell, Rockwell
2	Tensile Test
3	Flexural Test
4	Torsional Test
5	Impact Test
6	Shear Test
7	Fatigue Test
8	Preparation of specimen for metallograpic examination of different engineering materials. Identification of microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & metal matrix composites
9	Heat treatment: Annealing, normalizing, hardening and tempering of steel. Hardness studies of heat-treated samples.
10	To study the wear characteristics of ferrous, non-ferrous and composite materials for different parameters.
11	Visual Testing Technique, Dye penetration testing. To study the defects of Cast and Welded specimens.
12	Magnetic Particle Inspection.
13	Ultrasonic Inspection.
14	Eddy Current Inspection

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

1. CO1: Apply the relations among materials and their properties.
2. CO2: Differentiate the formation, properties and significance of the alloys through different experiments.
3. CO3: Differentiate the types, advantages and applications of various NDT methods.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. Common to all Programmes
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER –II / III / IV

Aadalitha Kannada

Course Code	**18KAK28/39/49**	CIE Marks	100
Teaching Hours/Week (L:T:P)	(0:2:0)		
Credits	01		

ಆಡಳಿತ ಕನ್ನಡ ಕಲಿಕೆಯ ಉದ್ದೇಶಗಳು:

- ಪದವಿ ವಿದ್ಯಾರ್ಥಿಳಾಗಿರುವುದರಿಂದ ಆಡಳಿತ ಕನ್ನಡದ ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.
- ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಕನ್ನಡ ಭಾಷೆಯ ವ್ಯಾಕರಣದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾ ರಚನೆಯಲ್ಲಿನ ನಿಯಮಗಳನ್ನು ಪರಿಚಯಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾ ಬರಹದಲ್ಲಿ ಕಂಡುಬರುವ ದೋಷಗಳು ಹಾಗೂ ಅವುಗಳ ನಿವಾರಣೆ. ಮತ್ತು ಲೇಖನ ಚಿಹ್ನೆಗಳನ್ನು ಪರಿಚಯಿಸುವುದು.
- ಸಾಮಾನ್ಯ ಅರ್ಜಿಗಳು, ಸರ್ಕಾರಿ ಮತ್ತು ಅರೆ ಸರ್ಕಾರಿ ಪತ್ರವ್ಯವಹಾರದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡಿಸುವುದು.
- ಭಾಷಾಂತರ ಮತ್ತು ಪ್ರಬಂಧ ರಚನೆ ಬಗ್ಗೆ ಅಸಕ್ತಿ ಮೂಡಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾಭ್ಯಾಸ ಮತ್ತು ಸಾಮಾನ್ಯ ಕನ್ನಡ ಹಾಗೂ ಆಡಳಿತ ಕನ್ನಡದ ಪದಗಳ ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.

ಪರಿವಿಡಿ (ಪಠ್ಯಪುಸ್ತಕದಲ್ಲಿರುವ ವಿಷಯಗಳ ಪಟ್ಟಿ)

ಅಧ್ಯಾಯ – 1 ಕನ್ನಡಭಾಷೆ – ಸಂಕ್ಷಿಪ್ತ ವಿವರಣೆ.

ಅಧ್ಯಾಯ – 2 ಭಾಷಾ ಪ್ರಯೋಗದಲ್ಲಾಗುವ ಲೋಪದೋಷಗಳು ಮತ್ತು ಅವುಗಳ ನಿವಾರಣೆ.

ಅಧ್ಯಾಯ – 3 ಲೇಖನ ಚಿಹ್ನೆಗಳು ಮತ್ತು ಅವುಗಳ ಉಪಯೋಗ.

ಅಧ್ಯಾಯ – 4 ಪತ್ರ ವ್ಯವಹಾರ.

ಅಧ್ಯಾಯ – 5 ಆಡಳಿತ ಪತ್ರಗಳು.

ಅಧ್ಯಾಯ – 6 ಸರ್ಕಾರದ ಆದೇಶ ಪತ್ರಗಳು.

ಅಧ್ಯಾಯ – 7 ಸಂಕ್ಷಿಪ್ತ ಪ್ರಬಂಧ ರಚನೆ (ಪ್ರಿಸೈಸ್ ರೈಟಿಂಗ್), ಪ್ರಬಂಧ ಮತ್ತು ಭಾಷಾಂತರ.

ಅಧ್ಯಾಯ – 8 ಕನ್ನಡ ಶಬ್ದಸಂಗ್ರಹ.

ಅಧ್ಯಾಯ – 9 ಕಂಪ್ಯೂಟರ್ ಹಾಗೂ ಮಾಹಿತಿ ತಂತ್ರಜ್ಞಾನ.

ಅಧ್ಯಾಯ – 10 ಪಾರಿಭಾಷಿಕ ಆಡಳಿತ ಕನ್ನಡ ಪದಗಳು ಮತ್ತು ತಾಂತ್ರಿಕ/ ಕಂಪ್ಯೂಟರ್ ಪಾರಿಭಾಷಿಕ ಪದಗಳು.

ಆಡಳಿತ ಕನ್ನಡ ಕಲಿಕೆಯ ಫಲಿತಾಂಶಗಳು:

- ಆಡಳಿತ ಭಾಷೆ ಕನ್ನಡದ ಪರಿಚಯವಾಗುತ್ತದೆ.
- ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಕನ್ನಡ ಭಾಷೆಯ ವ್ಯಾಕರಣದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡುತ್ತದೆ.
- ಕನ್ನಡ ಭಾಷಾ ರಚನೆಯಲ್ಲಿನ ನಿಯಮಗಳು ಮತ್ತು ಲೇಖನ ಚಿಹ್ನೆಗಳು ಪರಿಚಯಿಸಲ್ಪಡುತ್ತವೆ.
- ಸಾಮಾನ್ಯ ಅರ್ಜಿಗಳು, ಸರ್ಕಾರಿ ಮತ್ತು ಅರೆ ಸರ್ಕಾರಿ ಪತ್ರವ್ಯವಹಾರದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡುತ್ತದೆ.
- ಭಾಷಾಂತರ ಮತ್ತು ಪ್ರಬಂಧ ರಚನೆ ಬಗ್ಗೆ ಅಸಕ್ತಿ ಮೂಡುತ್ತದೆ.
- ಕನ್ನಡ ಭಾಷಾಭ್ಯಾಸ ಮತ್ತು ಸಾಮಾನ್ಯ ಕನ್ನಡ ಹಾಗೂ ಆಡಳಿತ ಕನ್ನಡದ ಪದಗಳು ಪರಿಚಯಿಸಲ್ಪಡುತ್ತವೆ.

ಪರೀಕ್ಷೆಯ ವಿಧಾನ : ನಿರಂತರ ಆಂತರಿಕ ಮೌಲ್ಯಮಾಪನ – ಅಖಇ **(ಅಟಿಣಟಿಣಜಿಠಿ ಐಟಿಣಜಡಿಟಿಚಿಟಿ ಇತಚಿಟಿಣಚಿಣಟಿ):**
ಕಾಲೇಜು ಮಟ್ಟದಲ್ಲಿಯೆ ಆಂತರಿಕ ಪರೀಕ್ಷೆಯನ್ನು 100 ಅಂಕಗಳಿಗೆ ವಿಶ್ವವಿದ್ಯಾಲಯದ ನಿಯಮಗಳು ಮತ್ತು ನಿರ್ದೇಶನದಂತೆ ನಡೆಸತಕ್ಕದ್ದು.

ಪಠ್ಯಪುಸ್ತಕ : ಆಡಳಿತ ಕನ್ನಡ ಪಠ್ಯ ಪುಸ್ತಕ (ಎಚಿಟಿಟಿಚಿಜಚಿ ಚಿಠಿಡಿ ಂಜಟಿಟಿಡಿಚಿಣಟಿ)
ಸಂಪಾದಕರು
ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ
ಪ್ರೊ. ವಿ. ಕೇಶವಮೂರ್ತಿ
ಪ್ರಕಟಣೆ : ಪ್ರಸಾರಾಂಗ, ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

B. E. Common to all Programmes
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER –II & III/IV

Vyavaharika Kannada

Course Code	**18KVK28/39/49**	CIE Marks	100
Teaching Hours/Week (L:T:P)	(0:2:0)		
Credits	01		

Course Learning Objectives:
The course will enable the students to understand Kannada and communicate in Kannada language.

Table of Contents:
Chapter - 1: Vyavaharika kannada – Parichaya (Introduction to Vyavaharika Kannada).
Chapter - 2: Kannada Aksharamale haagu uchcharane (Kannada Alpabets and Pronunciation).
Chapter - 3: Sambhashanegaagi Kannada Padagalu (Kannada Vocabulary for Communication).
Chapter - 4: Kannada Grammar in Conversations (Sambhashaneyalli Kannada Vyakarana).
Chapter - 5: Activities in Kannada.

Course Outcomes:
At the end of the course, the student will be able to understand Kannada and communicate in Kannada language.

ಪರೀಕ್ಷೆಯ ವಿಧಾನ : ನಿರಂತರ ಆಂತರಿಕ ಮೌಲ್ಯಮಾಪನ – ಅಖಇ **(ಅಟಿಣಟಿಣಠಾ ಖಟಿಣಜಡಿಟಿಚಿಟ ಇತಿಚಿಟಣಚಿಣಟಿ):**
ಕಾಲೇಜು ಮಟ್ಟದಲ್ಲಿಯೆ ಆಂತರಿಕ ಪರೀಕ್ಷೆಯನ್ನು 100 ಅಂಕಗಳಿಗೆ ವಿಶ್ವವಿದ್ಯಾಲಯದ ನಿಯಮಗಳು ಮತ್ತು ನಿರ್ದೇಶನದಂತೆ ನಡೆಸತಕ್ಕದ್ದು.

ಖಿಜ್ಞಾಧಜ್ಞಾ (ಪಠ್ಯಪುಸ್ತಕ): ವ್ಯಾವಹಾರಿಕ ಕನ್ನಡ ಪಠ್ಯ ಪುಸ್ತಕ (ಗಿಥಿಚಿತಚಿಖಿಚಿಡಿಖಾಚಿ ಏಚಿಟಿಟಿಚಿಜಚಿ ಖಿಜ್ಞಾ ಃಜ್ಞಾ)
ಸಂಪಾದಕರು
ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ
ಪ್ರೊ. ವಿ. ಕೇಶವಮೂರ್ತಿ
ಪ್ರಕಟಣೆ : ಪ್ರಸಾರಾಂಗ, ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

B. E. Common to all Programmes
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER - III

CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND CYBER LAW (CPC)

Course Code	**18CPC39/49**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Course Learning Objectives: To

- know the fundamental political codes, structure, procedures, powers, and duties of Indian government institutions, fundamental rights, directive principles, and the duties of citizens
- Understand engineering ethics and their responsibilities; identify their individual roles and ethical responsibilities towards society.
- Know about the cybercrimes and cyber laws for cyber safety measures.

Module-1

Introduction to Indian Constitution:
The Necessity of the Constitution, The Societies before and after the Constitution adoption. Introduction to the Indian constitution, The Making of the Constitution, The Role of the Constituent Assembly - Preamble and Salient features of the Constitution of India. Fundamental Rights and its Restriction and limitations in different Complex Situations. Directive Principles of State Policy (DPSP) and its present relevance in our society with examples. Fundamental Duties and its Scope and significance in Nation building.

Module-2

Union Executive and State Executive:
Parliamentary System, Federal System, Centre-State Relations. Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism. State Executives – Governor, Chief Minister, State Cabinet, State Legislature, High Court and Subordinate Courts, Special Provisions (Articles 370.371,371J) for some States.

Module-3

Elections, Amendments and Emergency Provisions:
Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44, 61, 73,74, ,75, 86, and 91,94,95,100,101,118 and some important Case Studies. Emergency Provisions, types of Emergencies and its consequences.

Constitutional special provisions:
Special Provisions for SC and ST, OBC, Women, Children and Backward Classes.

Module-4

Professional / Engineering Ethics:
Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India): Profession, Professionalism, and Professional Responsibility. Clash of Ethics, Conflicts of Interest. Responsibilities in Engineering Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility. Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering

Module-5

Internet Laws, Cyber Crimes and Cyber Laws:
Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship. Cybercrimes and enforcement agencies.

Course Outcomes: On completion of this course, students will be able to,

CO 1: Have constitutional knowledge and legal literacy.
CO 2: Understand Engineering and Professional ethics and responsibilities of Engineers.
CO 3: Understand the the cybercrimes and cyber laws for cyber safety measures.

Question paper pattern for SEE and CIE:

- The SEE question paper will be set for 100 marks and the marks scored by the students will

proportionately be reduced to 60. The pattern of the question paper will be objective type (MCQ). • For the award of 40 CIE marks, refer the University regulations 2018.				
Sl. No.	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
Textbook/s				
1	Constitution of India, Professional Ethics and Human Rights	Shubham Singles, Charles E. Haries, and et al	Cengage Learning India	2018
2	Cyber Security and Cyber Laws	Alfred Basta and et al	Cengage Learning India	2018
Reference Books				
3	Introduction to the Constitution of India	Durga Das Basu	Prentice –Hall,	2008.
4	Engineering Ethics	M. Govindarajan, S. Natarajan, V. S. Senthilkumar	Prentice –Hall,	2004

B. E. Common to all Programmes
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER - III

ADDITIONAL MATHEMATICS – I
(Mandatory Learning Course: Common to All Programmes)
(A Bridge course for Lateral Entry students under Diploma quota to BE/B. Tech. programmes)

Course Code	**18MATDIP31**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	**0**	Exam Hours	03

Course Learning Objectives:

- To provide basic concepts of complex trigonometry, vector algebra, differential and integral calculus.
- To provide an insight into vector differentiation and first order ODE's.

Module-1

Complex Trigonometry: Complex Numbers: Definitions and properties. Modulus and amplitude of a complex number, Argand's diagram, De-Moivre's theorem (without proof).
Vector Algebra: Scalar and vectors. Addition and subtraction and multiplication of vectors- Dot and Cross products, problems.

Module-2

Differential Calculus: Review of successive differentiation-illustrative examples. Maclaurin's series expansions-Illustrative examples. Partial Differentiation: Euler's theorem-problems on first order derivatives only. Total derivatives-differentiation of composite functions. Jacobians of order two-Problems.

Module-3

Vector Differentiation: Differentiation of vector functions. Velocity and acceleration of a particle moving on a space curve. Scalar and vector point functions. Gradient, Divergence, Curl-simple problems. Solenoidal and irrotational vector fields-Problems.

Module-4

Integral Calculus: Review of elementary integral calculus. Reduction formulae for $\sin^n x$, $\cos^n x$ (with proof) and $\sin^m x \cos^n x$ (without proof) and evaluation of these with standard limits-Examples. Double and triple integrals-Simple examples.

Module-5

Ordinary differential equations (ODE's. Introduction-solutions of first order and first-degree differential equations: exact, linear differential equations. Equations reducible to exact and Bernoulli's equation.

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

- CO1: Apply concepts of complex numbers and vector algebra to analyze the problems arising in related area.
- CO2: Use derivatives and partial derivatives to calculate rate of change of multivariate functions.
- CO3: Analyze position, velocity and acceleration in two and three dimensions of vector valued functions.
- CO4: Learn techniques of integration including the evaluation of double and triple integrals.
- CO5: Identify and solve first order ordinary differential equations.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	43rd Edition, 2015
Reference Books				

1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2015
2	Engineering Mathematics	N. P .Bali and Manish Goyal	Laxmi Publishers	7th Edition, 2007
3	Engineering Mathematics Vol. I	Rohit Khurana	Cengage Learning	1st Edition, 2015

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

COMPLEX ANALYSIS, PROBABILITY AND STATISTICAL METHODS
(Common to all programmes)
[As per Choice Based Credit System (CBCS) scheme]

Course Code	**18MAT41**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide an insight into applications of complex variables, conformal mapping and special functions arising in potential theory, quantum mechanics, heat conduction and field theory.
- To develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, design engineering and microwave engineering.

Module-1

Calculus of complex functions: Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms and consequences.
Construction of analytic functions: Milne-Thomson method-Problems.

Module-2

Conformal transformations: Introduction. Discussion of transformations:$w = Z^2, w = e^z, w = z + \frac{1}{z}, (z \neq 0)$.Bilinear transformations- Problems.
Complex integration: Line integral of a complex function-Cauchy's theorem and Cauchy's integral formula and problems.

Module-3

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Binomial, Poisson, exponential and normal distributions- problems (No derivation for mean and standard deviation)-Illustrative examples.

Module-4

Statistical Methods: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation -problems. Regression analysis- lines of regression –problems.
Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form-
$y = ax + b, y = ax^b and y = ax^2 + bx + c.$

Module-5

Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation and covariance.
Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness of fit.

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

- Use the concepts of analytic function and complex potentials to solve the problems arising in electromagnetic field theory.
- Utilize conformal transformation and complex integral arising in aerofoil theory, fluid flow visualization and image processing.
- Apply discrete and continuous probability distributions in analyzing the probability models arising in engineering field.
- Make use of the correlation and regression analysis to fit a suitable mathematical model for the statistical data.
- Construct joint probability distributions and demonstrate the validity of testing the hypothesis.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.

