ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. AVIONICS
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM

THE VISION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

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

THE MISSION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

The Mission of the Department of Aerospace Engineering is to

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

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PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. **PEO 1:** Successful Moulding of Graduate into Avionics Professional: Graduates of the programme will acquire adequate knowledge both in practical and theoretical domains in the field of Avionics Engineering through rigorous post graduate education.
II. **PEO 2:** Successful Career Development: Graduates of the programme will have successful technical and managerial career in Avionics industries and aviation engineering management.
III. **PEO 3:** Contribution to Avionics Field: Graduates of the programme will have innovative ideas and potential to contribute for the development and current needs of the Aviation Industries.
IV. **PEO 4:** Sustainable interest for Lifelong learning: Graduates of the programme will have sustained interest to learn and adapt new technology developments to meet the changing industrial scenarios.
V. **PEO 5:** Motivation to pursue research in Avionics field: Graduates will have interest and strong desire to undertake research oriented jobs and responsibilities in Universities and Industries.

PROGRAMME OUTCOMES (POs)

On successful completion of the programme,

PO	Graduate Attribute	Programme outcome
1.	Engineering knowledge	Postgraduate will be able to use the Engineering knowledge acquired from the basic courses offered in the programme to pursue either doctoral studies or a career as an academician / scientist or engineer.
2.	Conduct investigations of complex problems	Postgraduate will have a firm scientific, technological and communication base that helps him/her to conduct investigations of complex problems in the avionics industry and R&D organizations and other professional fields.
3.	The Engineer and society	Postgraduate will be capable of doing research in inter and multidisciplinary areas which will result in more efficient and cheaper products that are beneficial to society.
4.	Environment and sustainability	Postgraduate will exhibit awareness of contemporary issues on environment focusing on the necessity to develop new efficient system and testing methods for the solution of problems related to avionics industry.
5.	Individual and team work	Postgraduate will be trained towards developing and understanding the importance of design and development of avionics subsystems from system integration point of view which requires team work.

6.	Report writing skill	Postgraduate will have the ability to write and present a substantial technical report / document.

PROGRAMME SPECIFIC OUTCOMES

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

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

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

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

Mapping of PEOs with POs

PEO	Programme Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
I	3	3	2			1
II	3	3			3	2
III	3	3	3	3	2	2
IV	3	3	2	3	2	3
V	3	3	2	2	2	3

MAPPING OF COURSE OUTCOME WITH PROGRAMME OUTCOME AND PROGRAMME SPECIFIC OUTCOME

Subjects	Programme Outcomes						Programme Specific Outcome			
	1	2	3	4	5	6	1	2	3	4
FOUNDATION COURSES										
Aerospace Engineering	3	2	1	2	1	2.8	3	2	2	1
Electronic Systems	2.8	2				2.6	2.8	2.4		3
PROFESSIONAL CORE COURSES (PCC)										
Digital Avionics	3	2.3	2.25	2.6	2	2.6	3	2.6	2	3
Flight Instrumentation	3	2.8	2.4		2	2.6	3	3	2	3
Avionics Data Bus Laboratory	3	3	3	1	2	2.6	3	3	2	2.8
Avionics Programming Laboratory	3	1.8	1			2.6	3	3		3
Navigation Systems	3	2.8	2.4		2	2.6	3	3	2	3
Aerospace Guidance and Control	3	2.4	1			2.6	3	3		3
Rocketry and Space Mechanics	3	3	2	2		2.6	3	3		3
Navigation and Guidance Laboratory	3	3	3	3	2	2.6	3	3	2	3
PROFESSIONAL ELECTIVES										
Modern Control Theory for Aerospace Applications	3	3		2		2.6	3	3	2	3
Avionics System Engineering	3	2.2	2			2.6	3	2		3
Airworthiness, Standards and Certification	3	2.8	1.8	2	2	2.6	3	3	2	3
Elements of Satellite Technology	3	2	1			2.6	3	2.6		3
Indian Drone Policy, Rules and Regulations	1.2	1.6	1	1.3	2	2.6	2	2.5	2	2.2
Flight Dynamics	3	2.4	3	1	1	2.6	3	2	2	1
Fault Tolerant Control	3	2	1			2.6	3	2.8		3
Real time Embedded System	3	2.2	2			2.6	3	1.75		3

Missile Technology	2.8	3	1	1		2.6	2.8	2.2		2.8
UAV System Design	2	1	1			2.6	2	2		1.5
Aircraft Modeling and Simulation for Avionics Engineers	3	2.4			1	2.6	3	3	1	3
Launch Vehicle Dynamics and Control	3	2.6	1		1.75	2.6	3	3	1.75	3
Electronic Warfare	3	1.8	1.5	1		2.6	3	1.8		3
Spacecraft Communication Systems	3	2	1			2.6	3	2.8		3
Geospatial Drone Data Processing	1	1	1.5		1	2.6	1.4	1.6	1	1.5
Digital Fly by Wire Control	3	2.8	2.4		2.2	2.6	3	3	2	3
Image Analysis and Machine Vision for Aerospace Applications	3	3		2		2.6	3	3	2	3
Spacecraft Attitude and Control	3	2	1			2.6	3	2.8		3
Drones for Disaster Management	2	1.3	1.6	1.5	2	2.6	2	2.5	2	2.5
Active Control Technology	3	2	1			2.6	3	2.8		3
Theory of Detection and Estimation of Digital Signals	3	2	1			2.6	3	2.8		3
Missile Guidance and Control	3	2.2				2.6	3	2.2		3
Drones for Civil and Military Applications	1	1.5	1		1	2.6	1.4	1.67	1	2.33
Electric Propulsion System	1.8	3	1.5	2	2	2.6	3	1	3	
Missile And Launch Vehicle Aerodynamics	2.8	2.6	1	2	1.6	2.6	3	2	2	1
Thrust Vector Control Technology	3	3	2	2.5		2.6	3	2.8		3

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CURRICULA AND SYLLABI

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3153	Advanced Mathematical Methods	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	AV3101	Digital Avionics	PCC	3	1	0	4	4
4.	AV3151	Flight Instrumentation	PCC	3	0	0	3	3
5.	AV3102 AV3103	Bridge Core course Aerospace Engineering (For Non-Aero Students) (OR) Electronic Systems (For Aero Students)	FC	3	1	0	4	4
6.		Professional Elective I	PEC	3	0	0	3	3
PRACTICALS								
7.	AV3111	Avionics Data Bus Laboratory	PCC	0	0	4	4	2
8.	AV3112	Avionics Programming Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**3**	**8**	**29**	**25**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AV3201	Navigation Systems	PCC	3	0	0	3	3
2.	AV3202	Aerospace Guidance and Control	PCC	3	0	4	7	5
3.	AV3203	Rocketry and Space Mechanics	PCC	3	0	0	3	3
4.		Professional Elective II	PEC	3	0	0	3	3
5.		Professional Elective III	PEC	3	0	0	3	3
6.		Professional Elective IV	PEC	3	0	0	3	3
PRACTICALS								
7.	AV3211	Navigation and Guidance Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**0**	**8**	**26**	**22**

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective V	PEC	3	0	0	3	3
2.		Professional Elective VI	PEC	3	0	0	3	3
PRACTICALS								
3.	AV3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**6**	**0**	**12**	**18**	**12**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	AV3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 71

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER			CREDITS	SEMESTER
			L	T	P		
1.	MA3153	Advanced Mathematical Methods	4	0	0	4	1
2.	AV3102 AV3103	**Bridge course** Aerospace Engineering (For Non-Aero Students) (OR) Electronic Systems (For Aero Students)	3	1	0	4	1
		Total Credits				**8**	

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	AV3101	Digital Avionics	3	1	0	4	1
2.	AV3151	Flight Instrumentation	3	0	0	3	1
3.	AV3111	Avionics Data Bus Laboratory	0	0	4	2	1
4.	AV3112	Avionics Programming Laboratory	0	0	4	2	1

5.	AV3201	Navigation Systems	3	0	0	3	2
6.	AV3202	Aerospace Guidance and Control	3	0	4	5	2
7.	AV3203	Rocketry and Space Mechanics	3	0	0	3	2
8.	AV3211	Navigation and Guidance Laboratory	0	0	4	2	2
					TOTAL CREDITS	**26**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
					TOTAL CREDITS	**3**	

PROFESSIONAL ELECTIVES

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AV3001	Modern Control Theory for Aerospace Applications	PEC	3	0	0	3	3
2.	AV3002	Avionics System Engineering	PEC	3	0	0	3	3
3.	AL3051	Airworthiness, Standards and Certification	PEC	3	0	0	3	3
4.	AO3051	Elements of Satellite Technology	PEC	3	0	0	3	3
5.	AV3003	Indian Drone Policy, Rules and Regulations	PEC	3	0	0	3	3
6.	AV3004	Flight Dynamics	PEC	3	0	0	3	3
7.	AV3005	Fault Tolerant Control	PEC	3	0	0	3	3
8.	AV3006	Real time Embedded System	PEC	3	0	0	3	3
9.	AV3007	Missile Technology	PEC	3	0	0	3	3
10.	AV3008	UAV System Design	PEC	3	0	0	3	3
11.	AV3009	Aircraft Modeling and Simulation for Avionics Engineers	PEC	3	0	0	3	3
12.	AV3010	Launch Vehicle Dynamics and Control	PEC	3	0	0	3	3
13.	AV3011	Electronic Warfare	PEC	3	0	0	3	3
14.	AV3012	Spacecraft Communication Systems	PEC	3	0	0	3	3
15.	AV3013	Geospatial Drone Data Processing	PEC	3	0	0	3	3

16.	AV3014	Digital Fly by Wire Control	PEC	3	0	0	3	3
17.	AV3015	Image Analysis and Machine Vision for Aerospace Applications	PEC	3	0	0	3	3
18.	AO3016	Spacecraft Attitude and Control	PEC	3	0	0	3	3
19.	AV3016	Drones for Disaster Management	PEC	3	0	0	3	3
20.	AV3017	Active Control Technology	PEC	3	0	0	3	3
21.	AV3018	Theory of Detection and Estimation of Digital Signals	PEC	3	0	0	3	3
22.	AV3019	Missile Guidance and Control	PEC	3	0	0	3	3
23.	AV3020	Drones for Civil and Military Applications	PEC	3	0	0	3	3
24.	AO3055	Electric Propulsion Systems	PEC	3	0	0	3	3
25.	AO3052	Missile and Launch Vehicle Aerodynamics	PEC	3	0	0	3	3
26.	AV3021	Thrust Vector Control Technology	PEC	3	0	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AV3311	Project Work I	0	0	12	6	3
2.	AV3411	Project Work II	0	0	24	12	4
					TOTAL CREDITS	**18**	

SUMMARY

	Name of the Programme: M.E.AVIONICS						
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**	**% Distribution**
		I	**II**	**III**	**IV**		
1.	FC	8	-	-	-	8	11.11 %
2.	PCC	11	13	-	-	24	33.82%
3.	PEC	3	9	6	-	18	25.00 %
4.	RMC	3	-	-	-	3	4.16 %
5.	EEC	-	-	6	12	18	25.00 %
6.	**TOTAL CREDIT**	**25**	**23**	**12**	**12**	**71**	

MA3153 ADVANCED MATHEMATICAL METHODS L T P C
4 0 0 4

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method

UNIT II LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform: Definitions, properties -Transform of error function, Bessel's function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations: Heat equation, Wave equation

UNIT III FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

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

UNIT I CALCULUS OF VARIATIONS 12

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

UNIT V TENSOR ANALYSIS 12

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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

CO1 On successful completion of the course, the students will be able to
CO2 get familiarized with the methods which are required for solving system of linear, Non linear equations and eigenvalue problems.
CO3 develop the mathematical methods of applied mathematics and mathematical physics
CO4 solve boundary value problems using integral transform methods apply the concepts of calculus of variations in solving various boundary value problems
CO5 familiarize with the concepts of tensor analysis.

REFERENCES:

1. Andrew L.C. and Shivamoggi B.K., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolts L., "Differential Equations and the Calculus of Variations", MIR Publishers, Moscow, 2003.
3. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, New Delhi, 2017.
4. Gupta A.S., "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi, 2004.

5. James G., “Advanced Modern Engineering Mathematics”, Pearson Education, 4th Edition, Horlow, 2016.
6. Burden, R.L., and Faires, J.D., “Numerical Analysis – Theory and Applications”, Cengage Learning, India Edition, New Delhi, 2010.
7. O'Neil P.V., “Advanced Engineering Mathematics”, Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.
8. Ramanaiah, G.T., “Tensor Analysis”, S. Viswanathan Pvt. Ltd., Chennai, 1990.
9. Sankara Rao K., “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt. Ltd., 3rd Edition, New Delhi, 2010.
10. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.

CO-PO Mapping:

COs	POs					
	1	2	3	4	5	6
1	3	3	3	3	2	2
2	3	3	3	3	2	2
3	3	3	3	3	2	2
4	3	3	3	3	2	2
5	3	3	3	3	2	2
AVG	3	3	3	3	2	2

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

AV3101 DIGITAL AVIONICS L T P C

3 1 0 4

UNIT I INTRODUCTION TO AVIONICS 12

Role for Avionics in Civil and Military Aircraft systems, Avionics sub-systems -design- Introduction to control surface actuation system, Fly-by-wire Actuators, defining avionics System/subsystem-Requirements & importance of ‘ilities’- Avionics system architectures – Integrated Modular Avionics - Guidance and Certification Considerations

UNIT II AVIONICS SYSTEM DATA BUSES, DESIGN AND INTEGRATION 12

MIL-STD-1553B, ARINC-429, ARINC-629, CSDB, AFDX and its Elements, CAN Bus, ARINC 825, ARINC 826, Avionics system design, Development and integration-Use of simulation tools, stand alone and integrated Verification and Validation.

UNIT III AVIONICS SYSTEM ESSENTIALS: DISPLAYS, I/O DEVICES AND POWER 12

Trends in display technology, Civil and Military aircraft cockpits, MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display, virtual cockpit-Civil and Military Electrical Power requirement standards, comparing the Military and Civil Requirements and Tips for Power System Design.

UNIT IV MAINTENANCE AND PACKAGING 12

BIT and CFDS, Automatic Test Equipment - Speeds maintenance - ATLAS, Remote diagnostics and maintenance support-Life Cycle Costs for Military and Civil Avionics -Modular Avionics

Packaging - Trade-off studies - ARINC and DOD types - system cooling - EMI/EMC requirements & standards.