- There will be two full questions (with a maximum of four sub- questions) from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition,2016
2	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	44th Edition, 2017
3	Engineering Mathematics	Srimanta Pal et al	Oxford University Press	3rd Edition,2016
Reference Books				
1	Advanced Engineering Mathematics	C. Ray Wylie, Louis C.Barrett	McGraw-Hill	6th Edition 1995
2	Introductory Methods of Numerical Analysis	S.S.Sastry	Prentice Hall of India	4th Edition 2010
3	Higher Engineering Mathematics	B. V. Ramana	McGraw-Hill	11th Edition,2010
4	A Text Book of Engineering Mathematics	N. P. Bali and Manish Goyal	Laxmi Publications	2014

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/
4. VTU EDUSAT PROGRAMME - 20

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

Aerodynamics-I

Course Code	**18AS42/18A42**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:1:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Understand the basics of fluid mechanics as a prerequisite to Aerodynamics
- Acquire knowledge on typical airfoil characteristics and two-dimensional flows over airfoil and study the incompressible over finite wings
- Assimilate the understanding of application of finite wing theory and high lift systems

Module-1

Review of Basic Fluid Mechanics

Continuity, momentum and energy equation, Control volume approach to Continuity, momentum and energy equation, Types of flow, pathlines, streamlines, and streaklines, units and dimensions, inviscid and viscous flows, compressibility, Mach number regimes. Vorticity, Angular velocity, Stream function, velocity potential function, Circulation, Numericals, Mach cone and Mach angle, Speed of sound.

Module-2

Airfoil Characteristics

Fundamental aerodynamic variables, Airfoil nomenclature, airfoil characteristics. wing planform geometry, aerodynamic forces and moments, centre of pressure, pressure coefficient, aerodynamic center, calculation of airfoil lift and drag from measured surface pressure distributions, typical airfoil aerodynamic characteristics at low speeds. Types of drag-Definitions.

Module-3

Two Dimensional Flows & Incompressible Flow Over Airfoil

Uniform flow, Source flow, Sink flow, Combination of a uniform flow with source and sink. Doublet flow. Non-lifting flow over a circular cylinder. Vortex flow. Lifting flow over a circular cylinder. Kutta-Joukowski theorem and generation of Lift, D'Alembert's paradox, Numericals,

Incompressible flow over airfoils: Kelvin's circulation theorem and the starting vortex, vortex sheet, Kutta condition, Classical thin airfoil theory for symmetric and cambered airfoils. Numericals.

Module-4

Biot-Savart law and Helmholtz's theorems, Vortex filament: Infinite and semi-infinite vortex filament, Induced velocity. Prandtl's classical lifting line theory: Downwash and induced drag. Elliptical and modified elliptical lift distribution. Lift distribution on wings. Limitations of Prandtl's lifting line theory. Extended lifting line theory- lifting surface theory, vortex lattice method for wings. Lift, drag and moment characteristics of complete airplane.

Module-5

Applications of Finite Wing Theory & High Lift Systems

Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane, ground effects. Swept wings: Introduction to sweep effects, swept wings, pressure coefficient, typical aerodynamic characteristics, Subsonic and Supersonic leading edges. Introduction to high-lift systems, flaps, leading-edge slats and typical high – lift characteristics. critical Mach numbers, Lift and drag divergence, shock induced separation, Effects of thickness, camber and aspect ratio of wings, Transonic area rule, Tip effects. Introduction to Source panel & vortex lattice method.

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

1. CO1: Evaluate typical airfoil characteristics and two-dimensional flows over airfoil.
2. CO2: Compute and analyse the incompressible flow over finite wings.
3. CO3: Apply finite wing theory and design high lift systems from the aerodynamics view point.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fundamental of Aerodynamics	Anderson J.D	McGraw-Hill International Edition, New York	5th edition,2011
2	Aerodynamics for Engineering Students	E. L. Houghton, P.W. Carpenter	Elsevier, New York	5th edition,2010
Reference Books				
3	Aerodynamics	Clancy L. J.	Sterling book house, New Delhi	2006
4	Theoretical Aerodynamics	Louis M. Milne-Thomson	Dover Publications, USA	Imported Edition,2011

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

AEROSPACE STRUCTURES – I

Course Code	**18AS43**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Comprehend the basic concepts of stress and strain.
- Acquire the knowledge of types of loads on aerospace vehicles.
- Understand the theory of elasticity.

Module-1

Design for Static Strength: Introduction: Normal, shear, biaxial and tri-axial stresses, Stress tensor, Principal Stresses, Stress Analysis, Design considerations, Codes and Standards. Static Strength: Static loads and factor of safety, Theories of failure: Maximum normal stress theory, Maximum shear stress theory, Maximum strain theory, Strain energy theory, and Distortion energy theory, failure of brittle and ductile materials, Stress concentration, and Determination of Stress concentration factor.

Module-2

Design for Impact and Fatigue Strength: Impact Strength: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia. Fatigue Strength: Introduction, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, modifying factors: size effect, surface effect, Stress concentration effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.

Module-3

Loads on Aircraft: Structural nomenclature, Types of loads, load factor, Aerodynamics loads, Symmetric manoeuvre loads, Velocity diagram, Function of structural components.
Aircraft Materials: Metallic and non-metallic materials, Use of Aluminium alloy, titanium, stainless steel and composite materials. Desirable properties for aircraft application.

Module-4

Theory of Elasticity: Theory of Elasticity: Concept of stress and strain, derivation of Equilibrium equations, strain displacement relation, compatibility conditions and boundary conditions. Plane stress and Plane strain problems in 2D elasticity. Principle Stresses and Orientation of Principle Directions.
Structures: Statically Determinate and Indeterminate structures, Analysis of plane truss, Method of joints, 3D Truss, Plane frames, Composite beam, Clapeyron's Three Moment Equation.

Module-5

Energy Methods: Strain Energy due to axial, bending and Torsional loads. Castigliano's theorem, Maxwell's Reciprocal theorem.
Columns: Columns with various end conditions, Euler's Column curve, Rankine's formula, Column with initial curvature, Eccentric loading, south-well plot.

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

1. CO1: Apply the basic concepts of stress and strain analysis.
2. CO2: Compute the impact stress.
3. CO3: Identify appropriate materials for suitable application based on properties.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft Structures for Engineering Students	Megson, T.H.G	Butterworth-Heinemann	6th edition,2016
2	Analysis of Aircraft Structures – An Introduction	Donaldson, B.K	Cambridge University Press	2nd edition,2012
Reference Books				
1	Design of Machine Elements	V.B. Bhandari	Tata McGraw Hill Publishing Company Ltd., New Delhi	2nd Edition, 2007
2	Theory of Elasticity	Timoshenko and Goodier	McGraw Hill Co	3rd edition,2010
3	Strength of Materials	Timoshenko, S	CBS	3rd edition,2004
4	Aircraft Structures	Peery, D.J., and Azar, J.J	McGraw, Hill, N.Y	2nd edition, 1993
5	Analysis and Design of Flight vehicles Structures	Bruhn. E.H	Tri – state off set company, USA	1985

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

Mechanisms and Machine Theory

Course Code	**18AS44/18AE44**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the theory of mechanisms including velocity, acceleration and static force analysis.
- Acquire knowledge of spur gears, gear train, balancing of rotating and reciprocating masses.
- Understand the concept of governors and gyroscope.

Module-1

Introduction to Mechanisms:
Types of constrained motion, Link and its types, joints and its types, kinematic pair and its types, degrees of freedom, Grubler's criterion, Types of kinematic chains and inversions:
Inversions of Four bar chain: Beam engine, coupling rod of a locomotive, Watt's indicator mechanism. Inversions of Single Slider Crank Chain: Pendulum pump or Bull engine, Oscillating cylinder engine, Rotary internal combustion engine, Crank and slotted lever quick return motion mechanism, Whitworth quick return motion mechanism. Inversions of Double Slider Crank Chain: Elliptical trammels, Scotch yoke mechanism, Oldham's coupling. Straight line motion mechanisms: Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism and Ratchet and Pawl mechanism, Ackerman steering gear mechanism.

Module-2

Velocity, Acceleration and static force analysis of Mechanisms (Graphical Methods):
Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism and Simple Mechanisms by vector polygons.
Static force analysis: Introduction: Static equilibrium, Equilibrium of two and three force members. Members with two forces and torque. Free body diagrams, principle of virtual work. Static force analysis of four bar mechanism and slider-crank mechanism with and without friction.

Module-3

Spur Gears and Gear Trains
Spur Gears: Gear terminology, law of gearing, Path of contact, Arc of contact, Contact ratio of spur gear, Interference in involute gears, Methods of avoiding interference.
Gear Trains: Simple gear trains, Compound gear trains, Reverted gear trains, Epicyclic gear trains, Analysis of epicyclic gear train (Algebraic and tabular methods), torques in epicyclic trains.

Module-4

Balancing of Rotating and Reciprocating Masses
Balancing of Rotating Masses: Balancing of Several Masses Rotating in the Same Plane, Balancing of Several Masses Rotating in Different Planes (only Graphical Methods).
Balancing of Reciprocating Masses: Primary and Secondary Unbalanced Forces of Reciprocating Masses, Partial Balancing of Unbalanced Primary Force in a Reciprocating Engine, Balancing of Primary and secondary Forces of Multi-cylinder In-line Engines, Balancing of Radial Engines (only Graphical Methods)

Module-5

Governors and Gyroscope
Governors: Types of governors; force analysis of Porter and Hartnell governors, Controlling force, stability, sensitiveness, isochronism, effort and power of Porter and Hartnell governors.
Gyroscopes: Vectorial representation of angular motion, gyroscopic couple, effect of gyroscopic couple on plane disc and aeroplane

Course Outcomes:

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

1. CO1: Apply the theory of velocity, acceleration and static force analysis to design of mechanisms.
2. CO2: Design spur gears, gear train, balancing of rotating and reciprocating masses.
3. CO3 : Apply governors and gyroscope

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Machines	**Rattan S.S**	Tata McGraw-Hill Publishing Company Ltd., New Delhi	3rd edition -2009
2	Theory of Machines & Mechanisms	**J.J. Uicker, G.R. Pennock, J.E. Shigley**	OXFORD	3rd Ed. 2009
Reference Books				
1	Theory of Machines	**R. S. Khurmi, J.K. Gupta**	Eurasia Publishing House	2008
2	Design of Machinery	**Robert L Norton**	McGraw Hill	2001
3	Mechanism and Machine theory	Ambekar	PHI Learning Pvt. Ltd	2007

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

INTRODUCTION TO SPACE TECHNOLOGY

Course Code	**18AS45**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the fundamentals of aerospace propulsion.
- Understand the orbit mechanics and orbit maneuvers.
- Acquire the knowledge of satellite attitude dynamics and space mission operations.

Module-1

Fundamentals of Aerospace Propulsion: Space Mission, Types, Space Environment, Launch Vehicle Selection. Introduction to rocket propulsion-fundamentals of solid propellant rockets, Fundamentals of liquid propellant rockets, Rocket equation, Tsiolkovsky rocket equation, Concepts of Specific Impulse.

Two-dimensional trajectories of rockets and missiles, Multi-stage rockets-Vehicle sizing, Two stage Multi-stage Rockets, Trade-off Ratios-Single Stage to Orbit, Sounding Rocket, Aerospace Plane, Gravity Turn Trajectories, Impact point calculation, injection conditions-Flight dispersions, Burnout velocity.

Module-2

Atmospheric Reentry: Introduction-Steep Ballistic Reentry, Ballistic Orbital Reentry, Skip Reentry, "Double-Dip" Reentry, Skip reentry, glide reentry, reentry corridor, reentry dynamics for ballistic reentry, reentry heating, Aero-braking, Lifting Body Reentry.

Module-3

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

Module-4

Satellite Attitude Dynamics: Torque free Axi-symmetric rigid body, Attitude Control for Spinning Spacecraft, Attitude Control for Non-spinning Spacecraft, The Yo-Yo Mechanism, Gravity – Gradient Satellite, Dual Spin Spacecraft, Attitude Determination.

Module-5

Space Mission Operations: Supporting Ground Systems Architecture and Team interfaces, Mission phases and Core operations, Team Responsibilities, Mission Diversity, Standard Operations Practices, Mission operation architecture, Mission operation fundamentals – Command, Planning, Tracking, Telemetry.

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

1. CO1: Distinguish the types of aerospace propulsion.
2. CO2: Determine the attitude of the satellites.
3. CO3: Support the space mission operations.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Spaceflight Dynamics	W.E. Wiesel	McGraw Hill	2nd edition,2014
2	Rocket Propulsion and Space Dynamics	J.W. Cornelisse	J.W. Freeman & Co., Ltd., London	1982
Reference Books				
1	Fundamentals of Space Systems	Vincet L. Pisacane	Oxford University Press	2005
2	Understanding Space: An Introduction to Astronautics	J.Sellers	McGraw Hill	2nd edition,2000
3	Introduction to Space Flight	Francis J Hale	Pearson	1993
4	Elements of Space Technology for aerospace Engineers	Meyer Rudolph X	Meyer Rudolph X, Academic Press	1999

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SEMESTER - IV

COMPOSITE MATERIALS

Course Code	**18AS46**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the advantages of composite materials compared to conventional materials
- Evaluate the properties of polymer matrix composites with fiber reinforcements
- Explain the manufacturing process and applications of composite materials

Module-1

Introduction to Composite Materials: Definition, classification of composite materials, classification of reinforcement - particulate, short fiber, whiskers, long fibers composites. matrix materials – metals, ceramics, polymers (including thermoplastics and thermosets), Carbon-Carbon Composites.

Metal Matrix Composites: MMC with particulate and short fiber reinforcement, liquid and solid state processing of MMC – stir casting, squeeze casting. Properties of MMCs, Applications of Al, Mg, Ti based MMC.

Module-2

Processing of Polymer Matrix Composites: Thermoset Polymers

Hand layup Process, Vacuum Bagging Process, Post Curing Process, Filament winding, Pultrusion, Pulforming, Autoclave Process.

Processing of Polymer Matrix Composites: Thermoplastic Polymers

Extrusion process, Injection Moulding Process, Thermo-forming process. **Post Processing of Composites –** Adhesive bonding, drilling, cutting processes.

Module-3

Micro-Mechanical Behavior of a Lamina: Determination of elastic constants-Rule of mixtures, transformation of coordinates, micro-mechanics based analysis and experimental determination of material constants.

Macro-Mechanical Behavior of a Lamina: Global and local axis for angle lamina, determination of global and local stresses and moduli, for 2D-UD lamina with different fiber orientation and different fiber materials glass, carbon and aramid fiber reinforcement.

Module-4

Failure Analysis: Failure Theory – Tsai-Hill, Tsai-Wu, Max Stress and Max Strain Classical plate theory- Stress and strain variation in a laminate- Resultant forces and moments- A B & D matrices- Strength analysis of a laminate.

Module-5

Inspection & Quality Control : Destructive & Non-Destructive Testing, Tensile, Compression, Flexural, Shear, Hardness; ultrasonic testing – A-B-C scan.

Applications of Composites Materials: Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, marine, recreational and Sports equipment, future potential of composites.

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

1. CO1 : Explain the advantages of using composite materials as an alternative to conventional materials for specific applications
2. CO2: Describe the advanced fabrication and processing for producing composite parts.
3. CO3: Evaluate the micro- and macro-mechanical behavior of composite laminates.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Composite Materials- Science and Engineering	K.K Chawla	Springer	2nd edition,1998
2	Mechanics of Composites	Autar Kaw	CRC Press	2nd edition, 2006
Reference Books				
1	Composite Materials Handbook	Mein Schwartz	Department of Defense, USA	2002
2	Non-Destructive Testing of Composite Materials	Ajay Kapadia	TWI Publications	2006
3	Mechanics of Composite Materials	R M Jones	Taylor & Francis	2nd Edn,2015

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SEMESTER – IV

ENERGY CONVERSION AND FLUID MECHANICS LAB

Course Code	**18ASL47**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Familiarize with the flash point, fire point and viscosity of lubricating oils.
- Study IC engine parts, opening and closing of valves to draw the valve-timing diagram.
- Gain the knowledge of various flow meters and the concept of fluid mechanics.
- Understand the Bernoulli's Theorem.

Sl. No.	Experiments
1	Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Pensky Martins Apparatus.
2	Determination of Calorific value of solid, liquid and gaseous fuels.
3	Determination of Viscosity of lubricating oil using Torsion viscometers.
4	Valve Timing diagram of 4-stroke IC Engine.
5	Calculation of work done and heat transfer from PV and TS diagram using Planimeter.
6	Performance Test on **Four stroke Petrol Engine** and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet.
7	Performance Test on Four stroke Multi-cylinder Engine and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet.
8	Calibration of Venturimeter.
9	Determination of Coefficient of discharge for a small orifice by a constant head method.
10	Determination of Viscosity of a Fluid.
11	Calibration of contracted Rectangular Notch.
12	Verification of Bernoulli's equation.
13	Pipe friction apparatus with loss of head on pipe fittings.
14	Determination of Coefficient of loss of head in a sudden contraction and friction factor.

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

1. Operate the instrument and measure the BP, FP, IP and AF ratio.
2. Find the efficiency of the engine and Estimate the calorific value of the given fuel.
3. Verify the Bernoulli's equation.
4. Evaluate the viscosity of fluid.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

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SEMESTER - IV

COMPUTER AIDED AIRCRAFT DRAWING

Course Code	**18ASL48/18AEL48**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:2:0)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Understand and interpret drawings of machine and aircraft components
- Prepare assembly drawings either manually or by using standard CAD packages.
- Familiarize with standard components and their assembly of an aircraft.

Sl. No.	Experiments
	PART A
1	**Sections of Solids:** Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections.
2	**Orthographic Views:** Conversion of pictorial views into orthographic projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings) Hidden line conventions. Precedence of lines.
	PART B
3	**Thread Forms:** Thread terminology, sectional views of threads. ISO Metric (Internal & External) BSW (Internal & External) square and Acme. Sellers thread, American Standard thread.
4	**Fasteners:** Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.
5	**Keys & Joints:** Parallel key, Taper key, Feather key, Gibhead key and Woodruff key.
6	**Riveted Joints:** Single and double riveted lap joints, butt joints with single/double cover straps (Chain and Zigzag, using snap head rivets). Cotter joint (socket and spigot), knuckle joint (pin joint) for two rods.
7	**Couplings:** Split Muff coupling, protected type flanged coupling, pin (bush) type flexible coupling, Oldham's coupling and universal coupling (Hooks' Joint)
	PART C
8	Modelling of propeller and hub assembly
9	Modelling of wing assembly
10	Modelling of fuselage assembly
11	Modelling of Engine Mounts
12	Modelling of main rotor blade assembly of helicopter
13	Modelling of UAV assembly
14	Modelling of Landing Gear Assembly

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

- CO1 : Distinguish drawings of machine and aircraft components
- CO2: Identify assembly drawings either manually or by using standard CAD packages.
- CO3: Practice with standard components and their assembly of an aircraft.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. COMMON TO ALL PROGRAMMES
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – V

ENVIRONMENTAL STUDIES

Course Code	**18CIV59**	CIE Marks	40
Teaching Hours / Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Module - 1

Ecosystems (Structure and Function): Forest, Desert, Wetlands, Riverine, Oceanic and Lake.
Biodiversity: Types, Value; Hot-spots; Threats and Conservation of biodiversity, Forest Wealth, and Deforestation.

Module - 2

Advances in Energy Systems (Merits, Demerits, Global Status and Applications)**:** Hydrogen, Solar, OTEC, Tidal and Wind.
Natural Resource Management (Concept and case-studies): Disaster Management, Sustainable Mining, Cloud Seeding, and Carbon Trading.

Module - 3

Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies)**:** Surface and Ground Water Pollution; Noise pollution; Soil Pollution and Air Pollution.
Waste Management & Public Health Aspects: Bio-medical Wastes; Solid waste; Hazardous wastes; E-wastes; Industrial and Municipal Sludge.

Module - 4

Global Environmental Concerns (Concept, policies and case-studies):Ground water depletion/recharging, Climate Change; Acid Rain; Ozone Depletion; Radon and Fluoride problem in drinking water; Resettlement and rehabilitation of people, Environmental Toxicology.

Module - 5

Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems, ISO14001; Environmental Stewardship- NGOs.
Field work: Visit to an Environmental Engineering Laboratory or Green Building or Water Treatment Plant or Waste water treatment Plant; ought to be Followed by understanding of process and its brief documentation.

Course Outcomes: At the end of the course, students will be able to:

- CO1: Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale,
- CO2: Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment.
- CO3: Demonstrate ecology knowledge of a complex relationship between biotic and abiotic components.
- CO4: Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues.

Question paper pattern:

- The Question paper will have 100 objective questions.
- Each question will be for 01 marks
- Student will have to answer all the questions in an OMR Sheet.
- The Duration of Exam will be 2 hours.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Environmental Studies	Benny Joseph	Tata Mc Graw – Hill.	2nd Edition, 2012
2.	Environmental Studies	S M Prakash	Pristine Publishing House, Mangalore	3rd Edition, 2018

3	Environmental Studies – From Crisis to Cure	R Rajagopalan	Oxford Publisher	2005
Reference Books				
1	Principals of Environmental Science and Engineering	Raman Sivakumar	Cengage learning, Singapur.	2nd Edition, 2005
2	Environmental Science – working with the Earth	G.Tyler Miller Jr.	Thomson Brooks /Cole,	11th Edition, 2006
3	Text Book of Environmental and Ecology	Pratiba Sing, Anoop Singh& Piyush Malaviya	Acme Learning Pvt. Ltd. New Delhi.	1st Edition

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SEMESTER - V

MANAGEMENT AND ENTREPRENEURSHIP

Course Code	**18AS51/18AE51**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic concepts of management, planning, organizing and staffing.
- Acquire the knowledge to become entrepreneur.
- Comprehend the requirements towards the small-scale industries and project preparation.

Module-1

Management: Definition, Importance – Nature and Characteristics of Management, Management Functions, Roles of Manager, Levels of Management, Managerial Skills, Management & Administration, Management as a Science, Art & Profession

Planning: Nature, Importance and Purpose Of Planning, Types of Plans, Steps in Planning, Limitations of Planning, Decision Making – Meaning, Types of Decisions- Steps in Decision Making.

Module-2

Organizing and Staffing: Meaning, Nature and Characteristics of Organization – Process of Organization, Principles of Organization, Departmentalisation, Committees –meaning, Types of Committees, Centralization Vs Decentralization of Authority and Responsibility, Span of Control (Definition only), Nature and Importance of Staffing, Process of Selection and Recruitment.

Directing and Controlling: Meaning and Nature of Directing-Leadership Styles, Motivation Theories Communication – Meaning and Importance, Coordination- Meaning and Importance, Techniques of Coordination. Controlling – Meaning, Steps in Controlling.

Module-3

Social Responsibilities of Business: Meaning of Social Responsibility, Social Responsibilities of Business towards Different Groups, Social Audit, Business Ethics and Corporate Governance.

Entrepreneurship: Definition of Entrepreneur, Importance of Entrepreneurship, concepts of Entrepreneurship, Characteristics of successful Entrepreneur, Classification of Entrepreneurs, Intrapreneur – An Emerging Class, Comparison between Entrepreneur and Intrapreneur, Myths of Entrepreneurship, Entrepreneurial Development models, Entrepreneurial development cycle, Problems faced by Entrepreneurs and capacity building for Entrepreneurship.

Module-4

Modern Small Business Enterprises: Role of Small Scale Industries, Concepts and definitions of SSI Enterprises, Government policy and development of the Small Scale sector in India, Growth and Performance of Small Scale Industries in India, Sickness in SSI sector, Problems for Small Scale Industries, Impact of Globalization on SSI, Impact of WTO/GATT on SSIs, Ancillary Industry and Tiny Industry (Definition only).

Institutional Support for Business Enterprises: Introduction, Policies & Schemes of Central–Level Institutions, State-Level Institutions.

Module-5

Project Management: Meaning of Project, Project Objectives & Characteristics, Project Identification-Meaning & Importance; Project Life Cycle, Project Scheduling, Capital Budgeting, Generating an Investment Project Proposal, Project Report-Need and Significance of Report, Contents, Formulation, Project Analysis-Market, Technical, Financial, Economic, Ecological, Project Evaluation and Selection, Project Financing, Project Implementation Phase, Human & Administrative aspects of Project Management, Prerequisites for Successful Project Implementation.

New Control Techniques- PERT and CPM, Steps involved in developing the network, Uses and Limitations of PERT and CPM

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

1. CO1: Explain about the management and planning.
2. CO2: Apply the knowledge on planning, organizing, staffing, directing and controlling.
3. CO3: Describe the requirements towards the small-scale industries and project preparation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Principles of Management	P.C.Tripathi, P.N.Reddy	Tata Mc Graw Hill	
2	Dynamics of Entrepreneurial Development & Management	Vasant Desai	Himalaya Publishing House	
3	Entrepreneurship Development	Poornima. M. Charantimath	Pearson Education	2006
Reference Books				
1	Management Fundamentals-Concepts, Application, Skill Development	Robers Lusier-Thomson		
2	Entrepreneurship Development	S.S. Khanka	S. Chand & Co	
3	Management	Stephen Robbins	Pearson Education	17th Edition,2003

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SEMESTER - V

AERODYNAMICS - II

Course Code	**18AS52/18AE52**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Understand the concepts of compressible flow and shock phenomenon
- Acquire the knowledge of oblique shock and expansion wave formation.
- Appreciate the measurement in high speed flow.

Module-1

One Dimensional Compressible Flow: Energy, Momentum, continuity and state equations, velocity of sound, Adiabatic steady state flow equations, Flow through converging, diverging passages, Performance under various back pressures. Numericals.

Module-2

Normal Shock: Prandtl Meyer equation and Rankine – Hugonoit relation, Normal shock equations: Property ratios in terms of upstream Mach number. Numericals. Moving Normal Shock wave.

Module-3

Oblique shocks and Expansion waves: Prandtl equation and Rankine – Hugonoit relation, Normal shock equations, Pitot static tube, corrections for subsonic and supersonic flows, Oblique shocks and corresponding equations, Hodograph and pressure turning angle, shock polars, flow past wedges and concave corners, strong, weak and detached shocks, Flow past convex corners, Prandtl –Meyer expansion function, Reflection and interaction of shocks and expansion, waves, Families of shocks. Basics of Fanno and Rayleigh Flow.

Module-4

Differential Equations of Motion for Steady Compressible Flows:
Basic potential equations for compressible flow. Linearisation of potential equation-small perturbation theory. Methods for solution of nonlinear potential equation –Introduction, Method of characteristics, Boundary conditions, Pressure coefficient expression, small perturbation equation for compressible flow - Prandtl, Glauret and Geothert's rules - Ackert's supersonic airfoil theory, Von-Karman rule for transonic flow, Lift, drag pitching moment and center of pressure of supersonic profiles.

Module-5

Measurements in High speed Flow: Types of subsonic wind tunnels - Balances and measurements - Interference effects- transonic, Supersonic and hypersonic wind tunnels and characteristic features, their operation and performance - Shock tubes and shock tunnels - Free flight testing - Measurements of pressure, velocity and Mach number -Flow visualization methods of subsonic and supersonic flows.

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

1. CO1: Utilize the concepts of compressible flow and shock phenomenon
2. CO2: Apply knowledge of oblique shock and expansion wave formation.
3. CO3: Measure the parameters high speed flow.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year

Textbooks				
1	Modern Compressible Flow	John D Anderson	Mc Graw Hill	3rd edition, 2012
2	Gas Dynamics	Radhakrishnan E	Prentice Hall of India	5th edition,2014
Reference Books				
1	Dynamics and Thermodynamics of Compressible fluid flow	Ascher. H. Saphiro	John Wiley & Sons	1st edition,1977
2	Fundamentals of Compressible flow	Yahya, S. M	NEW AGE	2009
3	Elements of Gas Dynamics	H.W. Liepmann and A. Roshko	Dover Publications Inc	2003
4	Compressible Fluid Dynamics with Computer Application	Hodge B. K, Koenig K	Prentice Hall, New York	1st edition,1995
5	Elements of gas dynamics	Zucrow, M.J. and Anderson, J.D	McGraw - Hill Book Co., New York	1989

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SEMESTER - V

AEROSPACE PROPULSION

Course Code	**18AS53**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the working principles of gas turbine and ramjet propulsion systems, the design principles of inlets, combustion chambers, nozzles used in them.
- Learn the operation of compressors and turbines in gas turbine propulsion systems.
- Understand the operation of rocket propulsion.

Module-1

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

Module-2

Introduction to rocket propulsion: Classification and applications of rockets – Reaction principle – Thrust equation – Classification of rockets based on propellants used – solid, liquid and hybrid – Comparison of these engines with special reference to rocket performance – electric propulsion – classification- electro thermal – electro static – electromagnetic thrusters- geometries of Ion thrusters- beam/plume characteristics – hall thrusters.
Fundamentals and Definitions – Thrust, Exhaust Velocity, Energy and efficiencies, multiple propulsion systems, typical performance values, variable thrust and simple problems.

Module-3

Liquid Propellant rocket engine: Types of propellants, propellant tanks, propellant feed systems, gas pressure feed systems, tank pressurization, turbopump feed system, rocket engines for maneuvering and orbit adjustments.
Liquid Propellants: propellant properties, liquid oxidizers, liquid fuels, liquid monopropellants, gaseous propellant, safety and environment concern. Combustion process and instability.

Module-4

Solid Propellant Rocket engine: Basic relations and propellant burning rate, performance issues, propellant grain and grain configuration, propellant grain stress and strain, altitude control and side manoeuvres with solid propellant rocket motors
Solid Propellants: Classification, propellant characteristics, hazards, propellant ingredients, other propellant categories, liners, insulators and inhibitors, propellant processing and manufacturing, ignition and combustion instability.

Module-5

Nozzle Theory and Thermodynamics Relations: review of thermodynamics relations, ideal rocket propulsion systems, isentropic flow through nozzles, nozzle configuration, real nozzles, nozzle alignment, over expanded, under expanded nozzles and optimum expansion in nozzles
Thrust Chambers: Injectors, flow characteristics, factors influencing injection behavior, heat transfer analysis, starting and ignition, life of thrust chambers, random variable thrust, sample thrust chamber design analysis, Thrust Vector Control with single nozzle and multiple nozzles. Integration with vehicle.

Course Outcomes:

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

1. CO1: Analyze the engineering concepts of air breathing propulsion systems.
2. CO2: Distinguish the different types of compressors.
3. CO3: Choose the propellant based on the application.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Rocket Propulsion Elements	G. P. Sutton	Wiley India Pvt Ltd	7th Edition,2010
2	Gas Turbine Theory	Cohen, H. Rogers, G.F.C. and Saravanamuttoo H.I.H	DORLING KINDERSLEY	5th edition,2002
Reference Books				
1	Introduction to Rocket Propulsion	James R	Church of Care	2018
2	Rocket and Spacecraft Propulsion	Martin J 1 Turner	Springer	Third Edition
3	Aerothermodynamics of gas turbines and rocket prolusion	G.C. Oates	AIAA Education Series	Third Edition
4	Mechanics and Thermodynamics of Propulsion	Hill,P.G. and Peterson, C.R	Pearson	2nd edition,2009

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SEMESTER - V

AEROSPACE STRUCTURES - II

Course Code	**18AS54**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Comprehend the basic concepts of theory of bending.
- Acquire the knowledge of shear flow and buckling.
- Understand the missile and satellite structures.

Module-1

Introduction: Elementary theory of bending – Introduction to semi-Monocoque structures - Stresses in beams of symmetrical and unsymmetrical sections -Box beams – General formula for bending stresses- principal axes method – Neutral axis method.

Module-2

Shear Flow: Shear stresses in beams – Shear flow in stiffened panels - Shear flow in thin walled open tubes – Shear centre – Shear flow in open sections with stiffeners.

Module-3

Shear Flow Analyses: Shear flow in closed sections with stiffeners– Angle of twist - Shear flow in two flange and three flange box beams – Shear centre - Shear flow in thin walled closed tubes - Bredt-Batho theory - Torsional shear flow in multi cell tubes - Flexural shear flow in multi cell stiffened structures.

Module-4

Failure concepts: Stability problems of thin walled structures– Buckling of sheets under compression, shear, bending and combined loads - Crippling stresses by Needham's and Gerard's methods–Sheet stiffener panels-Effective width, Inter rivet and sheet wrinkling failures-Tension field web beams(Wagner's).

Module-5

Launch Vehicle and Spacecraft Structures: Launch vehicle structures – Loads and stresses, thin walled pressure vessels, Buckling of beams, thin wall assumption. spacecraft - mini, micro structures, inflatable structures, flying effector, nanotubing.

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

1. CO1: Compute the shear flow in open and closed section.
2. CO2: Analyze the stability problems of thin walled structures.
3. CO3: Distinguish the mini and micro structures.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Aircraft Structures for Engineering Students	Megson, T.M.G	ELSEVIER	5th edition,2013
2	Analysis and Design of Flight Vehicle Structures	E.F. Bruhn	Tristate Offset Co	1980
Reference Books				

1	Aircraft Structures	Peery, D.J. and Azar, J.J	McGraw-Hill,New York	2nd Edition,1993
2	Theory of Plates and Shells	Stephen P. Timoshenko & S.woinowsky Krieger	McGraw-Hill, Singapore	2nd edition, 2010
3	Theory and Analysis of Flight structures	Rivello, R.M	McGraw-Hill, N.Y	1993

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SEMESTER - V

AIRCRAFT SYSTEMS & INSTRUMENTATION

Course Code	**18AS55/18AE55**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the aircraft control systems.
- Understand the aircraft systems.
- Acquire the knowledge of aircraft instruments.

Module-1

Airplane Control Systems: Conventional Systems, fully powered flight controls, Power actuated systems, Modern control systems, Digital fly by wire systems, Auto pilot system active control Technology.