UNIT V SYSTEM ASSESSMENT, VALIDATIONAND CERTIFICATION 12

Fault tolerant systems - Hardware and Software, Evaluating system design and Future architecture -Hardware assessment-FARs guide certification requirements-Fault Tree analysis – Failure mode and effects analysis – Criticality, damaging modes and effects analysis - Software development processmodels - Software Assessment and Validation -Civil and Military standards - Certification of Civil Avionics.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the role of avionics systems and compare the different avionics architecture

CO2 Compare different avionics databus and explain the system design and integration process

CO3 Identify the different cockpit displays and explain avionics power systems

CO4 Explain the importance of maintenance, modular avionics packaging and EMI/EMC standards

CO5 Perform documentation on hardware and software development for certification process.

REFERENCES:

1. Albert Helfrick, Principles of Avionics, Avionics Communication Inc, USA, 2012.
2. Spitzer, C.R. Digital Avionics Systems, Prentice Hall, Englewood Cliffs, N.J., U.S.A., 1987.
3. Cary R. Spitzer, The Avionics Handbook, CRC Press, 2000.
4. Collinson R.P.G. Introduction to Avionics, Chapman and Hall, 1996.
5. Jim Curren, Trend in Advanced Avionics, IOWA State University, 1992.
6. Middleton, D.H. Avionics Systems, Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3					3	3	2		3
2	3	2	2	2	2	2	3	3	2	3
3	3		2			3	3	2		3
4	3	3	3	3		2	3	3		3
5	3	2	2	3	2	3	3	3	2	3

AV3151 FLIGHT INSTRUMENTATION L T P C

3 0 0 3

UNIT I MEASUREMENT SCIENCE AND DISPLAYS 9

Instrumentation brief review - Concept of measurement - Functional elements of an instrument system- Transducers - classification of aircraft instruments-Requirements and standards – Instrument Elements and Mechanism - Instrument displays panels and cockpit layout, Aircraft instruments Grouping - Electronic Flight Instrument System.

UNIT II AIR DATA INSTRUMENTS AND SYNCHRO TRANSMISSION SYSTEMS 9

Earth's Atmosphere – Basic Air data system – Air Data instruments-airspeed, altitude, Vertical speed indicators - Probes – Posittion Error - Altitude alerting systems,Mach meter, Mach Warning system, Static Air temperature, Angle of attack measurement, Stall Warning system,Stick Shaker - Synchronous data transmission system – Synchros systems – Resolver synchros – Synchrotel

UNIT III GYROSCOPIC AND ADVANCED FLIGHT INSTRUMENTS 9

Gyroscope and its properties, gyro system, Gyro horizon, Erection systems for Gyro Horizons Direction gyro-direction indicator, Rate gyro-rate of turn and slip indicator, Turn coordinator, acceleration and turning errors, Standby Attitude Director Indicator, Gyro stabilized Direction Indicating Systems, Advanced Direction Indicators, Horizontal Situation Indicator.

UNIT IV AIRCRAFT COMPASS SYSTEMS & FLIGHT MANAGEMENT SYSTEM 9

Aircraft magnetism - Direct reading compass, magnetic heading reference system-detector element, monitored gyroscope system, DGU, RMI, deviation compensator. FMS- Flight planning-flight path optimization-operational modes-4D flight management

UNIT V POWER PLANT INSTRUMENTS & FLIGHT DATA RECORDING 9

Pressure measurement, temperature measurement, fuel quantity measurement, engine power and control instruments-measurement of RPM, manifold pressure, torque, exhaust gas temperature, EPR, Engine Fuel Indicators, engine vibration monitoring, Cockpit Voice Recorder and Flight Data Recorder.

TOTAL :45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1 Understand and apply the concept of measurement, classification of aircraft instrumentation, displays and layouts standards

CO2 Explain about the various air data systems and synchronous data transmissions systems

CO3 Apply the principle of gyroscope to various Advanced Aircraft Instruments

CO4 Classify the aircraft magnetism, understand the Compass systems and FMS in 4D flight management in the Avionics domain requirements

CO5 Explain the operation and importance of Power plant & engine instruments and flight data recorder.

REFERENCES:

1. Pallet, E.H.J. Aircraft Instruments & Integrated systems, Dorl.ing Kindersley (India) Pvt. Ltd,, 2011.
2. David Wyatt. 'Aircraft Flight Instruments and Guidance Systems', Routledge, Taylor & Francis Group, 2015.
3. Harry L. Stilz, Aerospace Telemetry, Vol I to IV, Prentice-Hall Space Technology Series, 1961.
4. Sawhney A.K, ' Electronic Measurements and Instrumentation ' Dhanpat Rai & Co, 2017
5. Murthy, D.V.S., Transducers and Measurements, McGraw-Hill, 1995.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	3			2	3	3		3
2	3	3	3			3	3	3		3
3	3	3	2			2	3	3		3

4	3	3	2			3	3	3		3
5	3	3	2		2	3	3	3	2	3

AV3102 AEROSPACE ENGINEERING L T P C
3 1 0 4

UNIT I INTRODUCTION TO AERONAUTICS 12
Classification of flight vehicles - Anatomy of flight vehicles - Airfoil and wing nomenclature - Aerodynamic forces - lift and drag - high lift devices - Mach number and different speed regimes - Types of drag and methods of drag reduction in airplanes - International Standard Atmosphere (ISA) - Pitot static tube – IAS, EAS and TAS - Basic instruments for flying- Hydraulic, Pneumatic and Fuel systems of Aircraft - Engine Control System.

UNIT II FLIGHT PERFORMANCE 12
Steady and level flight - Thrust and Power required curves - Cruise velocity expression - Stall velocity -Steady climb - ROC and Climb angle - Powerless glide - ROD and Glide angle - Range and Endurance of jet and propeller-driven aircraft. Estimation of take-off and landing distances, level turn - minimum turn radius - maximum turn rate, bank angle and load factor - V-n diagram.

UNIT III STATIC STABILITY AND CONTROL 12
Static and dynamic stability, Criteria for longitudinal static stability, contribution to stability by wing, tail, fuselage, wing fuselage combination, Neutral point-Stick fixed and Stick free conditions, Free elevator factor, , elevator control power, elevator angle to trim, Directional stability-yaw and sideslip, Criterion of directional stability, contribution to static directional stability by wing, fuselage, tail, rudder requirements, Lateral stability-Dihedral effect, criterion for lateral stability - contribution of various components.

UNIT IV DYNAMIC STABILITY 12
Equations of motion - Small disturbance theory - Different types of axes system. Estimation of longitudinal stability derivatives - Routh's discriminant, solving the stability quartic, Phugoid motion, Factors affecting the period and damping. Dutch roll and spiral instability, Auto rotation and spin.

UNIT V AIRCRAFT PROPULSION AND MATERIALS 12
Introduction to Aircraft structures - Loads -Types of construction- Aircraft materials. Different types of load carrying members on Wing and Fuselage. Aircraft propulsion, Rocket propulsion, Construction and working of Turbo jet, Turbo prop, Turbo fan, Turbo shaft and Ram jet engines.

TOTAL : 60 PERIODS

COURSE OUTCOMES:
Upon completion of the course, Students will be able to
- **CO1** Determine the properties of atmosphere at a given altitude in ISA and categorize flight vehicle configurations.
- **CO2** Evaluate the level flight performance like cruise, climbing and gliding capabilities and maneuvering performance such as turn, take-off and landing of a given aircraft.
- **CO3** Ensure longitudinal, directional and lateral stability and trim of a flight vehicle design.
- **CO4** Demonstrate the dynamic instabilities of an aircraft like Autorotation, Spin and Dutch roll.
- **CO5** Select an efficient engine as per the design requirement and identify different structural components of an aircraft.

REFERENCES:

1. Anderson, J.D., Introduction to Flight, 9th edition, 2022, McGraw-Hill.
2. Kermode, A.C., Flight without Formulae, , 11th edition, 2011, Pearson Education.
3. Shevell, R. A., Fundamentals of Flight, , 2nd edition, 2004, Pearson Education.
4. Pilot's Handbook of Aeronautical Knowledge, 2016, FAA-H-8083-25B.
5. Anderson, D. F. and Eberhardt, S., Understanding Flight, 2nd edition, 2009, McGraw-Hill.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	1	2	1	3	3	2	2	1
2	3	2	1	2	1	3	3	2	2	1
3	3	2	1	2	1	2	3	2	2	1
4	3	2	1	2	1	3	3	2	2	1
5	3	2	1	2	1	3	3	2	2	1

AV3103 ELECTRONIC SYSTEMS L T P C
3 1 0 4

UNIT I TRANSISTORS AND LINEAR IC's 12

Introduction to electronic devices, BJT, modes of operation - classification of transistors-OP-AMP specifications, applications, voltage comparator, A/D and D/A converter, sample and hold circuit, timer, VCO, PLL, interfacing circuits, Introduction to analog computer.

UNIT II SIGNAL GENERATORS AND DC POWER SUPPLIES 12

Mutivibrators using IC555, Schmitt Trigger. RC phase shift oscillator, Wien bridge oscillator, Crystal oscillator. LC oscillators. Relaxation oscillators, Rectifiers, DC-DC converters, Voltage Regulators.

UNIT III DIGITAL SYSTEMS 12

Number system, Review of TTL, ECL, CMOS- Logic gates, Flip Flops, Shift Register, Counter, Multiplexer, Demultiplexer / Decoder, Encoder, Adder, Arithmetic functions, analysis and design of clocked sequential circuits, Asynchronous sequential circuits, Finite State Machines.

UNIT IV MICROPROCESSOR BASED SYSTEMS 12

Introduction to Microprocessor design using Digital Circuits – 8085 microprocessor, Architecture – External Memory interfacing – Peripheral IC Interfacing-interfacing with Alpha numeric displays – Recent trends in advanced processors: SOC, DSP, FPGA, CPLD.

UNIT V MICROCONTROLLER BASED SYSTEMS 12

8051 microcontroller – Architecture – Assembly language Programming–Timer and Counter Programming – D/A and A/D interfacing – Multiple Interrupts – Analog interfacing and industrial control, Interfacing of LVDTs, Resolvers, Encoders, hall effect sensors, LCD panels, Stepper motor controller, Interfacing BLDC motors using ESC.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the operation and applications of basic electronic devices and Linear IC's

CO2 Design signal generator and DC power supplies using analog ICs.
CO3 Design a digital circuit using Logic Gates/flop-flops and understand their implementation in microprocessor/microcontroller
CO4 Explain the architecture of a basic microprocessor and Select suitable peripherals for interfacing with microprocessors/microcontroller.
CO5 Compare microprocessor with microcontroller and control the peripherals using assembly language Programming

REFERENCES:

1. Gayakwad, Ramakant A., Op-Amps and Linear Integrated Circuits, 4th Edition, Prentice Hall/ Pearson Higher Education, New Delhi, 2015.
2. Sedha, R.S. Electronic Devices and Circuits, S Chand Publications, New Delhi, 2010.
3. Jacob Millman, Christos C Halkias, Satyabrata Jit. Electronic Devices and Circuits, 4th Edition, Tata McGraw Hill, New Delhi, 2015.
4. Muhammad H. Rashid, Power Electronics Devices, Circuits, and Applications, 4th Edition, Pearson Education, England, 2017.
5. Donald P Leach, Albert Paul Malvino, Goutam Saha, Digital Principles and Applications, 8th Edition, Tata McGraw Hill, New Delhi, 2014.
6. M. Morris Mano, "Digital Design", 3rd Edition, Pearson Education, 2001.
7. John Crisp, —Introduction to Microprocessor and Microcontroller, Newnes Publication, London, 2004.
8. William Kleitz, Microprocessor and Microcontroller Fundamentals: The 8085 and 8051 Hardware and Software, Prentice Hall Inc, New York, 1997

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	2					3	2	1		3
2	3	1				3	3	3		3
3	3	3				2	3	3		3
4	3	2				2	3	2		3
5	3	2				3	3	3		3

AV3111 AVIONICS DATA BUS LABORATORY L T P C
0 0 4 2

LIST OF EXPERIMENTS

1. Installation and testing of MIL –STD-1553 (Self test)
2. Installation and testing of ARINC-429 and ARINC -629 (Self test)
3. Installations and testing of AFDX card (Self test)
4. Configuring MIL –STD-1553 cards in transmitting and receiving mode.
5. Configuring ARINC-429 and ARINC -629 cards in transmitting and receiving mode.
6. Using the interactive driver to transmit or receive the data
    a. On a single PC by loop back connection.
    b. PC to PC by connecting a shielded pair of wires.
7. Transmit and receive the messages
    a. Using loop back connection with single card.
    b. Using connector (shielded pair of wires).

8. Configuring CAN bus in transmitting and receiving mode.
9. Transmit and receive messages using CAN bus
10. Simulation of data bus converter

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Install and test the connections in avionics databus

CO2 Configure the different modules as transmitter, receiver and monitoring terminals

CO3 Configure MIL-STD-1553B, ARIINC 429 and AFDX cards in transmitting and receiving mode.

CO4 Extract data, represented in different word and message formats, from the databus.

CO5 Simulate the functions of a databus converter

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3	3	1	2	2	3	3	2	2
2	3	3	3	1	2	2	3	3	2	3
3	3	3	3	1	2	3	3	3	2	3
4	3	3	3	1	2	3	3	3	2	3
5	3	3	3	1	2	3	3	3	2	3

AV3112 AVIONICS PROGRAMMING LABORATORY

L T P C
0 0 4 2

LIST OF EXPERIMENTS

1. Basic addition, Subtraction, Multiplication and Division using ADA
2. Print passenger and flight details using control and string operations.
3. Matrix multiplication in ADA using loop statements.
4. Subprogram using functions
5. Swapping of numbers with and without third variables
6. Exception handling.
7. Exploring Packages in ADA.
8. File handling 'statistics of character types in given file'.
9. A program to integrate INS and GPS flight data. .
10. Hardware Implementation by using STM32 or Raspberry Pi using ADA.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Conversant with the basics of ADA programming language

CO2 Capable of writing, testing, and debugging simple ADA programs

CO3 Use methods and classes using packages

CO4 Design file and exception handling

CO5 Implement engineering algorithms using ADA

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	1				3	3			3
2	3	1				2	3	3		3
3	3	3				2	3	3		3
4	3	2	1			3	3	3		3
5	3	2				3	3	3		3