Module-2

Aircraft Systems: Hydraulic systems, Study of typical workable system, components, Pneumatic systems, Advantages, Working principles, Typical Air pressure system, Brake system, Typical Pneumatic power system, Components, Landing Gear systems, Classification.

Module-3

Engine Systems: Fuel systems for Piston and jet engines, Components of multi engines. lubricating systems for piston and jet engines - Starting and Ignition systems - Typical examples for piston and jet engines.

Module-4

Auxiliary System: Basic Air cycle systems, Vapour Cycle systems, Evaporative vapour cycle systems, Evaporative air cycle systems, Fire protection systems, Deicing and anti-icing systems.

Module-5

Aircraft Instruments: Flight Instruments and Navigation Instruments, Gyroscope, Accelerometers, Air speed Indicators, TAS, EAS, Mach Meters, Altimeters, Principles and operation, Study of various types of engine instruments, Tachometers, Temperature gauges, Pressure gauges, Operation and Principles.

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

1. CO1: Distinguish the conventional and modern control systems.
2. CO2: Classify the aircraft systems.
3. CO3: Categorize different types of aircraft instruments.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Aircraft Systems: Mechanical, Electrical and Avionics-Subsystem Integration	Ian Moirand Allan Seabridge	Wiley India Pvt Ltd	3rd edition, 2012
2	Aircraft Instruments and Integrated Systems	Pallet, E.H.J	Longman Scientific and Technical	1996
Reference Books				

1	Aircraft Systems (Fundamentals of Flight Vol. IV)	Lalit Gupta and OP. Sharma	HimalayanBooks	2006
2	Gas Turbine Technology	Treager. S	McGraw-Hill	3rd edition,2013
3	The aircraft Engineers Handbook, No 4, Instruments	R.W. Sloley and W.H. Coulthard		6th Edition, 2005
4	Pneumatic Systems	SR. Majumdar	Tata McGraw Hill Publishing Co	1st Edition, 2001
5	Aircraft Hydraulic Systems	William A Neese	Himalayan Books	2007

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SEMESTER - V

FLIGHT MECHANICS

Course Code	**18AS56**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the Flight Forces, Flight Performance in level flight.
- Understand the concept of static stability and control.
- Acquire the knowledge of Equations of Motions and dynamic stability.

Module-1

Flight Environment, Flight Forces and Steady Flight Performance: The atmosphere as flight environment. The International Standard Atmosphere Model. The Force and Moment Systems of an Aircraft. Steady state performance.

Static Longitudinal Stability and Control (Stick Fixed): Degree of freedom of rigid bodies in space. Static Longitudinal stability - Stick fixed. Effects of fuselage and nacelle - Influence of CG location - Power effects - Stick fixed neutral point.

Module-2

Static Longitudinal Stability and Control-Stick free: Introduction, Hinge moment parameters, Control surface floating characteristics and aerodynamic balance, Estimation of hinge moment parameters, The trim tabs, Stick-free Neutral point, Stick force gradient in unaccelerated flight, Restriction on aft C.G.

Module-3

Static Directional and Lateral Stability and Control

Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin. One engine inoperative condition. Weather cocking effect.

Static lateral stability. Estimation of dihedral effect. Effect of wing sweep, flaps, and power. Lateral control, Estimation of lateral control power, Aileron control forces, Balancing the aileron. Coupling between rolling and yawing moments. Adverse yaw effects. Aileron reversal.

Module-4

Equations of Motions (EOMs)

Derivation of rigid body equations of motion, Orientation and position of the airplane, gravitational and thrust forces, Small disturbance theory. Aerodynamic force and moment representation, Derivatives due to change in forward speed, Derivatives due to the pitching velocity, Derivatives due to the time rate of change of angle of attack, Derivatives due to rolling rate, Derivatives due to yawing rate.

Module-5

Dynamic Stability

Dynamic longitudinal stability. Types of modes of motion: phugoid motion, short period motion. Routh's stability criteria. Factors affecting period and damping of oscillations.

Dynamic lateral and directional stability. Response to aileron step-function, side-slip excursion. Dutch roll and Spiral instability. Auto- rotation and spin. Stability derivatives for lateral and directional dynamics.

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

1. CO1: Apply the basic concepts of aircraft performance, and stability.
2. CO2: Use static stability concepts and stability parameters.
3. CO3: Estimate the dynamic stability derivatives.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Airplane Performance stability and Control	Perkins, C.D., and Hage, R.E	John Wiley Son Inc, New York	1988
2	Flight Stability and Automatic Control	Nelson, R.C	McGraw-Hill Book Co	2007
Reference Books				
1	Performance, Stability, Dynamics and Control of Airplanes	Bandu N. Pamadi	AIAA	2nd Edition Series, 2004
2	Introduction to flight	John D. Anderson, Jr	McGraw-Hill	2000
3	The Principles of the Control and Stability of Aircraft	W.J. Duncan	Cambridge University Press	2016
4	Dynamics of Flight Stability and Control	Etkin, B	John Wiley, New York	1982

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SEMESTER - V

AERODYNAMICS LAB

Course Code	**18ASL57/18AEL57**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Be acquainted with basic principles of aerodynamics using wind tunnel.
- Acquire the knowledge on flow visualization techniques.
- Understand the procedures used for calculating the lift and drag.

Sl. No.	Experiments
1	Calibration of a subsonic wind tunnel: test section static pressure and total head distributions.
2	Smoke flow visualization studies on a two-dimensional circular cylinder at low speeds.
3	Smoke flow visualization studies on a two dimensional airfoil at different angles of incidence at low speeds
4	Smoke flow visualization studies on a two dimensional multi element airfoil with flaps and slats at different angles of incidence at low speeds
5	Tuft flow visualization on a wing model at different angles of incidence at low speeds: identify zones of attached and separated flows.
6	Surface pressure distributions on a two-dimensional smooth circular cylinder at low speeds and calculation of pressure drag.
7	Surface pressure distributions on a two-dimensional rough circular cylinder at low speeds and calculation of pressure drag.
8	Surface pressure distributions on a two-dimensional symmetric airfoil and estimation of center of
9	Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence,
10	Calculation of total drag of a two-dimensional circular cylinder at low speeds using pitot-static probe wake survey.
11	Calculation of total drag of a two-dimensional cambered airfoil at low speeds at incidence using pitot-static probe wake survey.
12	Measurement of a typical boundary layer velocity profile on the tunnel wall (at low speeds) using a pitot probe and calculation of boundary layer displacement and momentum thickness.
13	Calculation of aerodynamic coefficients and forces acting on a model aircraft at various Angle of Attack and speeds using wind tunnel balance (With and Without Yaw).
14	Pressure measurements on aerofoil for a case of reverse flow.

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

1. CO1: Apply the flow visualization techniques.
2. CO2: Estimate the pressure distribution over the bodies.
3. CO3: Calculate the lift and drag.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

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SEMESTER - V

PROPULSION LAB

Course Code	**18ASL58**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(0:2:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Understand how to do the heat transfer
- Comprehend the analysis over the surface of the aircraft structure,
- Study the working of different jet engines, study of propellants etc.

Sl. No.	Experiments
1	Study of forced convective heat transfer over a flat plate.
2	Study of free convective heat transfer over a flat plate.
3	Determination of heat of combustion of aviation fuel.
4	Measurement of burning velocity of a premixed flame.
5	Flame stability of pre-mixed flame through flame stability setup.
6	Study of Free Jet/Wall Jet.
7	Investigation of the pressure in a convergent – divergent nozzle for under expanding and over expanding conditions.
8	Preparation of a Solid Propellant.
9	Computation of burning rate of the propellant.
10	Determine the Calorific value of liquid fuel.
11	Measurement of Ignition delay of a single propellant with different shapes.
12	Determine the specific impulse of solid motor.
13	Performance study of Hybrid Motor using a thrust stand.
14	Analysis of grain stress and strain of a solid propellant.

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

1. CO1: Analyze the performance of jet engine.
2. CO2: Evaluate the performance of a propellant.
3. CO3: Differentiate among different equipments required for study of propulsion.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

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SEMESTER – V

ENVIRONMENTAL STUDIES

Course Code	**18CIV59**	CIE Marks	40
Teaching Hours / Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Module - 1

Ecosystems (Structure and Function): Forest, Desert, Wetlands, Riverine, Oceanic and Lake.
Biodiversity: Types, Value; Hot-spots; Threats and Conservation of biodiversity, Forest Wealth, and Deforestation.

Module - 2

Advances in Energy Systems (Merits, Demerits, Global Status and Applications)**:** Hydrogen, Solar, OTEC, Tidal and Wind.
Natural Resource Management (Concept and case-studies): Disaster Management, Sustainable Mining, Cloud Seeding, and Carbon Trading.

Module - 3

Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies)**:** Surface and Ground Water Pollution; Noise pollution; Soil Pollution and Air Pollution.
Waste Management & Public Health Aspects: Bio-medical Wastes; Solid waste; Hazardous wastes; E-wastes; Industrial and Municipal Sludge.

Module - 4

Global Environmental Concerns(Concept, policies and case-studies):Ground water depletion/recharging, Climate Change; Acid Rain; Ozone Depletion; Radon and Fluoride problem in drinking water; Resettlement and rehabilitation of people, Environmental Toxicology.

Module - 5

Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems, ISO14001; Environmental Stewardship- NGOs.
Field work: Visit to an Environmental Engineering Laboratory or Green Building or Water Treatment Plant or Waste water treatment Plant; ought to be Followed by understanding of process and its brief documentation.

Course Outcomes: At the end of the course, students will be able to:

- CO1: Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale,
- CO2: Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment.
- CO3: Demonstrate ecology knowledge of a complex relationship between biotic and a biotic components.
- CO4: Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues.

Question paper pattern:

- The Question paper will have 100 objective questions.
- Each question will be for 01 marks
- Student will have to answer all the questions in an OMR Sheet.
- The Duration of Exam will be 2 hours.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Environmental Studies	Benny Joseph	Tata Mc Graw – Hill.	2nd Edition, 2012

2.	Environmental Studies	S M Prakash	Pristine Publishing House, Mangalore	3rd Edition, 2018
3	Environmental Studies – From Crisis to Cure	R Rajagopalan	Oxford Publisher	2005
Reference Books				
1	Principals of Environmental Science and Engineering	Raman Sivakumar	Cengage learning, Singapur.	2nd Edition, 2005
2	Environmental Science – working with the Earth	G.Tyler Miller Jr.	Thomson Brooks /Cole,	11th Edition, 2006
3	Text Book of Environmental and Ecology	Pratiba Sing, AnoopSingh& PiyushMalaviya	Acme Learning Pvt. Ltd. New Delhi.	1st Edition

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SEMESTER - VI

MISSILES AND LAUNCH VEHICLES

Course Code	**18AS61**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:1:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Understand the types of space launch vehicles and missiles.
- Study the solid and liquid rocket motors.
- Acquire the knowledge on launch vehicle dynamics, attitude control, rocket testing and materials.

Module-1

Introduction: Space launch Vehicles and military missiles, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation, similarities and differences. Some famous space launch vehicles and strategic missiles.

Module-2

Solid Propellant Rocket Motor Systems: Solid Propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, preparation, loading, structural design of grain. Liners, insulators and inhibitors, function, requirements, materials. Rocket motor casing – materials. Nozzles, types, design, construction, thermal protection. Igniters, types, construction. Description of modern solid boosters I) Space Shuttle SRB, II)the Arienne SRB

Liquid Propellant Rocket Motor Systems: Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build up, system calibration, integration and optimisation – safety and environmental concerns. Description of the space shuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines.

Module-3

Aerodynamics Of Rockets And Missiles: Classification of missiles. Airframe components of rockets and missiles, Forces acting on a missile while passing through atmosphere, method of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion, re-entry body design considerations.

Module-4

Launch Vehicle Dynamics: Tsiolskovsky's rocket equation, range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging. Earth launch trajectories – vertical segment, the gravity turn, constant pitch trajectory, orbital injection. Actual launch vehicle trajectories, types. Examples, the Mu 3-S-II, Ariane, Pegasus launchers. Reusable launch vehicles, future launchers, launch assist technologies.

Attitude Control Of Rockets And Missiles: Rocket Thrust Vector Control – Methods of Thrusts Vector Control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; stage separation dynamics, separation techniques.

Module-5

Rocket Testing: Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground Testing, Flight Testing, Trajectory monitoring, post -accident procedures. Descriptions of a typical space launch vehicle launch procedure.

Materials: Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for thermal protection and for pressure vessels.

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

1. CO1: Identify the types of space launch vehicles and missiles.
2. CO2: Distinguish the solid and liquid propellant motors.
3. CO3: Classify different types of materials used for rockets and missies.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Rocket Propulsion Element	George P Sutton and Oscar Biblarz	John Wiley and Sons Inc	7th edition, 2010
2	Missile Aerodynamics	Jack N Neilson	AIAA	1st edition, 1988
Reference Books				
1	Missile Configuration Design	S S Chin		
2	Rocket Propulsion and Space-Flight Dynamics	Cornelisse, J.W., Schoyer H.F.R. and Wakker,. K.F	Pitman	1979
3	Rocket and Spacecraft propulsion	Turner, M.J.L	Springer	3rd edition,2010
4	Space Vehicle Dynamics	Ball, K.J., Osborne, G.F.	Oxford University Press	1967
5	Materials for Missiles and Spacecraft	Parker, E.R	McGraw Hill	1982

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Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

COMPUTATIONAL FLUID DYNAMICS

Course Code	**18AS62**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Know the basic equations of fluid dynamics, boundary layer and discretization.
- Understand the source and vortex panel method.
- Know about FDM, FVM and FEM.

Module-1

Introduction: CFD Applications. Need for Parallel Computers in CFD algorithms. Models of flows. Substantial derivative, Divergence of velocity. Continuity, Momentum, and Energy Equations-Derivation in various forms. Integral versus Differential form of equations. Comments on governing equations. Physical boundary conditions. Forms of equations especially suitable for CFD work. Shock capturing, and shock fitting.

Module-2

Mathematical Behaviour of Partial Differential Equations: Classification of partial differential equations. Cramer Rule and Eigen value methods for classification. Hyperbolic, parabolic, and elliptic forms of equations. Impact of classification on physical and computational fluid dynamics. Case studies: steady inviscid supersonic flow, unsteady inviscid flow, steady boundary layer flow, and unsteady thermal conduction, steady subsonic inviscid flow.

Module-3

Grid Generation and Adaptive Grids: Need for grid generation and Body-fitted coordinate system. Structured Grids-essential features. Structured Grid generation techniques- algebraic and numerical methods. Unstructured Grids-essential features. Unstructured Grid generation techniques- Delaunay-Voronoi diagram, advancing front method. Surface grid generation, multi-block grid generation, and meshless methods. Grid quality and adaptive grids. Structured grids adaptive methods and unstructured grids adaptive methods.

Module-4

Discretisation & Transformation:
Discretisation: Finite differences methods, and difference equations. Explicit and Implicit approaches. Unsteady Problem -Explicit versus Implicit Scheme. Errors and stability analysis. Time marching and space marching. Reflection boundary condition. Relaxation techniques. Alternating direction implicit method. Successive over relaxation/under relaxation. Second order Lax-Wendroff method, mid-point Leap frog method, upwind scheme, numerical viscosity, and artificial viscosity.
Transformation: Transformation of governing partial differential equations from physical domain to computational domain. Matrices and Jacobians of transformation. Example of transformation. Generic form of the Governing flow equations in Strong Conservative form in the Transformed Space.

Module-5

Finite Volume Technique and Some Applications: Spatial discretisation- cell centered and cell vertex techniques (overlapping control volume, duel control volume). Temporal discretisation- Explicit time stepping, and implicit time stepping. Time step calculation. Upwind scheme and high resolution scheme. Flux vector splitting, approximate factorisation. Artificial dissipation and flux limiters. Unsteady flows and heat conduction problems. Upwind biasing.

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

1. CO1 : Differentiate the FDM, FVM and FEM
2. CO2: Perform the flow, structural and thermal analysis.
3. CO3 : Utilize the discretization methods according to the application.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Applied Computational Fluid Dynamics	Gupta . S.C	Wiley, India	2019
2	Computational Fluid Dynamics	John D. Anderson	McGraw Hill	2013
Reference Books				
1	Computational Fluid Dynamics - An Introduction	John F. Wendt	Springer	3rd Edition, 2013
2	Numerical Computation of Internal and External Flows	Charles Hirsch	Elsevier	1st edition, 2007
3	Computational Fluid Dynamics for Engineers	Klaus A Hoffmann and Steve T. Chiang		1993
4	Fundamentals of CFD	Tapan K. Sengupta	Universities Press	2004

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SEMESTER - VI

FINITE ELEMENT METHOD

Course Code	**18AS63/18AE63**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the importance of discretisation of domain using different finite elements
- Acquire the knowledge of different loading and boundary conditions
- Understand the governing methods of finite element analysis

Module-1

Introduction: Basic Concepts, Background Review: Stresses and Equilibrium, Plane stress, Plane strain, Potential energy and Equilibrium. Rayleigh - Ritz Method, Galerkin's Method, Simple applications in structural Analysis. Construction or discrete models - sub domains and nodes - simple elements for the FEM - Simplex, complex and multiples elements Polynomial selection -illustrative examples Elements and shape functions and natural coordinates, Use of local and natural coordinates, compatibility and convergence requirements of shape functions.