AV3201 NAVIGATION SYSTEMS L T P C
3 0 0 3

UNIT I NAVIGATION SYSTEMS & INERTIAL SENSORS 9

Principles of navigation - Design Trade-offs – Evolution of Air navigation - Concept of latitude and longitude (Geodetic and Geostatic) - Different co-ordinate frames - Transformation Techniques – Euler Angles – Direction Cosine matrices – Quaternions – Dual Quaternions - Introduction to Inertial Sensors -Accelerometers - Gyroscopes - Mechanical Gyro - Ring Laser gyro- Fiber optic gyro - MEMS system

UNIT II INERTIAL NAVIGATION SYSTEMS 9

Navigation Equations - - Earth in inertial space - INS Mechanization Equations - Stable Platform and Strap down- INS components: transfer function and error analysis - Coriolis effect - Rate corrections – Schuler Tuning - INS system block diagram - Initial calibration and Alignment Algorithms

UNIT III RADIO NAVIGATION 9

Different types of radio navigation – Non-directional Beacons - ADF, VOR, DME - Doppler - Hyperbolic Navigations -LORAN, DECCA and Omega -TACAN- VORTAC - Future trends

UNIT IV LANDING SYSTEMS AND AIR TRAFFIC MANAGEMENT 9

Mechanic of Landing – Visual flight Rules – Categories of Landing - Instrument Landing System-Microwave Landing System- Satellite based Landing system – Ground controlled approach system- Surveillance systems-Airborne Collision Avoidance Systems

UNIT V SATELLITE NAVIGATION & HYBRID NAVIGATION 9

Introduction to GPS -system description - basic principles -position and velocity determination-signal structure- Spread spectrum concepts- Errors – DGPS concepts: LAAS, WAAS - Estimation and mixed mode navigation -Integration of GPS and INS- Kalman Filter - Utilization of navigation systems in aircraft.

TOTAL:45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1 Explain the need for different axis systems and select the suitable system for the given Condition.

CO2 Derive the necessary mathematical knowledge that are needed in modelling the navigation process and methods.

CO3 Analyze various Navigation systems such as Inertial Measurement systems, Radio Navigation Systems, Satellite Navigation – GPS; Landing aids.

CO4 Understand the operation of various Automatic Landing systems

CO5 Explain the concepts of Satellite Navigation and Deploy these skills effectively in the analysis and understanding of hybrid navigation systems in an aircraft.

REFERENCES:

1. Myron Kyton, Walfred Fried, ‘Avionics Navigation Systems’, John Wiley & Sons, 2009
2. Collinson R.P.G, ’Introduction to Avionics Systems’, Springer Publisher, 3rd Edition 2011.
3. Nagaraja, N.S. Elements of Electronic Navigation‖, Tata McGraw-Hill Pub. Co., New Delhi, 2nd edition, 2017.
4. Paul. D. Groves. ‘Principles of GNSS, Inertial, and Multi sensor Integrated Navigation Systems’, Artech House, 2013.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	3			2	3	3		3
2	3	3	3			3	3	3		3
3	3	3	2			3	3	3		3
4	3	3	2			2	3	3		3
5	3	3	2		2	3	3	3	2	3

AV3202 AEROSPACE GUIDANCE AND CONTROL L T P C

3 0 4 5

UNIT I INTRODUCTION 9

Introduction to Guidance and control - Definition, Historical background – Coordinate Frame - Equations of motion – Lineraization, Fundamentals of attitude estimation,using Eulers and Quaternion Technique.

UNIT II AUGMENTATION SYSTEMS 9

Need for automatic flight control systems, First order system and second order system and its equation. Types of Feedback Technique, Control augmentation systems, Design of Limited authority and Full Authority Augmentation systems - Effects of various feedback in longitudinal and later control system. Stability augmentation systems, Gain scheduling concepts.

UNIT III LONGITUDINAL AUTOPILOT 9

Displacement Autopilot -Pitch Orientation Control system, Pitch rate Control system Acceleration Control System, Importance of Pitch, roll and Yaw damper control system, Velocity Control system, Mach control system, Altitude Control system, Angle of attack control system, Glide Slope Coupler and Automatic Flare Control and Flight path stabilization, Longitudinal control law design using root locus and Bode technique.

UNIT IV LATERAL AUTOPILOT 9

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

UNIT V MISSILE AND LAUNCH VEHICLE GUIDANCE 9

Operating principles and design of guidance laws, homing guidance laws- short range, Launch Vehicle- Operating environment Mission Design, Implicit guidance schemes, Explicit guidance, Q guidance schemes, Trajectory design and Flight sequence, Navigation guidance and control aspects.

LIST OF EXPERIMENTS:

1. Stability analysis using Root locus, Bode plot, Nyquist plot and Polar plot techniques
2. Development of Longitudinal and Lateral Equations of Motion
3. Improvement of Aircraft Dynamics by pole placement technique
4. Design of PID and LQR Control algorithm for an aircraft dynamics
5. Design of longitudinal autopilot –Pitch Control, Pitch rate Control , Airspeed, Altitude, Acceleration Control, Automatic Glide Slope Control System and Flare Control System
6. Design of Automatic Lateral beam guidance system- Roll, Roll Damper, Yaw Control and Yaw Damper Control
7. Design of Van-Guard Missile system
8. Implementation of Hardware-In-Loop Simulation (HILS) for fixed wing aircraft
9. Development of basic stabilization for Helicopters
10. Development of stabilization for Quadcopters.

TOTAL:60+45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the equations governing the aircraft dynamics and the process of linearizing them.
CO2 Define the various guidance schemes and requirements for aircrafts and missiles.
CO3 Apply the principle of stability and control augmentation systems.
CO4 Analyze the oscillatory modes and methods of suppressing them
CO5 Design the controller for lateral, longitudinal and directional control of aircrafts.

REFERENCES:

1. Blake Lock, J.H Automatic control of Aircraft and missiles, John Wiley Sons, New York, 1990.
2. Thomas R. Yechout, Steven L. Morris, David E. Bossert, Wayne F. Hallgren, James K. Hall— Introduction to Aircraft Flight Mechanics, AIAA Education series, 2014.
3. Collinson R.P.G, ‘Introduction to Avionics’, Chapman and Hall, India, 1996.
4. Garnel. P. & East. D. J, ‘Guided Weapon control systems’, Pergamon Press, Oxford, 1977.
5. Michael V. Cook ‘Flight Dynamics Principles: A Linear Systems Approach to Aircraft Stability and Control’, Elsevier, 2013.
6. Nelson R.C, ‘Flight stability & Automatic Control’, McGraw Hill, 1989.
7. Pierre T. Kabamba, Anouck R. Girard. ‘Fundamentals of Aerospace Navigation and Guidance’, Cambridge university press, 2014.
8. Stevens B.L & Lewis F.L, ‘Aircraft control & simulation’, John Wiley Sons, New York, 1992.
9. B.N Suresh & K.Sivan, Integrated design for space transportation system’, springer 2015.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	1				3	3	3		3
2	3	3	1			2	3	3		3

3	3	2	1			3	3	3		3
4	3	3	1			2	3	3		3
5	3	3	1			3	3	3		3

AV3203 ROCKETRY AND SPACE MECHANICS L T P C
3 0 0 3

UNIT I ORBITAL MECHANICS 9

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

UNIT II SATELLITE DYNAMICS 9

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

UNIT III ROCKET MOTION 9

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

UNIT IV ROCKET AERODYNAMICS 9

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

UNIT V STAGING AND CONTROL OF ROCKET VEHICLES 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 To explain the fundamental laws of orbital mechanics and will be able to analyse the two and three body problems

CO2 To calculate orbital parameters and perform conceptual trajectory designs for geocentric or interplanetary missions.

CO3 To evaluate the planar motion of rockets for different flight conditions.

CO4 To evaluate the forces and moments acting on airframe of a missile.

CO5 To conceptually design an optimal multistage rocket and compare different methods of stage separation

REFERENCES:

1. Cornelisse,JW, “Rocket Propulsion and Space Dynamics”, J.W. Freeman & Co., Ltd., London, 1982.
2. Howard D. Curtis, “Orbital Mechanics for Engineering Students (with MATLAB examples)”, Butterworth-Heinemann Publishing, 4th edition, 2019.
3. Parker,ER, “Materials for Missiles and Spacecraft”, McGraw-Hill Book Co., Inc., 1982.
4. Suresh. B N & Sivan. K, “Integrated Design for Space Transportation System”, Springer India, 2015.
5. Sutton,GP, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8 th Edition, 2010.
6. Van de Kamp, “Elements of Astromechanics”, Pitman Publishing Co., Ltd., London, 1980.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3				3	3	3		3
2	3	3				2	3	3		3
3	3	3	2			2	3	3		3
4	3	3				3	3	3		3
5	3	3	2	2		3	3	3		3

AV3211 NAVIGATION AND GUIDANCE LABORATORY L T P C
0 0 4 2

LIST OF EXPERIMENTS

1. Calibration of MEMS accelerometers using Multi-position and all attitude test
2. Calibration of MEMS gyroscopes using rate test and all attitude test
3. Sensor data fusion using complementary filter
4. Angle estimation based on Euler‘s and Quaternion approach using MEMS based Inertial Measurement Unit (IMU)
5. Development of Hybrid Navigation - INS/GPS Integration using Kalman filter
6. Error analysis of GPS receiver using GPS trainer kit
7. Software in loop Simulation of Way Point Navigation
8. Software in loop Simulation of UAV landing guidance
9. Camera calibration for estimation of Intrinsic and extrinsic parameter
10. Optical Flow Estimation on real-time images
11. Development of Object detection and tracking algorithms

(Experiments 7 & 8 may be used with flight simulators like Flight gear, X-Plane, etc.)

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Calibrate MEMS IMU and fuse the sensor data using complementary filter

CO2 Develop and test the hybrid navigation system by integrating the INS/GPS modules.

CO3 Develop and test the guidance algorithm by performing software-in-loop simulation using waypoint navigation.

CO4 Calibrate the camera and perform image processing for optical flow estimation

CO5 Develop algorithms for object detection and tracking in real-time images

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3	3	3	2	2	3	3	2	3
2	3	3	3	3	2	3	3	3	2	3
3	3	3	3	3	2	3	3	3	2	3
4	3	3	3	3	2	2	3	3	2	3
5	3	3	3	3	2	3	3	3	2	3

AV3001 MODERN CONTROL THEORY FOR AEROSPACE APPLICATIONS **L T P C**
3 0 0 3

UNIT I INTRODUCTION **9**
Basic Concepts - Review of Classical Control -Representation of Linear Systems -First and Second Order Linear Differential Equations – Linear differential equations, Laplace transforms, Fourier transforms, Mathematical modeling of dynamic systems – 6 DOF Equations of motion for Aircraft models - Transfer Functions- Time Response of Linear DynamicalSystems - Stability of Linear Time Invariant Systems

UNIT II STATE SPACE ANALYSIS **9**
Concept of state, state variables and state model, state modeling of linear systems- State space representation using physical variables, phase variables & canonical variables - Controllability and Observability - State Feedback- Pole Placement

UNIT III NON-LINEAR SYSTEMS **9**
Types of Non-Linearity – Typical Examples – Properties of nonlinear systems – Nonlinear differential equations – Numerical solutions to nonlinear differential equations – common physical non-linearity saturation, friction, backlash, dead zone, relay-Stability analysis of
Nonlinear systems- Mathematical modeling of non-linear systems- Stability Steady-State Accuracy. Frequency domain analysis Bode plot Root locus, Analytical Methods Continuous-Time Control System Design

UNIT IV NONLINEAR SYSTEM ANALYSIS **9**
BIBO and Asymptotic stability – Phase plane analysis (analytical and graphical methods) –– Stability Analysis by Describing function method -Lyapunov Theory – Constructions of Lyapunov Functions -Nonlinear Observer - Back-Stepping - Linear Quadratic (LQ) Observer - An Overview of Kalman FilterTheory-Kalman Filter Design- Discretization of continuous system, Sampling theory, Bilineartransformation, Tustin transformation, Discrete transfer functions solution to discrete equations, Analysis of continuous and Discrete-Time Control Systems. Discrete-Time Control System DesignExample

UNIT V OPTIMAL CONTROL **9**
Introduction: Classical control optimization, formulation of optimal control problem- Optimal state regulator design: Lyapunov equation-Matrix Riccati equation- Stability Analysis of Dynamic Systems- Linear Quadratic Regulator- LQR steady state optimal control- Applications- State Variable Feedback and Controllability- Pole Placement or Eigenvalue Assignment- State Variable

Observers – Application for Aircraft models

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Apply mathematical knowledge and basics of science and engineering to develop model for non-linear system.

CO2 Analyze non-linear system based on the first principle model.

CO3 Analyze the solution for complex non-linear system.

CO4 Develop various control schemes for non-linear systems.

CO5 Linearize non-linear system for developing linear control

REFERENCES:

1. Gopal, M., "Digital Control and State Variable Methods: Conventional and Intelligent Control Systems", Fourth Edition, Tata Mc-Graw Hill, 2012
2. Thompson, J. M. T., and Stewart, H. B.," Nonlinear Dynamics and Chaos", John Wiley & Sons, 2002.
3. Bequette, B.W., "Process Control Modeling, Design and Simulation", Prentice Hall of India, 2008.
4. Bequette, B.W., "Process Control: Modeling, Design and Simulation", Prentice Hall International series in Physical and Chemical Engineering Sciences, 2003.
5. Hangos, K.M., Bokor, J., and Szederkrnyi, G., "Analysis and control of Non-linear Process systems", 2004.
6. Shankar Sastry, "Nonlinear Systems: Analysis, Stability, and Control", Springer New York, 2013.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3		2		2	3	3		3
2	3	3		2		2	3	3		3
3	3	3		2		3	3	3		3
4	3	3		2		3	3	3	2	3
5	3	3		2		3	3	3	2	3

AV3002 AVIONICS SYSTEM ENGINEERING L T P C
3 0 0 3

UNIT I INTRODUCTION TO SYSTEMS ENGINEERING 9

Overview of Systems Engineering -Systems Engineering Concept Map - Systems Definition - The seven steps Systems Engineering- Conceptual System Design- System Engineering Process Requirements and Management- Trade Studies- Integrated Product and Process Development

UNIT II THE AIRCRAFT SYSTEMS AND DESIGN 9

Introduction-Everyday Examples of Systems-Aircraft Systems-Generic Systems-Product Life Cycle-Different Phases-Whole Life Cycle Tasks-Systems Analysis- Design Drivers in the Project, Product, Operating Environment-Interfaces with the Subsystems- Mission analysis

UNIT III SYSTEM ARCHITECTURES AND INTEGRATION 9

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

UNIT IV PRACTICAL CONSIDERATIONS AND CONFIGURATION CONTROL 9

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

UNIT V SYSTEMS RELIABILITY AND MAINTAINABILITY 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Describe the importance of systems engineering process in product development

CO2 Categorize different aircraft systems and will be able to differentiate the avionics architectures

CO3 Analyze the different stages of product development and factors influencing in each stage

CO4 Design the different alternatives during design process

CO5 Plan, organize and document the task related to product design, development and testing.