Module-2

Fundamentals of Finite Element Method: Construction of shape functions for bar element and beam element, Bar elements, uniform bar elements, uniform section, mechanical and thermal loading, varying section, truss analysis, Frame element, Beam element, problems for various loadings and boundary conditions.

Module-3

Analysis of Two and Three dimensional Elements: Shape functions of Triangular, Rectangular and Quadrilateral elements, different types of higher order elements, constant and linear strain triangular elements, stiffness matrix Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family.

Module-4

Theory of Isoparametric Elements and Axisymmetric: Isoparametric, sub parametric and super-parametric elements, characteristics of Isoparametric quadrilateral elements, structure of computer program for FEM analysis, description of different modules, pre and post processing, Axisymmetric formulation finite element modeling of triangular and quadrilateral element.

Module-5

Field Problems: Heat transfer problems, Steady state fin problems, 1D heat conduction governing equation, Derivation of element matrices for two dimensional problems, Dynamic consideration- Formulation-Hamilton's principle, Element mass matrices.

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

1. CO1: Apply discretisation technique for domain decomposition.
2. CO2 : Evaluate the effects of different loading and boundary conditions
3. CO3 : Analyze the governing equations of finite element analysis

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Finite Elements in engineering	Chandrupatla T. R	PHI	3rd edition, 2002
2	Finite element Analysis	Bhavikatti	New Age International	3rd edition,2015
Reference Books				
1	Finite element analysis in engineering design	Rajasekharan. S	Wheeler Publishers	
2	Finite Element Procedures	Bathe. KJ	PHI Pvt. Ltd., New Delhi	1996
3	The Finite Element Method	Zienkiewicz. O.C	Elsevier	7th edition,2013
4	Finite Elements Method in Engineering	Rao S. S	Elsevier	5th edition, 2008
5	Finite Element analysis - Theory and Programming	C.S. Krishnamurthy	Tata McGraw Hill Co. Ltd, New Delhi	2nd edition,2011

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SEMESTER – VI

HYPERSONICS

Course Code	**18AS641**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basics of hypersonic flows.
- Understand the approximate methods for inviscid hypersonic flows.
- Acquire the knowledge of viscous interactions in hypersonic flows.

Module-1

Basics of Hypersonic Flows: 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.

Module-2

Surface Inclination Methods For Hypersonic Inviscid Flows: Local surface inclination methods, modified Newtonian Law, Newtonian theory – tangent wedge or tangent cone and shock expansion methods, Calculation of surface flow properties.

Module-3

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

Module-4

Viscous Hypersonic Flow Theory: Navier–Stokes equations, boundary layer equations for hypersonic flow, hypersonic boundary layer, hypersonic boundary layer theory and non similar hypersonic boundary layers, hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating, heat flux estimation

Module-5

Viscous Interactions In Hypersonic Flows: Strong and weak viscous interactions, hypersonic shockwaves and boundary layer interactions, Estimation of hypersonic boundary layer transition, Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

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

1. CO1: Apply the basics of hypersonic flows.
2. CO2: Apply the approximate methods for inviscid hypersonic flows.
3. CO3: Classify the viscous interactions in hypersonic flows.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Hypersonic and High Temperature Gas Dynamics	John D. Anderson, Jr	AIAA Series	2nd revised edition,2006

2	Modern Compressible Flow with Historical perspective Hypersonic Series	John D. Anderson, Jr	McGraw Hill	3rd edition,2012
Reference Books				
1	Hypersonic Air Breathing propulsion	William H. Heiser and David T. Pratt	AIAA	1994
2	Hypersonic Aerothermodynamics	John T. Bertin	AIAA Inc	1994

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SEMESTER - VI

THEORY OF VIBRATIONS

Course Code	**18AS642**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic concepts of vibrations.
- Understand the working principle of vibration measuring instruments.
- Acquire the knowledge of numerical methods for multi-degree freedom systems.

Module-1

Introduction: Types of vibrations, S.H.M, principle of super position applied to Simple Harmonic Motions. Beats, Fourier theorem and simple problems.

Module-2

Undamped Free Vibrations: Single degree of freedom systems. Undamped free vibration, natural frequency of free vibration, Spring and Mass elements, effect of mass of spring, Compound Pendulum.
Damped Free Vibrations: Single degree of freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement.

Module-3

Forced Vibration: Single degree of freedom systems, steady state solution with viscous damping due to harmonic force. Solution by Complex algebra, reciprocating and rotating unbalance, vibration isolation, transmissibility ratio due to harmonic excitation and support motion.
Vibration Measuring Instruments & Whirling of Shafts: Vibration of elastic bodies – Vibration of strings – Longitudinal, lateral and torsional Vibrations.

Module-4

Systems with Two Degrees of Freedom: Introduction, principle modes and Normal modes of vibration, co-ordinate coupling, generalized and principal co-ordinates, Free vibration in terms of initial conditions. Geared systems. Forced Oscillations-Harmonic excitation. Applications: Vehicle suspension, Dynamic vibration absorber and Dynamics of reciprocating Engines.
Continuous Systems: Introduction, vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler's equation for beams.

Module-5

Numerical Methods for Multi-Degree Freedom Systems:
Introduction, Influence coefficients, Maxwell reciprocal theorem, Dunkerley's equation. Orthogonality of principal modes, Method of matrix iteration-Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle. Holzer's method, Stodola method.

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

1. CO1: Apply the principle of super position to Simple Harmonic Motions.
2. CO2: Determine the vibrations using vibration instruments.
3. CO3: Analyze the multi-degree freedom systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Vibration with Applications	W.T. Thomson and Marie Dillon Dahleh	Pearson Education	5th edition, 2008
2	Mechanical Vibrations	V.P. Singh	Dhanpat Rai & Company Pvt. Ltd	2016
Reference Books				
1	Mechanical Vibrations	S.S. Rao	Pearson Education Inc	4th Edition,2003
2	Mechanical Vibrations	S. Graham Kelly	Tata McGraw Hill	Special Indian edition, 2007
3	Theory & Practice of Mechanical vibrations	J.S. Rao & K. Gupta	New Age International Publications, New Delhi	2001
4	Elements of Vibrations Analysis	Leonanrd Meirovitch	Tata McGraw Hill	Special Indian edition, 2007

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SEMESTER – VI

INTRODUCTION TO ASTROPHYSICS AND SPACE ENVIRONMENT

Course Code	**18AS643**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basics of astrophysics and space environment.
- Study the relativistic quantum mechanics.
- Acquire the knowledge of sun and solar system.

Module-1

Introduction: Overview of major contents of universe, Black body radiation, specific intensity, flux density, luminosity, Basics of radiative transfer (Emission/absorption coefficients, source functions), Magnitudes, distance modulus, Color index, Extinction, Color temperature, effective temperature, Brightness temperature, bolometric magnitude/luminosity, Excitation temperature, kinetic temperature, Utility of stellar spectrum.

Module-2

Basic knowledge of stellar atmospheres: Binaries, variable stars, clusters, open and globular clusters, Laws of planetary motion, Motions and Distances of Stars, Statistical and moving cluster parallax, Velocity Dispersion, Compact objects (BH-systems, Accretion rate/efficiency, Eddington luminosity), Shape, size and contents of our galaxy, Normal and active galaxies, High energy physics (introduction to X-ray and Gamma-ray radiation processes), Newtonian cosmology, microwave background, early universe.

Module-3

Relativistic Quantum Mechanics: Scattering, classical radiation field, creation, annihilation and number operators. Quantized radiation field, unified approach to emission, absorption, and scattering of photons by atoms, radiation damping and resonance fluorescence, dispersion relations and causality, relativistic wave equation (Klein- Gordon and Dirac equations), basics of quantum electrodynamics.

Module-4

Sun & Solar System: The sun, helioseismology, convection, solar magnetism: flux tubes, sun spots, dynamo, solar cycle, chromosphere, corona, solar wind, physical processes in the solar system; dynamics of the solar system; physics of planetary atmospheres; individual planets; comets, asteroids, and other constituents of the solar system; extra-solar planets; formation of the solar system, stars, and planets.

Module-5

Space Environment: Introduction, Vacuum Environments and its effect, Neutral environment and its effects, Plasma environment, Radiation Environment and its effects, Debris Environment and its effects.

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

1. CO1: Evaluate the Black body radiation, specific intensity, flux density, etc.
2. CO2: Apply the relativistic quantum mechanics.
3. CO3: Identify and sun and the solar system.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	The Physical Universe	Shu, F	University of California	1981

2	Theoretical Astrophysics	Padmanabhan, T.,	Cambridge University Press	south asian edition,2010
Reference Books				
1	Advanced Quantum Mechanics	Sakurai, JJ.,	Pearson Education India	1st edition,2002
2	The Sun: An Introduction	Stix, M	Springer	Reprinted edition, 2012
3	The Space Environment	Alan C. Tribble	Princeton University Press	Revised edition, 2003

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SEMESTER - VI

RADAR AND MICROWAVE ENGINEERING

Course Code	**18AS644**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basics of Radars.
- Understand the wave propagation and waveguides.
- Acquire the knowledge of MTI, SST and types of Radars.

Module-1

Introduction to Radar: Basics, Radar Frequencies, Radar Range Equation, Types of Radar, Doppler Effect, FMCW Radar, Secondary Radar and its applications, Comparison of primary and secondary radar.

Module-2

Radar Transmitter: Introduction, Block diagram, Modulator, Line type modulator, Hard tube modulator, duplexer, balanced duplexer and circulator.

Module-3

Wave Guides: Basics, Propagation, field configuration, modes, group and phase velocity, cut off wavelength, waveguide dimensions, types of waveguides, WG Tees, hybrid junction, bends, twists and tapers.

Module-4

Radar Receiver: Functions, block diagram, noise figure, detection and extraction of information, automatic detectors, false alarm, missed detection, clutter and reduction techniques, CFAR, AGC, STC, side lobe suppression, radar data processing, pulse compression technique, radar displays, synthetic displays.

Module-5

Moving Target Indicator: Principles, Block diagram of MTI, delay line canceller, blind speed, Digital MTI.
SST Radars: Search and surveillance Radar, Principles of tracking radar .
Types of Radars in IAF: MPR, Rohini, LLLWR, LLTR, TRS-2215, THD 1955.

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

1. CO1: Apply of concepts of Radars.
2. CO2: Classify the modulators, duplexer and circulators.
3. CO3: Identify the applications of different types of radars.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to Radar Systems	M. I. Skolnik	Tata McGraw-Hill	2017
2	Radar Principles	Peyton Z Peebles	Wiley	1998
Reference Books				
1	Microwave Devices and Circuits	Liao	Pearson	3rd edition,2003
2	Fundamentals of Radar Signal Processing	Mark Richards	McGraw Hill	2nd Edition,2014

3	Principles of Radar	Toomay J.C	Prentice Hall India	2010
4	Introduction to Airborne Radar	George W. Stimson, Hugh Griffiths	SciTech	3rd Edition,2014

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SEMESTER - VI

DESIGN, MODELLING & ANALYSIS LAB

Course Code	**18ASL66**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Understand the procedure to draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures.
- Acquire the knowledge of types of meshing.
- Understand the basics of flow and stress analysis.

Sl. No.	Experiments
1	Modeling of Symmetric Aerofoil Geometry, And Generation of Body Fitting Mesh.
2	Modeling of Cambered Aerofoil Geometry, And Generation of Body Fitting Mesh.
3	Modeling of 2-D Incompressible and Inviscid Flow over an Aerofoil. Computations and Analysis for Velocity Vectors and Pressures Distributions.
4	Modeling of 2-D Incompressible and Viscous Flow over an Aerofoil. Computations and Analysis for Velocity Vectors and Pressures Distributions.
5	Geometric Modeling and Mesh Generation of 2-D Convergent Divergent Nozzle and Analyses of Flow for Adiabatic Conditions.
6	Grid generation on fore portion of a spacecraft model.
7	High speed flow analysis past blunt object in presence of a bow shock wave.
8	Structural Modeling of a 3-D Wing.
9	Structural Modeling of fuselage bulk head of a spacecraft.
10	Shear flow analysis under defined load conditions on a spar of 3D wing.
11	Shear flow analysis under defined load conditions in a bulkhead.
12	Estimation of shear flow in a plate of varying stiffness under bending and torsion.
13	Free and forced vibration analysis of a structural frame.
14	Analysis of active vibration control in a smart material part.

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

1. CO1: Draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures.
2. CO2: Apply different types of meshing.
3. CO3: Perform the flow and stress analysis.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

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SEMESTER - VI

AIRCRAFT STRUCTURES LAB

Course Code	**18ASL67**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Learn about the simply supported beam, cantilever beam.
- Understand the Maxwell's theorem and Poisson ration.
- Acquire the knowledge about buckling load, shear failure and shear centre.

Sl. No.	Experiments
1	Deflection of a Simply Supported Beam.
2	Deflection of a cantilever Beam
3	Beam with combined loading by using superposition theorem
4	Verification of Maxwell's Reciprocal Theorem for beams with. a) Constant cross section b) Varying cross section
5	Determination of Young's Modulus using strain gages.
6	Determination of natural frequency, mode shapes of a cantilever beam for the following cases. a) Constant cross section b) Varying cross section c) Constant cross section and varying stiffness.
7	Buckling load of slender Eccentric Columns and Construction of Southwell Plot
8	Shear Failure of Bolted and Riveted Joints
9	Determination of damping coefficient of a cantilever beam for the following cases.
10	Determination of shear flow and shear centre through shear flow for the case of close section beam – Symmetrical bending.
11	Tensile, Compressive and Flexural testing of a composite material plate.
12	Estimation of natural frequency and mode shapes of a two rotor system.
13	Determining of Shear centre location for closed and open section beams through deflection measurements.
14	Determination of shear flow and shear centre through shear flow for the case of beam of open section – Unsymmetrical bending.

Course Outcomes:

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

1. CO1: Compute the deflection of simply supported beam and cantilever beam.
2. CO2: Verify the Maxwell's theorem.
3. CO3: Determine the buckling load, shear failure and shear centre.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

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SEMESTER – VI

HISTORY OF FLIGHT & TECHNOLOGY FORECAST

Course Code	**18AS651/18AE651**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Study the basic concepts of flying.
- Understand about the aircraft structures and materials.
- 3. Acquire the knowledge of aircraft power plants.

Module-1

Introduction
Early Developments – Ornithopters, Balloon Flight, Sir George Cayley – The true inventor of Airplane, the Interregnum, Otto Lilienthal – The Glider Man, Percy Pilcher – Extending the Glider Tradition.

Module-2

Wilbur and Orville Wright – Inventors of First Practical Airplane, Aeronautical Triangle – Langley, Wrights and Glenn Curtiss, Problem of Propulsion, Faster and Higher, biplanes and monoplanes, Developments in aerodynamics, materials, structures and propulsion over the years.

Module-3

Aircraft Configurations:
Different types of flight vehicles, classifications. Components of an airplane and their functions. Conventional control, Powered control, Basic instruments for flying - Typical systems for control actuation.

Module-4

Airplane Structures and Materials:
General types of construction, Monocoque, semi-monocoque and geodesic constructions, Typical wing and fuselage structure. Metallic and non-metallic materials, Use of aluminium alloy, titanium, stainless steel and composite materials. Stresses and strains – Hooke's law – Stress - strain diagrams - elastic constants.

Module-5

Power Plants:
Basic ideas about piston, turboprop and jet engines - Use of propeller and jets for thrust production - Comparative merits, Principles of operation of rocket, types of rockets and typical applications, Exploration into space.

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

1. CO1: Identify the aspects of aircrafts.
2. CO2: Classify the aircraft materials.
3. CO3: Describe the instruments and power plants used in airplanes.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to Flight	Anderson, J.D	McGraw-Hill	1995

2	Introduction to Aeronautics: A design perspective	Stephen. A. Brandt	AIAA Education Series	2nd Edition,2004
Reference Books				
1	Mechanics of Flight	Kermode, A.C	Himalayan Book	1997
2	Flight without Formula	Kermode, A.C	Pearson	2009

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SEMESTER – VI

ELEMENTS OF JET PROPULSION SYSTEMS

Course Code	**18AS652/18AE652**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic principle and theory of aircraft propulsion.
- Understand the purpose of a centrifugal, axial compressors, axial and radial turbines
- Acquire knowledge of importance of nozzles & inlets and combustion chamber

Module-1

Introduction: Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, Working principles of internal combustion engine, Two – stroke and four – stroke piston engines, Gas- turbine engines, Cycle analysis of reciprocating engines and jet engines , advantages and disadvantages.

Module-2

Propeller Theories & Jet propulsion Types of propeller, Propeller thrust: momentum theory, Blade element theories, propeller blade design, propeller selection.

Jet Propulsion: Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust – Effect of pressure, velocity and temperature changes of air entering compressor – Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet – Performance characteristics.

Module-3

Inlets & Nozzles

Internal flow and Stall in Subsonic inlets, Boundary layer separation. Major features of external flow near a subsonic inlet. Relation between minimum area ratio and eternal deceleration ratio. Diffuser performance.

Supersonic inlets: Supersonic inlets, starting problem in supersonic inlets, Shock swallowing by area variation, External deceleration. Modes of inlet operation.

Nozzles: Theory of flow in isentropic nozzles, Convergent nozzles and nozzle choking, Nozzle throat conditions. Nozzle efficiency, Losses in nozzles. Over-expanded and under-expanded nozzles, Ejector and variable area nozzles, Thrust reversal.

Module-4

Gas Turbine Engine Compressors

Centrifugal compressors: Principle of operation of centrifugal compressors. Work done and pressure rise - Velocity diagrams, Diffuser vane design considerations. performance characteristics. Concept of Pre-whirl, Rotating stall.

Axial flow compressors: Elementary theory of axial flow compressor, Velocity triangles, Degree of reaction, three dimensional flow. Air angle distribution for free vortex and constant reaction designs, Compressor blade design. Axial compressor performance characteristics.

Module-5

Combustion chambers and Turbines

Classification of combustion chambers, important factors affecting combustion chamber design, Combustion process, Combustion chamber performance Effect of operating variables on performance – Flame tube cooling – Flame stabilization – Use of flame holders

Axial Flow Turbines: Introduction, Turbine stage, Multi-staging of turbine, Exit flow conditions, Turbine cooling, Heat transfer in turbine cooling.

Radial turbine: Introduction, Thermodynamics of radial turbines, Losses and efficiency.

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

1. CO1: Apply the basic principle and theory of aircraft propulsion.
2. CO2: Explain the functions of centrifugal, axial compressors, axial and radial turbines.
3. CO3: Analyse the performance of nozzles & inlets and combustion chamber.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft propulsion	Bhaskar Roy	Elsevier	2011
2	Gas Turbines	V. Ganesan	Tata McGraw-Hill, New Delhi	2010
Reference Books				
1	Mechanics & Thermodynamics of Propulsion	Hill, P.G. & Peterson, C.R	Addison – Wesley Longman INC	1999
2	Gas Turbine Theory	Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H	Longman	1989
3	Gas Turbine Engine Technology	Irwin E. Treager	Tata McGraw Hill Publishing Co. Ltd	7th Edition,2003
4	Fundamentals of Compressible Flow with Aircraft and Rocket propulsion	S. M. Yahya	New Age International Publications, New Delhi	4th Edition,2014

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SEMESTER – VI

BASICS OF ROCKETS & MISSILES

Course Code	**18AS653/18AE653**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the types of space launch vehicles and missiles.
- Study the solid and liquid rocket motors.
- Acquire the knowledge on launch vehicle dynamics, attitude control, rocket testing and materials.

Module-1

Introduction: Space launch Vehicles and military missiles, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation, similarities and differences. Some famous space launch vehicles and strategic missiles.

Module-2

Solid Propellant Rocket Motor Systems: Solid Propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, preparation, loading, structural design of grain. Liners, insulators and inhibitors, function, requirements, materials. Rocket motor casing – materials. Nozzles, types, design, construction, thermal protection. Igniters, types, construction. Description of modern solid boosters I) Space Shuttle SRB, II) the Arienne SRB

Liquid Propellant Rocket Motor Systems: Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build up, system calibration, integration and optimisation – safety and environmental concerns. Description of the space shuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines.

Module-3

Aerodynamics of Rockets and Missiles: Classification of missiles. Airframe components of rockets and missiles, Forces acting on a missile while passing through atmosphere, method of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion, re-entry body design considerations.

Module-4

Launch Vehicle Dynamics: Tsiolskovsky's rocket equation, range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging. Earth launch trajectories – vertical segment, the gravity turn, constant pitch trajectory, orbital injection. Actual launch vehicle trajectories, types. Examples, the Mu 3-S-II, Ariane, Pegasus launchers. Reusable launch vehicles, future launchers, launch assist technologies.

Attitude Control of Rockets and Missiles: Rocket Thrust Vector Control – Methods of Thrusts Vector Control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; stage separation dynamics, separation techniques.

Module-5

Rocket Testing: Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground Testing, Flight Testing, Trajectory monitoring, post -accident procedures. Descriptions of a typical space launch vehicle launch procedure.

Materials: Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for thermal protection and for pressure vessels.

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

4. CO1: Identify the types of space launch vehicles and missiles.
5. CO2: Distinguish the solid and liquid propellant motors.

6. CO3: Classify different types of materials used for rockets and missies.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Rocket Propulsion Element	George P Sutton and Oscar Biblarz	John Wiley and Sons Inc	7th edition, 2010
2	Missile Aerodynamics	Jack N Neilson	AIAA	1st edition, 1988
Reference Books				
1	Missile Configuration Design	SS. Chin	McGraw Hill	1961
2	Rocket Propulsion and Space-Flight Dynamics	Cornelisse, J.W, Schoyer H.F.R. and Wakker, K.F	Pitman	1979
3	Rocket and Spacecraft propulsion	Turner, M.J.L	Springer	3rd edition, 2010
4	Space Vehicle Dynamics	Ball, K.J., Osborne, G.F	Oxford University Press	1967
5	Materials for Missiles and Spacecraft	Parker, E.R	McGraw Hill	1982

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SEMESTER - VII

SPACE MECHANICS

Course Code	**18AS71**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic concepts of space mechanics and the general N-body.
- Study satellite injection and satellite orbit perturbations.
- Acquire the knowledge of interplanetary and ballistic missile trajectories.

Module-1

Space Environment: Peculiarities of space environment and its description, effect of space environment on materials of spacecraft structure and astronauts, manned space missions, effect on satellite life time.

Module-2

Basic Concepts and Two body Problem: The solar system, reference frames and coordinate systems, terminology related to the celestial sphere and its associated concepts, Kepler's laws of planetary motion and proof of the laws, Newton's universal law of gravitation, motion of body under central force field, two body problem, relations between position and time, orbital elements, orbit types.

Module-3

Satellite Injection and Satellite Perturbations: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach.

Module-4

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

Module-5

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

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

1. CO1: Apply the basic concepts of space mechanics and the general N-body.
2. CO2: Explain satellite injection and satellite orbit perturbations.
3. CO3: Distinguish between interplanetary and ballistic missile trajectories.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Rocket Propulsion and Space Dynamics	Cornelisse, J.W	W.H. Freeman&co	1984
2	Introduction to Space Dynamics	Thomson	Dover Publications	Revised edition,2012
Reference Books				

1	ElementsofAstromechanics	VandeKamp,P.	Pitman	1979
2	Space Flight Dynamics	Willian E. Wiesel	Create Space Independent Publishing Platform	3rd Edition ,2010
3	Rocket Propulsion Elements	George P. Sutton and Oscar Biblarz	Wiley India Pvt Ltd	7th edition, 2010

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SEMESTER - VII

CONTROL ENGINEERING

Course Code	**18AS72**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic concepts of control systems and mathematical models.
- Acquire the knowledge on block diagrams and signal flow graphs.
- Understand the frequency response analysis and various types of plots.

Module-1

Introduction to Control Systems and Mathematical Models

Introduction: Concept of controls, Open loop and closed loop systems with examples, Concepts of feedback and basic structure of feedback control system, requirements of an ideal control system.

Mathematical Models: Transfer function models of mechanical systems, electrical circuits, DC and AC motors in control systems, Analogous systems: Force voltage and Force current analogy.

Module-2

Block Diagrams and Signal Flow Graphs

Transfer functions definition and its properties, block representation of control systems and terminologies, block diagram algebra and reduction of block diagrams, Signal flow graph method, Mason's gain formula and its applications

Transient and Steady State Response Analysis

Introduction, type and order of systems, time response specifications, first order and second order system response to step, ramp and impulse inputs, concepts of time constant and its importance in speed of response.

Module-3

System stability analysis using Routh's – Hurwitz Criterion

Root Locus Plots

Definition of root loci, General rules for constructing root loci, Analysis using root locus plots, Determination of desired gain, limit gain, gain margin and conditional stability.

Frequency Response Analysis Using Bode Plots:

Bode attenuation diagrams for first and second order systems, Simplified Bode diagrams, Stability analysis using Bode plots and determination of phase margin and gain margin and gain

Module-4

Frequency Response Specification and Analysis using Polar plots:

Specification: Frequency response definition, frequency response specifications and its relationship with time response specifications.

Analysis: Polar plots, Nyquist stability criterion, Stability analysis, Relative stability concepts, Gain margin and phase margin, M&N circles.

Module-5

Feedback control systems:

Types of controllers – Proportional, Integral, Derivative controllers, Proportional – Integral, Proportional – Integral – Derivative controllers; Compensation methods – Series and feedback compensation, Lead, Lag and Lead-Lag Compensators.

State Variable Characteristics of Linear Systems:

Introduction to concepts of states and state variable representation of linear systems, Advantages and Disadvantages over conventional transfer function representation, state equations of linear continuous data system. Matrix representation of state equations, Solution of state equation, State transition matrix and its properties, controllability and observability, Kalman and Gilberts test.

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

4. CO1: Apply the concepts of control systems.
5. CO2: Reduce the block diagrams and signal flow graphs.
6. CO3: Determine the frequency response analysis by using various types of plots.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Control Engineering	U.A. Bakshi and V.U. Bakshi	Technical Publications	
2	Control Systems Engineering	A. Nagoor Kani	RBA Publications	2014
Reference Books				
1	Modern Control Engineering	Katsuhiko Ogatta	Pearson Education	2004
2	Control Systems Engineering	I.J. Nagrath and M. Gopal	New Age Publishers	2017
3	Modern Control Systems	Richard. C. Dorf and Robert.H. Bishop	Addison Wesley	1999
4	Control Systems Engineering	N.S. Nise	Wiley	6th Edition,2012

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SEMESTER - VII

AVIONICS SYSTEMS

Course Code	**18AS731**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the need for avionics in civil, military and space systems.
- Appreciate the use of microprocessors, data buses and avionics system architectures.
- Acquire the knowledge of display technologies, communication and navigation systems.

Module-1

Power Distribution System: Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilization-typical application to avionics. Need for Avionics in civil and military aircraft.

Module-2

Inertial Navigation System: Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing.
Electronic Flight Control System: Fly-by-wire system: - basic concept and features. Pitch and Roll rate: - command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common mode of failures and effects analysis.

Module-3

Electronic Flight Instrument Systems: Display -units, presentation, failure, and annunciation. Display of air data.
Introduction to Avionics Sub Systems and Electronic Circuits: Typical avionics subsystems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.

Module-4

Principles of Digital Systems: Digital Computers, Microprocessors, Memories
Flight Deck and Cockpits: Control and display technologies CRT, LED, LCD, EL and plasma panel, Touch screen, Direct voice input (DVI) - Civil cockpit and military cockpit : MFDS, HUD, MFK, HOTAS.

Module-5

Avionics Systems Integration: Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic Warfare, and fire control system. Avionics system architecture, Data buses, MIL–STD 1553 B.

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

1. CO1: Select the suitable data bus based on the application.
2. CO2: Identify the suitable navigation systems.
3. CO3: Distinguish the avionics system architecture.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
		Textbook/s		
1	Introduction to Avionics Systems	R.P.G. Collinson	Springer	3rd edition, 2011
2	Systems: Mechanics, Electrical and Avionics Subsystems	Ian Moir, Allan Seabridge	Wiley	3rd Edition, 2012

Reference Books				
1	Avionics Systems, Longman Scientific and Technical	Middleton, D.H., Ed.,	Longman Group UK Ltd., England	1989
2	Digital Avionic Systems	Spitzer, C.R	McGraw-Hill Inc., US	2nd edition, 1992
3	Aircraft Communications and Navigation Systems	Mike Tooley and David Wyatt	Butterworth Heinemann	2007
4	Introduction to Avionics	D.R. Cundy and R.S. Brown	Pearson	2010

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SEMESTER – VII

SPACE VEHICLE DESIGN

Course Code	**18AS732**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand space mission analysis and design process
- Acquire the knowledge of spacecraft configuration and structural design
- Comprehend the importance of space craft attitude control and instrumentation

Module-1

Introduction to Launch Vehicle: Launch Vehicles Available Launch Vehicle Capabilities Deciding which Launch Vehicle to Use..Characteristics of Spacecraft Necessary to Choose a Launch Vehicle Structures. Primary Structural Design Other Functional Divisions Mechanisms Used by the Other Subsystem. Materials for Constructing Spacecraft Manufacturing Techniques Applicable to the Structure.

Module-2

Propulsion: Rocket Propulsion Fundamentals, Ascent Flight Mechanics, Launch Vehicle selection, Entry flight Mechanics, Entry heating, entry vehicle design, Aero assisted orbit transfer.

Module-3

Introduction to Launch Vehicle structures: Loads on the vehicle structures, Stages, Motor case, Base shroud, Inter stages, Heat shield, Equipment Bay and their functions Modeling and Analysis Structures. Loads and Stresses Thin-Walled Pressure Vessels Buckling of Beams Thin-Wall Assumption. Finite Element Analysis.

Module-4

Vehicle Dynamics: Mode shape and frequencies of launch vehicles, Vibrations .Flexible Body Dynamics of Liquid propellant in Moving containers Sloshing, POGO Orbital Vibration Mitigation Vibrations Aero elastic phenomenon of launch vehicles.

Module-5

Technologies and Examples: Available Technologies, Available Launch Vehicles, New Technologies. Magnetically Inflated Cable System Flying Effector Nano tubing Example, Load and Deflection Nodal Analysis Example, Material Selection Analysis Example, Strained Example, Reaction Wheel Example, Space Shuttle Landing Example, Vibrations Example.

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

1. CO1 : Carry out space mission analysis and design process
2. CO2: Explain a spacecraft configuration.
3. CO3 : Apply the concepts of space craft attitude control and instrumentation

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Space Vehicle Design	M.D. Griffin, J.R. French	AIAA Series	1 9 9 1
2	Spacecraft Systems Engineering	P. Fortescue, J. stark, and G. Swinerd	Wiley-Blackwell	4th revised edition,2011

Reference Books				
1	Space Mission Analysis and design	W.J. Larson and J. R. Wertz.,	Springer	2nd edition,1992
2	Rocket and Spacecraft Propulsion	M.J.L. Turner	Springer	3rd edition,2009

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SEMESTER - VII

Air And Missile Defence Systems

Course Code	**18AS733**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the missile systems.
- Acquire the knowledge of missile airframes, guidance laws and control.
- Comprehend the importance of weapon delivery systems..

Module-1

Missile Systems Introduction

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

Module-2

Missile Airframes, Autopilots And Control

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

Module-3

Missile Guidance Laws

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

Module-4

Strategic Missiles

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

Module-5

Interception Guidance And Interception Of Maneuvering Targets: Proportional navigation geometry – proportional navigation linearized system and zero miss distance proportional navigation – optimal guidance law – mathematical modeling of pursuit – evasion – solution with constrained evader – stochastic analysis

Weapon Delivery Systems

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

Continued

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

1. CO1 : Students will understand the advanced concepts of missile guidance and control
2. CO2: Necessary mathematical knowledge that are needed in understanding the physical processes.
3. CO3: The students will have an exposure on various topics such as missile systems, missile airframes, autopilots, guidance laws.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Missile Guidance and control systems	Siouris, G.M	Springer	2003
2	Automatic Control of Aircraft and Missiles	Blakelock, J. H	John Wiley & Sons	2nd Edition,1990
Reference Books				
1	Tactical Missile Design	Fleeman, Eugene L	AIAA	First Edition,2001
2	Guided Weapon Control Systems	Garnell, P	Pergamon Press	2nd Edition,1980
3	Advances in Missile Guidance Theory	Joseph Ben Asher and Isaac Yaesh	AIAA	1998
4	Tactical and Strategic Missile Guidance	Paul Zarchan	AIAA	2007

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SEMESTER - VII

HEAT & MASS TRANSFER

Course Code	**18AS734/18AE734**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the different modes of heat transfer.
- Understand the free convection and forced convection.
- Acquire the knowledge of heat transfer problems in combustion chambers.

Module-1

Fundamentals: Different modes of heat transfer and mass and momentum transfer, elements of mass diffusion and boundary layer theory. Mass transfer definition and terms used in mass transfer analysis, Fick's First law of diffusion.

Module-2

Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems. Effect of variation of thermal conductivity on heat transfer in solids - Heat transfer problems in infinite and semi-infinite solids - Extended surfaces. One dimensional transient heat conduction: Systems with negligible internal resistance, Significance of Biot and Fourier Numbers, Chart solutions of transient conduction systems.

Module-3

Convection: Concepts of Continuity, Momentum and Energy Equations. Dimensional analysis-Buckingham's Pi Theorem - Application for developing non-dimensional correlation for convective heat transfer

Free Convection: Development of Hydrodynamic and thermal boundary layer along a vertical plate , Use of empirical relations for Vertical plates and pipes.

Forced Convection: External Flows, Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for Flat plates and Cylinders. Internal Flows, Concepts about Hydrodynamic and Thermal Entry Lengths, use of empirical correlations for Horizontal Pipe Flow and annulus flow.