REFERENCES:

1. Andrew P. Sage and James E. Armstrong. Introduction to Systems Engineering, WileyInterscience; 1st edition, 2000
2. Erik Aslaksen and Rod Belcher. Systems Engineering, Prentice Hall, 1992.
3. Ian Moir and Allan Seabridge. Design and Development of an Aircraft Systems, 2nd Edition, John Wiley & Sons Ltd, 2013.
4. Ian Moir and Allan Seabridge. Aircraft Systems Mechanical, electrical, and avionics subsystems integration, John Wiley & Sons Ltd, 2009.
5. Peter. Sydenham- Systems Approach to Engineering Design, Artech house, Inc, London, 2003.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2				2	3	1		3
2	3	2	2			3	3	2		3
3	3	2	2			3	3	3		3
4	3	2	2			2	3	2		3
5	3	3	2			3	3	2		3

AL3051 AIRWORTHINESS, STANDARDS AND CERTIFICATION **L T P C**
3 0 0 3

UNIT I AVIONICS SYSTEM ENGINEERING DEVELOPMENT CYCLE 9

Establishing the Avionics System Requirements by Mission Scenario Analysis, Functional Analysis, Physical Partitioning, Avionics Architectural Design, Specification, Development & Procurement of HW/SW of Sub systems. Stand alone testing of subsystems, Certification, Validation, Verification. SW/HW Integration, Systems Engineering Process Outputs, System Analysis and Control, System Work Breakdown Structure, Configuration Management, Flight Testing, Operational Test and Evaluation by user and Deployment.

UNIT II AVIATION STANDARDS 9

Design Development & Manufacturing Standards Associated with Aircraft & Avionics systems. Aviation Standards of MIL, DEFSTAN-970, AIR -2004, GOST & FAR Standards. Environmental Testing Standards (MIL-814), IEE Stds.

Design Standards for Airborne Electronic Hardware (DO-254)- Hardware Design Life Cycle Data, Hardware Design Processes, Certification, Validation & Verification Process, Safety Assessment Process, Configuration Management Process.

Standards for Aviation Software Design Phase (DO-170B)- Software Life Cycle, Planning, Certification, Verification, Configuration, Tool Qualification, SW Reliability Models & Assurance Process. Case Studies.

Certification Process During Integration of Aircraft Systems (SAE ARP4754) -Certification Process/Coordination. Safety Assessment, Validation, Verification, Configuration Mgt, Process Assurance. Case Studies

UNIT III AIRWORTHINESS CERTIFICATION 9

Civil & Military Aviation Certification, Regulatory and Advisory Agencies, Airworthiness Certification Process/Concepts, Type Records, Type Approval and Certificate of Design & Conformance, DDPMAS- 2022 (Vol 1&11), Certification approach in Re-Engineering & Indigenisation Process. SOFT concepts. Overview of Aircraft & Engine Certification.

UNIT IV RELIABILITY & MAINTAINABILITY CONCEPTS IN AVIONICS SYSTEMS 9

Reliability Concepts. Failure Rates, Infant Mortality curve, Reliability Definition, Types Reliability with Numerical Concepts of MTBF, MTTF and TBO. Maintainability, Maintenance and Availability concepts, Technical Reviews and Audits, Modeling and Simulation, Metrics, Risk Management Planning

UNIT V QUALITY ASSURANCE PROCESS IN AVIATION 9

Concepts and Definitions of Quality, Quality Gurus, Dimensions of Quality, Total Quality Mgt(TQM) Concepts Quality Philosophies and Concepts: Deming 14 Points; Quality Circles, Zero Defects; 5S concepts, Poka Yoka, Kaizen, Lean philosophy etc. Management tools for Quality, 7 QC tools & Six Sigma Concepts. Standards of Quality Process like ISO 9000, AS 9000, ISO 14000, ISO TS 16949. Quality Measurements like SQC and SPC with numerical, Fish Bone Diagram, Parato Analysis with Case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the different steps involved in the design and development of Avionic systems.

CO2 Apply the aviation standards during the design and development of hardware and software

CO3 Explain the importance of airworthiness certification and differentiate between different certification process

CO4 Explain the importance of system reliability and compare the different methods of expressing reliability and types of maintenance

CO5 Compare and select suitable quality assurance process and management tool for quality assurance.

REFERENCES:

1. IEEE Std 1220-1998, IEEE Standard for Application and Management of the SystemsEngineering Process, 2005.
2. Systems Engineering Fundamentals, Supplementary Text Prepared By Defence Acquisition University Press Fort Belvoir, Virginia 22060-5565, 2001
3. NASA Systems Engineering Handbook, SP-610S, June 1995
4. INCOSE, Systems Engineering Handbook, A “What To” Guide For All SE Practitioners,INCOSE-TP-2003-016-02, Version 2a, 1 June 2004
5. RTCA DO-178B/EUROCAE ED-12B, Software Considerations in Airborne Systems andEquipment Certification, RTCA Inc.,Washington, D.C, 1992.
6. DO-254/EUROCAE ED-80, Design Assurance Guidance For Airborne Electronic Hardware,RTCA Inc.,Washington, D.C, April 19, 2000
7. SAE ARP4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, SAE, Warrendale, PA, 1996.
8. SAE ARP4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Aircraft Airborne Systems and Equipment, Warrendale, PA, 1996.
9. DDPMAS -2020 (Vol 1& 2)
10. Besterfield, D. H, & Besterfield, M.C., et al. (2018). Total Quality Management. 5th Edition, Pearson Publications.
11. Bedi, K. (2010). Quality Management. New Delhi: Oxford Press Publications.
12. Gaither, N. F.(2002). Production & Operations Management. New Delhi: Thomson Learning Publications.
13. Ramakumar R, ‘Engineering Reliability, Fundamental & Applications’, Pearson Publication, 1992.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	1	1	2	3	3	3	2	3
2	3	3	2	2	2	2	3	3	2	3
3	3	3	2	2	2	2	3	3	2	3
4	3	3	2	2	2	3	3	3	2	3
5	3	3	2	3	2	3	3	3	2	3

AO3051 ELEMENTS OF SATELLITE TECHNOLOGY L T P C
3 0 0 3

UNIT I SATELLITE MISSION AND CONFIGURATION 9

Mission Overview – Requirements for different missions – Space Environment, Spacecraft configuration-Spacecraft Bus–Payload–Requirements and constraints– Initial configuration decisions and Trade-offs–Spacecraft configuration process– Subsystem layout–Types of Satellites– Types of Orbits-Applications.

UNIT II POWER SYSTEM 9

Power sources–Energy storage–Solar panels–Deployable solar panels–Spacecraft Power management –Power distribution–Power regulation and control-Deep Space Probes.