Module-4

Radiation & Heat Exchangers Design: Radiation: Introduction to physical mechanism - Radiation properties - Radiation shape factors - Heat exchange between non-black bodies - Radiation shields
Heat Exchangers: Classification of heat exchangers; overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problems.

Module-5

Heat and Mass Transfer Problems in Aerospace Engineering: Heat transfer problems in gas turbine combustion chambers - Rocket thrust chambers - Aerodynamic heating -Ablative heat transfer. Heat transfer problems in turbine and nozzle blades.

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

1. CO1: Describe the fundamental of heat and mass transfer.
2. CO2: Familiarize the student in the area of conduction, convection and radiation.
3. CO3: Analyze the problems due to heat transfer in several areas.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Heat transfer-A basic approach	Ozisik	Tata McGraw Hill	2002
2	Heat Transfer	Holman, J.P	McGraw Hill Book Co., Inc., New York	8th edition,1996
Reference Books				
1	Fundamentals of Engineering Heat and Mass Transfer	Sachdeva, S.C	Wiley Eastern Ltd., New Delhi	1981
2	Rocket Propulsion Elements	Sutton, G.P	John Wiley and Sons	5th Edn.1986
3	Gas Turbine and Jet and Rocket Propulsion	Mathur, M.and Sharma, R.P	Standard Publishers, New Delhi	1988
4	Heat transfer	P.K. Nag	Tata McGraw Hill	2002
5	Heat transfer, a practical approach	Yunus A-Cengel	Tata McGraw Hill	3rd edition, 2007

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SEMESTER - III

SATELLITE COMMUNICATION

Course Code	**18AS741**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the elements of satellite communication.
- Understand the Different modulation and Multiplexing Schemes.
- Acquire the knowledge of Satellite Telemetry, Tracking and Telecommand.

Module-1

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.

Module-2

Transmission, Multiplexing, Multiple Access And Coding: Different modulation and Multiplexing Schemes, Multiple Access Techniques FDMA, TDMA, CDMA and DAMA, Coding Schemes, Satellite Packet Communications.

Module-3

Satellite Link Design: Basic link analysis, Interference analysis, Rain induced attenuation and interference, Ionospheric characteristics, Link Design with and without frequency reuse.

Module-4

Satellite Telemetry, Tracking And Telecommand: Introduction to telemetry systems, Aerospace transducer, signal conditioning, multiplexing methods, Analog and digital telemetry, Command line and remote control system, Application of telemetry in spacecraft systems, Base Band Telemetry system, Computer command & Data handling , Satellite command system, Issues.

Module-5

Applications: VSAT-VSAT Technologies, Networks MSS-AMSS, MMSS.

Course Outcomes:

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

1. CO1: Apply of concepts of orbital mechanics.
2. CO2: Classify the modulation and Multiplexing Schemes.
3. CO3: Identify the applications of satellites.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Satellite Communication Systems Engineering	Wilbur L. Pritchard and Joseph A.Sciulli	Pearson Education India	2nd edition,2003
2	Satellite Communications	Timothy Pratt and Charles W.Bostain	John Wiley and Sons	2nd edition, 2006
Reference Books				
1	Digital Satellite Communication	Tri T Ha	McGraw Hill Education	2nd edition, 2008

2	Satellite Communications Fundamentals	Kadish, Jules E	Artech House	2000
3	Satellite communications: System and its design technology	Lida,Takashi ed	IOS Press,US	2000
4	Satellite communications systems: Systems, techniques and technology	Maral, Gerard,	John Wiley, Newyork	2002
5	Satellite communication applications handbook	Elbert, Bruce R	Artech house Boston .Publishers, New Delhi	2004

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SEMESTER – VII

WIND TUNNEL TECHNIQUES

Course Code	**18AS742/18AE742**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic of wind tunnel testing.
- Understand the types and functions of wind tunnel.
- Acquire the knowledge on conventional measurement techniques and special wind tunnel techniques.

Module-1

Principles Of Model Testing: Buckingham Theorem, Non dimensional numbers, Scale effect, Geometric Kinematic and Dynamic similarities.

Types And Functions Of Wind Tunnels: Classification and types, special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions, Layouts, sizing and design parameters.

Module-2

Calibration Of Wind Tunnels: Test section speed, Horizontal buoyancy, Flow angularities, Flow uniformity & turbulence measurements, Associated instrumentation, Calibration of subsonic & supersonic tunnels.

Module-3

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

Module-4

Special Wind Tunnel Techniques: Intake tests, store carriage and separation tests, Unsteady force and pressure measurements, Non-Intrusive Flow Diagnostics, Laser – Doppler Anemometry. Particle Image Velocimetry. Laser Induced Fluorescence

Module-5

Fundamentals of wind tunnel design – introduction, general considerations, general design procedure, main design criteria, wind tunnel component specification, design of various components of wind tunnel - test chamber, contraction, settling chamber, diffuser, power plant, turning vane, fan and drive system, safety net design

Course Outcomes:

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

1. CO1: Apply the principles and procedures for model testing in the wind tunnel.
2. CO2: Classify the types and functions of wind tunnel.
3. CO3: Distinguish the conventional measurement techniques and special wind tunnel techniques.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Low Speed Wind Tunnel Testing	Rae, W.H. and Pope, A.	John Wiley Publication	3rd edition, 2010
2	High Speed Wind Tunnel Testing	Pope, A., and Goin, L	John Wiley	1985
Reference Books				
1	Instrumentation, Measurements, and Experiments in Fluids	E. Rathakrishnan	CRC Press	2007
2	Experimental Fluid Mechanics	Bradsaw	Pergamon Press	2nd Revised edition,1970
3	Wind Tunnel Designs and their Diverse Engineering Applications	Noor Ahmed		2013
4	Advanced Flow diagnostic techniques			
5	Experimental Aerodynamics			

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SEMESTER – VII

GUIDANCE, NAVIGATION & CONTROL

Course Code	**18AS743/18AE743**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Comprehend the basic concepts of navigation, guidance and control.
- Acquire the knowledge of radar systems and other guidance systems.
- Understand the missile guidance and control system.

Module-1

Introduction
Concepts of navigation, guidance and control. Introduction to basic principles. Air data information.
Radar Systems
Principle of working of radar. MTI and Pulse Doppler radar. Moving target detector. Limitation of MTI performance. MTI from a moving platform (AMTI).

Module-2

Tracking with Radar
Mono pulse tracking. Conical scan and sequential lobbing. Automatic tracking with surveillance radar (ADT).
Other Guidance Systems
Gyros and stabilized platforms. Inertial guidance and Laser based guidance. Components of Inertial Navigation System. Imaging Infrared guidance. Satellite navigation. GPS.

Module-3

Transfer Functions
Input-output Transfer function. Basic altitude reference. Concepts of Open loop and Close Loop.
Missile Control System
Guided missile concept. Roll stabilization. Control of aerodynamic missile. Missile parameters for dynamic analysis. Missile autopilot schematics. Acceleration command and root locus.

Module-4

Missile Guidance
Proportional navigation guidance; command guidance. Comparison of guidance system performance. Bank to turn missile guidance.

Module-5

Integrated Flight/Fire Control System
Director fire control system. Tracking control laws. Longitudinal flight control system. Lateral flight control system. Rate of change of Euler angle, Auto Pilot.

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

1. CO1: Apply the basic concepts of navigation, guidance and control.
2. CO2: Compare the different types of missile guidance system performance.
3. CO3: Integrate the flight and fire control system.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Fundamentals of Aerospace Navigation and Guidance	P.T. Kabamba and A.R. Girard	Cambridge Aerospace Series	2014
2	Automatic control of Aircraft & Missiles	John H Blakelock	Wile –Inter Science Publication	2nd edition, May 1990
Reference Books				
1	Navigation	R.B. Underdown & Tony Palmer	Black Well Publishing	2001
2	Introduction to Radar Systems	Merrilh I. Skolnik	Tata Mc Graw Hill	3rd edition,2001
3	Missile Guidance and Control Systems	George M. Siouris	Springer	2004

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Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

GLOBAL NAVIGATION SATELLITE SYSTEMS

Course Code	**18AS744**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic of GPS.
- Comprehend the GPS Signals, orbits and errors.
- Acquire the knowledge on IRNSS.

Module-1

Overview of GPS:
Basic concept, system architecture, space segment, user segment, GPS aided Geo-augmented navigation (GAGAN) architecture

Module-2

GPS Signals
Signal structure, anti-spoofing (AS), selective availability, Difference between GPS and GALILEO satellite construction.

Module-3

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.

Module-4

GPS Errors:
GPS error sources – clock error, ionospheric error, tropospheric error, multipath, ionospheric error estimation using dual frequency GPS receiver.

Module-5

Overview of IRNSS:
Basics, NavIC System Architecture, Space Segment, Ground Segment, User Segment, IRNSS Services Carrier Frequencies, Data Structure, System Time, Frame Structure, Navigation Data, Ionosphere Correction Coefficients, TEC Calculation.

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

1. Describe about the GPS and its signals.
2. Classify the types of satellite constellation.
3. Identify the orbits, position and errors.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Global Navigation Satellite Systems	G S RAO	McGraw-Hill,New Delhi	2010
2	Understanding Satellite Navigation	Rajat Acharya	Academic Press	2014
Reference Books				

1	GPS – Theory andPractice	B. Hoffman – Wellenhof, H. Liehtenegger and J. Collins	Springer	2001
2	Fundamentals of GPS receivers – A software approach	James Ba – Yen Tsui,	JohnWiley & Sons	2001

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SEMESTER - VII

SPACE SIMULATION LAB

Course Code	**18ASL76**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:2:0)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

1. Understand the basics of stability analysis.
2. Acquire the knowledge on Hoffmann transfer and orbit manoeuvring.
3. Get the ideas about the orbital perturbations.

Sl. No.	Experiments
1	Plot root locus with variables in transfer function through MATLAB.
2	Plot root locus for a dynamic system through MATLAB.
3	Draw Bode plot for a transfer function in MATLAB and explain Gain margin and Phase margin.
4	Simulate a servo mechanism motion with feedback in the following domains a) Time Domain b) Laplace Domain
5	Simulate a space shuttle landing with parachute deployed.
6	Simulate Hohmann transfer orbit.
7	Perform a planetary orbit simulation.
8	Simulate the Position of a moving object using GNSS simulator/Given position vectors.
9	Model a satellite motion and determine time period for its orbital motion.
10	Perform trajectory simulation of a small atmospheric re-entry module.
11	Perform and validate with an experimental setup for a simple feedback servo experiment.
12	Perform 3-DOF Gyroscope experiment for System Identification.
13	Perform 2- DOF Rotor System experiment for Coupled Dynamic Analysis
14	Model and simulate a simple Magnetic Levitation system and validate with the experimental setup.

Course Outcomes:

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

1. Do the stability analysis using Root locus, Bode plot, Nyquist plot and Polar plot techniques.
2. Simulate the Hoffmann transfer and orbit maneuvering.
3. Simulate the trajectory of the rocket or missile.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

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SEMESTER - VII

AVIONICS AND INSTRUMENTATION LAB

Course Code	**18ASL77**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:2:0)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Understand the functions of different instruments required for flight operations.
- Understand analog /digital conversions and use of microprocessors.
- Understand functioning of MIL-STD-1553 B Data Bus.

Sl. No.	Experiments
1	Calibration and measurement with Air Speed Indicator.
2	Calibration and measurement with Altimeter
3	Calibration and measurement with Rate of climb indicator and attitude indicator
4	Calibration and measurement with - turn and slip indicator
5	Gyroscopic Instruments – demonstration for vertical speed hold
6	Gyroscopic Instruments – demonstrate for rate feedback modeling
7	Demonstration of use of radio magnetic indicator RMI
8	16 Channel Analog to Digital Converter & Generation of Ramp, Square, Triangular wave by Digital
9	Study of Pulse Amplitude Modulation (PAM) and Demodulation.
10	Study of MIL-STD-1553 B Data Bus
11	Addition and Subtraction of 8-bit and 16-bit numbers using microprocessor.
12	Interface programming with 4 digit 7 segment display and switches and LEDs
13	Encoder/Decoder Circuits. Multiplexer/Demultiplexer Circuits Addition/Subtraction of binary numbers.
14	Timer Circuits, Shift Registers, Binary Comparator Circuits.

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

1. Perform measurements on different instruments used for flight operations
2. Perform analog /digital conversions and use microprocessors.
3. Handle functioning of MIL-STD-1553B Data Bus.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

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SEMESTER – VII

MAINTENANCE, OVERHAUL & REPAIR OF AIRCRAFT SYSTEMS

Course Code	**18AS751/18AE751**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Comprehend the fundamentals of maintenance and certification.
- Acquire the knowledge of documentation for maintenance.
- Understand the Aircraft Maintenance, safety and trouble shooting.

Module-1

Fundamentals of Maintenance & Certification

Types of maintenance, Redesign, Failure rate pattern, Other maintenance considerations.
Aviation industry certification requirements, Type certificate (FAA form 8110.9), Airworthiness certificate (FAA form 8100-2), Aviation maintenance certifications, General, Airframe, Power plant, Avionics courses.

Module-2

Documentation for Maintenance

Manufacturers documentation, Airplane maintenance manual, Fault insulation manual, Illustrated parts catalogue, structural repair manual, wiring diagram manual, Master minimum equipment, Federal Aviation regulation (FAR), Advisory circulars, Airworthiness direction ATA document standards, Technical policies and procedure manuals (TPPM)

Module-3

Aircraft Management Maintenance

Structure, Role of aviation management, Line supervisory management, Management areas of concern in airlines, Manager of overhaul shops, Line maintenance control centre flight line (preflight & post flight), Aircraft Logbook, Maintenance crew skill requirements.

Module-4

Hanger Maintenance (on Aircraft) & Material Support

Introduction, organization of hanger maintenance, Non- routine item, parts availability, cannibalization, Types of shops- sheet metal shop, Aircraft interior shop, Engine shop, Avionics shop, ground support equipment, outsourcing of shop maintenance work, operation of overhaul shops, Material support, Material management inventory control, Support functions of material, Parts ordering, Storage, Issue, control and handling, Parts receiving quality control, calibration program, stock level adjustments, shelf life, exchanges, warranty & modifications of parts.

Module-5

Maintenance Safety & Trouble shooting

Safety regulations, occupational safety and health standards maintenance safety program, Airlines safety management, General safety rules, Accident & injury reporting, Hazardous materials storage and handling aircraft furnishing practices trouble shooting, Knowledge of malfunctions.

Course Outcomes:

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

1. CO1: Maintain the aircraft maintenance manual and logbook.
2. CO2: Do the quality control and calibration.
3. CO3: Incorporate the safety regulations and rules.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aviation Maintenance Management	Harry A Kinnison, Tariq Siddiqui	Mc Graw Hill education (India) Private Ltd	2013
2	Aircraft maintenance and repair	Kroes, Watkins, Delp	Mc Graw Hill	2013
Reference Books				
1	Aircraft Repair Manual	Larry Reithmaier	Palmar Books, Marquette	1992
2	Aircraft Maintenance	Brimm. DJ, Bogges, HE	Pitman publishing corp, London	1952

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SEMESTER - VII

FUNDAMENTALS OF AERODYNAMIC THEORY

Course Code	**18AS752/18AE752**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basics of fluid mechanics as a prerequisite to Aerodynamics
- Acquire knowledge on typical airfoil characteristics and two-dimensional flows over airfoil and study the incompressible over finite wings
- Assimilate the understanding of application of finite wing theory and high lift systems

Module-1

Review of Basic Fluid Mechanics

Continuity, momentum and energy equation, Control volume approach to Continuity, momentum and energy equation, Types of flow, pathlines, streamlines, and streaklines, units and dimensions, inviscid and viscous flows, compressibility, Mach number regimes. Vorticity, Angular velocity, Stream function, velocity potential function, Circulation, Numericals, Mach cone and Mach angle, Speed of sound.

Module-2

Airfoil Characteristics

Fundamental aerodynamic variables, Airfoil nomenclature, airfoil characteristics. wing planform geometry, aerodynamic forces and moments, centre of pressure, pressure coefficient, aerodynamic center, calculation of airfoil lift and drag from measured surface pressure distributions, typical airfoil aerodynamic characteristics at low speeds. Types of drag-Definitions.

Module-3

Two Dimensional Flows & Incompressible Flow Over Airfoil

Uniform flow, Source flow, Sink flow, Combination of a uniform flow with source and sink. Doublet flow. Non-lifting flow over a circular cylinder. Vortex flow. Lifting flow over a circular cylinder. Kutta-Joukowski theorem and generation of Lift, D'Alembert's paradox, Numericals.

Incompressible flow over airfoils: Kelvin's circulation theorem and the starting vortex, vortex sheet, Kutta condition, Classical thin airfoil theory for symmetric and cambered airfoils. Kutta-Joukowski theorem and generation of Lift, Numericals.

Module-4

Incompressible Flow Over Finite Wings

Biot-Savart law and Helmholtz's theorems, Vortex filament: Infinite and semi-infinite vortex filament, Induced velocity. Prandtl's classical lifting line theory: Downwash and induced drag. Elliptical and modified elliptical lift distribution. Lift distribution on wings. Limitations of Prandtl's lifting line theory. Extended lifting line theory- lifting surface theory, vortex lattice method for wings. Lift, drag and moment characteristics of complete airplane.

Module-5

Applications of Finite Wing Theory & High Lift Systems

Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane, ground effects. Swept wings: Introduction to sweep effects, swept wings, pressure coefficient, typical aerodynamic characteristics, Subsonic and Supersonic leading edges. Introduction to high-lift systems, flaps, leading-edge slats and typical high – lift characteristics. critical Mach numbers, Lift and drag divergence, shock induced separation, Effects of thickness, camber and aspect ratio of wings, Transonic area rule, Tip effects. Introduction to Source panel & vortex lattice method.

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

1. CO1 : Evaluate typical airfoil characteristics and two-dimensional flows over airfoil
2. CO2 : Compute and analyse the incompressible flow over finite wings
3. CO3 : Apply finite wing theory and design high lift systems from the aerodynamics view point

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fundamental of Aerodynamics	Anderson J.D	McGraw-Hill International Edition, New York	5th edition,2011
2	Aerodynamics for Engineering Students	E. L. Houghton, P.W. Carpenter	Elsevier, New York	5th edition,2010
Reference Books				
1	Aerodynamics	Clancy L. J.	Sterling book house, New Delhi	2006
2	Theoretical Aerodynamics	Louis M. Milne-Thomson	Dover Publications, USA	Imported Edition,2011

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SEMESTER – VII

UNMANNED AERIAL VEHICLES

Course Code	**18AE753/18AS753**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Comprehend the basic aviation history and UAV systems.
- Acquire the knowledge of basic aerodynamics, performance, stability and control.
- Understand the propulsion, loads and structures.

Module-1

Introduction

Aviation History and Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology, UAV fundamentals, Examples of UAV systems-very small, small, Medium and Large UAV

Module-2

The Air Vehicle

Basic Aerodynamics:

Basic Aerodynamics equations, Aircraft polar, the real wing and Airplane, Induced drag, the boundary layer, Flapping wings, Total Air-Vehicle Drag

Performance:

Overview, climbing flight, Range and Endurance – for propeller-driven aircraft, range- a jet-driven aircraft, Guiding Flight.

Module-3

Stability and Control

Overview, Stability, longitudinal, lateral, dynamic stability, Aerodynamics control, pitch control, lateral control, Autopilots, sensor, controller, actuator, airframe control, inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.

Module-4

Propulsion

Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, and Sources of Electrical Power.

Loads and Structures

Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques.

Module-5

Mission Planning and Control: Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch and Recovery Tradeoffs

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

1. CO1: Apply the basic concepts of UAV systems.
2. CO2: Explain the basic aerodynamics, performance, stability and control required for UAV.
3. CO3: Select the propulsion system and materials for structures.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to UAV Systems	Paul Gerin Fahlstrom, Thomas James Gleason	Wiley Publication	4th Edition,2012
2	Unmanned Aerial Vehicle	Landen Rosen	Alpha Editions	
Reference Books				
1	Unmanned Aerial Vehicles: DOD's Acquisition Efforts		Alpha Editions	
2	Unmanned Aerial Vehicles	Valavanis, Kimon P	Springer	2011
3	Handbook of Unmanned Aerial Vehicles	Valavanis**,** K., Vachtsevanos, George J	Springer	2015

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SEMESTER - VIII

SPACECRAFT SYSTEMS

Course Code	**18AS81**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the spacecraft mission and AOCS.
- Comprehend the power generation and storage systems.
- Acquire the knowledge on propulsion, structural and thermal systems.

Module-1

Satellite Mission And Configuration: Mission Overview – Requirements for different missions – Space Environment, Spacecraft configuration- Spacecraft Bus – Payload – Requirements and constraints – Initial configuration decisions and Trade-offs – Spacecraft configuration process – Broad design of Spacecraft Bus – Subsystem layout – Types of Satellites – Constellations – Applications.

Module-2

Attitude And Orbit Control System (AOCS): Coordinate system – AOCS requirements – Environment effects – Attitude stabilization – Attitude sensors – Actuators – Design of control algorithms.

Module-3

Power Generation: Study of Solar spectrum, Solar cells, Solar Panel design, Solar Panel Realization, Solar Panel testing, Effects of Solar cells and panels (IR, UV, Particles)

Energy Storage Technology

Types of batteries – Primary & Secondary batteries - Nickel Cadmium - Nickel-Hydrogen – Nickel metal hydride - Lithium-ion –Lithium Polymer - Silver Zinc– Electrical circuit model – Performance characteristics of batteries - Application of batteries in launch vehicles and satellites – Fuel Cell –Polymer Electrolyte membrane Fuel Cell – Regenerative Fuel Cell.

Module-4

Power Converters

DC – DC converters – Basic Convertors - Buck, Boost, Buck- boost converter –Derived converters: Fly back converter – Transformer coupled forward converter – Push-Pull converter - CUKs convertor–Resonant converter – Voltage and current regulators

Power Control, Conditioning And Distribution

Solar Array Regulators – Battery changing schemes – Protection Schemes - Distribution – Harness -Thermal Design - EMI/EMC/ESD/Grounding schemes for various types of circuits and systems

Module-5

Module -5

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.

Telemetry Systems: Base Band Telemetry system – Modulation – TT & C RF system – Telecommand system – Ground Control Systems.

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

1. Identify the spacecraft mission and configuration.
2. Describe the power requirements and its design concepts.
3. Classify the Propulsion, thermal control and telemetry systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Spacecraft Systems Engineering	Fortescue Peter	Wiley-Blackwell England	4th edition,2003
2	Spacecraft Power Systems	Patel Mukund R	CRC Press Boca Raton	1st edition,2005
Reference Books				
1	Satellite Communication Systems Engineering	Wilbur L. Pritchard and Joseph A.Sciulli	Prentice Hall, New Jersey	1986
2	Spacecraft Dynamics and control	Marcel j. sidi	Cambridge University Press	2000
3	Modern Spacecraft Dynamics and control	Kaplan m	Wiley Press	1976
4	Spacecraft navigation and guidance	Maxwell Noton	Springer	1998
5	Space Mission Analysis and Design	James R.Wertz and Wiley J.Larson		1999

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SEMESTER - VIII

SATELLITE NAVIGATION SYSTEMS

Course Code	**18AS821**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the spacecraft environment and design consideration.
- Comprehend the navigation concepts and navigation systems.
- Acquire the knowledge on control actuators and satellite TTC.

Module-1

Spacecraft Environment & Design Consideration: Orbit definition /Mission Requirements of LEO, GEO, GTO & HEO, Lunar orbits, IPO with respect to Power Generation, Power System Elements, Solar aspect angle Variations.

Module-2

Navigation Concepts: Fundamentals of spacecraft navigation systems and Position Fixing, Geometric concepts of Navigation, Elements, The Earth in inertial space, Earth's Rotation, Revolution of Earth, Different Coordinate Systems, Coordinates Transformation, Euler angle formulations, Direction cosine formulation, Quaternion formulation.

Module-3

Inertial Navigation Systems: Accelerometers, Pendulous type, Force Balance type, MEMs Accelerometers, Basic Principles of Inertial Navigation, Types, Platform and Strap down, Mechanization INS system, Rate Corrections, Block diagram, Acceleration errors, Coriolis effect, Schuler Tuning, Cross coupling, Gimbal lock , Alignment

Module-4

CONTROL ACTUATORS
Thrusters, Momentum Wheel, Control Moment Gyros, reaction wheel, Magnetic Torquers, Reaction Jets, Ion Propulsion, Electric propulsion, solar sails.

Module-5

Satellite Telemetry, Tracking and Telecommand: Introduction to telemetry systems, Aerospace transducer, signal conditioning, multiplexing methods, Analog and digital telemetry, Command line and remote control system, Application of telemetry in spacecraft systems, Base Band Telemetry system, Computer command & Data handling, Satellite command system, Issues

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

1. Identify the spacecraft environment for design consideration.
2. Apply the navigation concepts and systems.
3. Classify the control actuators.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Spacecraft Systems Engineering	Fortescue Peter	Wiley-Blackwell England	4th edition,2003
2	Spacecraft Power Systems	Patel Mukund R	CRC Press Boca Raton	1st edition,2005
Reference Books				
1	Satellite Communication Systems Engineering	Wilbur L. Pritchard and	Prentice Hall	1986
2	Spacecraft Dynamics and control, A Practical	Marcel j. sidi	Cambridge University Press	2000
3	Modern Spacecraft Dynamics and control	Kaplan m	Wiley Press	1976
4	Spacecraft navigation and guidance	Maxwell Noton	Springer	1998

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SEMESTER – VIII
Professional Elective - 4

CRYOGENICS

Course Code	**18AS822**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic of cryogenic engineering.
- Understand the cryogenic properties and insulation.
- Acquire the knowledge on storage of cryogenic liquids and equipments.

Module-1

Introduction to Cryogenic Engineering: Thermo physical and fluid dynamic properties of liquid and gas hydrogen, Thermo physical and fluid dynamic properties of liquid and gas helium, Liquefaction systems of hydrogen and helium gases, Liquefaction systems of hydrogen and helium gases, Refrigeration and liquefaction principals; Joule Thomson effect and inversion curve; Adiabatic and is enthalpic expansion with their comparison.

Module-2

Properties: Cryogenic fluids, Solids at cryogenic temperatures; Superconductivity, Recuperative - Linde - Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Regenerative - Stirling cycle and refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, Pulse Tube refrigerator; Liquefaction of natural gas.

Module-3

Cryogenic Insulation: Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapour Shields, Composite insulations.

Module-4

Storage and Instrumentation of Cryogenic liquids: Design considerations of storage vessel; Dewar vessels; Industrial storage vessels; Storage of cryogenic fluids in space; Transfer systems and Lines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow in Transfer system; Cool-down of storage and transfer systems, Measurement of strain, pressure, flow, liquid level and Temperature in cryogenic environment; Cryostats.

Module-5

Cryogenic Equipment: Cryogenic heat exchangers-recuperative and regenerative; Variables affecting heat exchanger and system performance; Cryogenic compressors, Pumps, expanders; Turbo alternators; Effect of component in efficiencies; System Optimization, Magneto-caloric refrigerator; 3 He- 4 He Dilution refrigerator; Cryo pumping; Cryogenic Engineering applications in energy, aeronautics, space, industry, biology, preservation Application of Cryogenic Engineering in Transport.

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

1. Recognize the basic of cryogenic engineering.
2. Identify the storage and instrumentation required for cryogenic liquids.
3. Classify the types of cryogenic equipments.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Cryogenic Engineering	T.M.Flynn,Marcel Dekker	CRC Press	2nd edition, 2004
2	Cryogenics: Applications and Progress	A Bose and P. Sengupta	Tata McGraw Hill	
Reference Books				
1	Handbook of Cryogenic Engineering	J.G.WeisendII, Taylor and Francis	CRC Press	1998
2	Cryogenic Systems	R .Barron	Oxford University Press	
3	Cryogenic Process Engineering	K.D.Timmerhaus and T. M. Flynn	PlenumPress	2013
4	Cryogenic Fundamentals	G. G. Haselden	Academic Press	
5	Advanced Cryogenics	C. A. Bailey	Springer	1971
6	Applied Cryogenic Engineering	R.W.Vance andW.M.Duke	JohnWiley&sons	1962

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SEMESTER – VIII

ROBOTICS

Course Code	**18AS823**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

1. Comprehend the mathematical representation of robots.
2. Understand the manipulators.
3. Acquire the knowledge of control, actuators and sensors.

Module-1

Introduction and Mathematical Representation of Robots: History of Robots, Types of Robots, Notation, Position and Orientation of a Rigid Body, Some Properties of Rotation Matrices, Successive Rotations, Euler Angles for fixed frames X- Y -Z and moving frame ZYZ. Transformation between coordinate system, Homogeneous coordinates, Properties of A/BT, Types of Joints: Rotary, Prismatic joint, Cylindrical joint, Spherical joint, Representation of Links using Denvit - Hartenberg Parameters: Link parameters for intermediate, first and last links, Link transformation matrices, Transformation matrices of 3R manipulator, PUMA560 manipulator, SCARA manipulator.

Module-2

Kinematics of Serial Manipulators: Direct kinematics of 2R, 3R, RRP, RPR manipulator, puma560 manipulator, SCARA manipulator, Stanford arm, Inverse kinematics of 2R, 3R manipulator, puma560 manipulator.

Velocity and Static's of Manipulators: Differential relationships, Jacobian, Differential motions of a frame (translation and rotation), Linear and angular velocity of a rigid body, Linear and angular velocities of links in serial manipulators, 2R, 3R manipulators, Jacobian of serial manipulator, Velocity ellipse of 2R manipulator, Singularities of 2R manipulators, Statics of serial manipulators, Static force and torque analysis of 3R manipulator, Singularity in force domain.

Module-3

Dynamics of Manipulators: Kinetic energy, Potential energy, Equation of motion using Lagrangian, Equation of motions of one and two degree freedom spring mass damper systems using Lagrangian formulation, Inertia of a link, Recursive formulation of Dynamics using Newton Euler equation, Equation of motion of 2R manipulator using Lagrangian Newton-Euler formulation

Trajectory Planning: Joint space schemes, cubic trajectory, Joint space schemes with via points, Cubic trajectory with a via point, Third order polynomial trajectory planning, Linear segments with parabolic blends, Cartesian space schemes, Cartesian straight line and circular motion planning

Module-4

Control: Feedback control of a single link manipulator- first order, second order system, PID control, PID control of multi link manipulator, Force control of manipulator, force control of single mass, Partitioning a task for force and position control- lever, peg in hole Hybrid force and position controller.

Actuators: Types, Characteristics of actuating system: weight, power-to-weight ratio, operating pressure, stiffness vs. compliance, Use of reduction gears, comparison of hydraulic, electric, pneumatic actuators, Hydraulic actuators, proportional feedback control, Electric motors: DC motors, Reversible AC motors, Brushless DC motors, Stepper motors- structure and principle of operation, stepper motor speed-torque characteristics

Module-5

Sensors: Sensor characteristics, Position sensors- potentiometers, Encoders, LVDT, Resolvers, Displacement sensor, Velocity sensor-encoders, tachometers, Acceleration sensors, Force and Pressure sensors piezoelectric, force sensing resistor, Torque sensors, Touch and tactile sensor, Proximity sensors-magnetic, optical, ultrasonic, inductive, capacitive, eddy-current proximity sensors.

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

1. Identify the mathematical representation of robots.
2. Classify the manipulators.
3. Classify the sensors and actuators.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fundamental Concepts and Analysis of Robotics	Ghosal A	Oxford	2006
2	Introduction to Robotics Analysis, Systems,	Niku, S. B	Pearso Education	2008
Reference Books				
1	Introduction to Robotics: Mechanics and Control	Craig, J. J	Addison-Welsey,	1989
2	Fundamentals of Robotics, Analysis and Control,	Schilling R. J	PHI	2011

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VIII

OPTIMIZATION TECHNIQUES

Course Code	**18AS824**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

1. Understand the unconstrained and constrained minimization.
2. Comprehend the direct search methods, discrete and dynamics programming.
3. Acquire the knowledge on finite element based optimization.

Module-1

Introduction: Non-linear programming. Mathematical fundamentals. Numerical evaluation of gradient.
Unconstrained Optimisation: One dimensional, single variable optimization. Maximum of a function. Unimodal-Fibonacci method. Polynomial based methods.

Module-2

Unconstrained Minimization: Multivariable functions. Necessary and sufficient conditions for optimality. Convexity. Steepest Descent Method -Convergence Characteristics. Conjugate Gradient Method. Linear programming -Simplex Method.

Module-3

Constrained Minimization: Non-linear programming. Gradient based methods. Rosens`s gradient, Zoutendijk`s method, Generalised reduced gradient, Sequential quadratic programming. Sufficient condition for optimality.

Module-4

Direct Search Methods: Direct search methods for nonlinear optimization. Cyclic coordinate search. Hooke and Jeeves Pattern search method. Generic algorithm.
Discrete and Dynamic Programming: Integer and discrete programming. Branch and bound algorithm for mixed integers. General definition of dynamic programming problem. Problem modeling and computer implementation. Shortest path problem

Module-5

Optimisation Application: Transportation problem. Transportation simplex method. Network problems. Maximum flow in net works. General definition of dynamic programming. Problem modeling and computer implementation.
Finite Element Based Optimisation : Parameter optimization using gradient methods -Derivative calculation. Shape optimisation. Topology optimisation of continuum structures.

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

1. Identify the unconstrained and constrained minimization effect of fluid properties.
2. Apply the direct search methods, discrete and dynamics programming.
3. Classify the optimisation application

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Optimisation Concepts and Applications in Engineering	Ashok D Belegundu and Tirupathi R . Chandrupatla	Pearson Education	2003
2	Practical Methods of Optimisation	Fletcher, R	Wiley, New York	2nd Edition, 2009
Reference Books				
1	Numerical Methods for Unconstrained Optimisation and Nonlinear Equations	Dennis J.E. and Schnabel, R. B	Prentice Hall	1983
2	Optimisation -Theory and Application	S.S. Rao	Wiley	1990