UNIT III ATTITUDE AND ORBIT CONTROL SYSTEM 9

Coordinate system –AOCS requirements–Environment effects – Attitude stabilization – Attitude sensors –Actuators–Orbit Control-Design of control algorithms.

UNIT IV PROPULSION SYSTEMS, STRUCTURES AND THERMAL CONTROL 9

Propulsion systems–Thermodynamic- Electrodynamic propellant systems –Design of Spacecraft structure– Structural elements–Material selection–Environmental Loads-guiding factors– Structural fabrication– Thermal control techniques– Active –Passive thermal control techniques-Heat balance equation.

UNIT V TELEMETRY SYSTEMS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Understand the importance of Spacecraft missions and configurations
CO2 Explain Spacecraft power system functions and importance
CO3 Explain spacecraft Attitude and orbital control system design
CO4 Understand satellite propulsion, thermal control and structure subsystems
CO5 Analyse satellite telemetry and telecommand systems

REFERENCES:

1. Space Mission Analysis and Design (Third Edition) by James R.Wertz and Wiley J.Larson – 1999.
2. James R.Wertz "Spacecraft Attitude Determination and Control", Kluwer Academic Publisher, 1988.
3. Marcel J.Sidi "Spacecraft Dynamics and Control", Cambridge University press, 1997.
4. Lecture notes on " Satellite Architecture", ISRO Satellite Centre Bangalore – 560 017

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3					3	3	1		3
2	3	2				3	3	3		3
3	3	2	1			2	3	3		3
4	3	2	1			3	3	3		3
5	3	2	1			2	3	3		3

AV3003 INDIAN DRONE POLICY, RULES AND REGULATIONS L T P C
3 0 0 3

UNIT I DRONE RULES AND REGULATION 9

Importance of Drone Rules and Regulation, - Overview of Drone Rules of Various Countries, - Indian Drone Rules History & Evolution, - Indian Drone Rules 2021, - Amendment on Indian Drone Rules

UNIT II DRONE TRAINING POLICY 9

Introduction to Drone Training, - Need of a Drone Pilot License/Certificate Remote Pilot,- Training Organization, - RPTO Authorization, - RPTO Syllabus, - Training and Procedure Manual, - Train The Trainer Program, - Log Maintenance

UNIT III DRONE CERTIFICATION SCHEME 9

Introduction to Certification Scheme for Unmanned Aircraft Systems, - Governing Structure, - Certification Criteria, - Technical Requirements for UAS, - Quality Standards, - Kinetic Energy Limits For Drones, - Guidelines For Flight Testing, - Certification Process, - Requirements For Certification Bodies, - Rules For Use Of Certification Mark, - Provisional Approval System For Certification Bodies

UNIT IV NATIONAL UTM POLICY 9

Introduction, - UTM Stakeholders, - UTM Architecture, - UTM Services, - UTM Participation, - Real-Time Identification and Tracking, - UTM Data Communication, Security and Privacy, - Integration Of UTM and ATM, - UTM Deployment Plan and Future Actions, - Case Study on UTM Policies of other Nations

UNIT V PRODUCTION LINKED INCENTIVE SCHEME FOR DRONES 9

Introduction and Objective, - Eligibility and Tenure of the Scheme,- Financial Outlay, - Project Management Agency, - Audit, Approval and disbursement of PLI, - Monitoring of the PLI scheme, - Guidelines, - Case Study on Drone PLI Schemes

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the importance of Drone Rules and Regulations
CO2 Explain the Drone Training Methodologies and Regulations
CO3 Develop knowledge on Drone Certification Scheme
CO4 Investigate on National UTM Policy
CO5 Differentiate on PLI Scheme for Drone and related components

REFERENCES:

1. Drone Rules 2021 & Drone Amendment Rules 2022, Ministry of Civil Aviation.
2. Drone Training Circulars 2022 & 2023, Ministry of Civil Aviation.
3. Certification scheme for Drones, 2022, Ministry of Civil Aviation.
4. National UTM Policy Framework, 2021, Ministry of Civil Aviation.
5. PLI scheme for Drones, 2021, Ministry of Civil Aviation.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	1	2	1			3	2	3		3

2	1	2	1	1		2	2	1		2
3	2	1		1	1	3	2	3	1	3
4	1	2	1	2	2	3	2		2	1
5	1	1			3	2	2	3	3	2

AV3004 FLIGHT DYNAMICS L T P C
3 0 0 3

UNIT I STEADY FLIGHT PERFORMANCE 9

Basics of Aerodynamics and ISA - Steady and level flight: thrust and power required/available - Steady Climb and Descent performance: climb angle and rate of climb, descent angle and rate of descent - Fuel Consumption and Endurance - Fuel Consumption and Range.

UNIT II MANEUVER PERFORMANCE 9

Steady Coordinated Turn - maximum producible load factor - Limitations on load factor - fastest and tightest turn - Vertical maneuver: pull-up and pull-down - V-n diagram - Take off and landing distance estimation.

UNIT III LONGITUDINAL STABILITY AND CONTROL 9

Static Equilibrium and Stability - Pitch Stability Analysis for a Wing-Tail Combination - Estimating the Downwash Angle on an aft Tail - Stick-Fixed Neutral Point and Static Margin. Stick free stability - Hinge moment, Free elevator factor, Power effects - propeller and jet aircrafts, longitudinal control, elevator effectiveness, elevator control power, elevator angle to trim, most forward C.G, elevator angle per 'g'.

UNIT IV LATERAL, DIRECTIONAL STABILITY AND TRIM 9

Yaw stability and trim - contribution by wing, fuselage, tail - Directional control, rudder requirements. Lateral stability - Dihedral effect, criteria for lateral stability, evaluation of lateral stability -contribution of fuselage, wing, wing fuselage, tail, total static lateral stability, roll control.

UNIT V AIRCRAFT DYNAMICS 9

Newton's second law for rigid aircraft dynamics - Axes system and transforms - Linearized equations of motion, Estimation of force and moment derivatives, Short period and Phugoid motion, Dutch roll, Roll and Spiral approximations.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Assess the performance of aircraft in steady and level flight and draw the hodographs for steady climb, powerless glide.

CO2 Compute the accelerated performance of an aircraft and also construct the V-n diagram with gust loads.

CO3 Perform preliminary design computations to meet static stability and trim requirements of conventional and unconventional aircraft configurations.

CO4 Evaluate dihedral effect of a given airplane and design the rudder by considering certain critical situations.

CO5 Analyse the longitudinal, lateral-directional modes of motion of an airplane and evaluate the associated stability and control derivatives.

REFERENCES:
1. Anderson,JD, “Aircraft Performance & Design”, First edition, Mc Graw Hill India, 2010.
2. Perkins C.D., &Hage, R.E. "Airplane Performance, Stability and control", 2011, Wiley India.
3. Nelson, R.C. "Flight Stability & Automatic Control", Second edition, 2017, McGraw-Hill.
4. McCormic, B.W., "Aerodynamics, Aeronautics & Flight Mechanics", Second edition, , 1995, John Wiley & Sons.
5. Michael V. Cook. "Flight Dynamics Principles", Second edition, 2007, Elsevier.
6. Pamadi, B.N. "Performance, Stability, Dynamics, and Control of Airplanes", 2004, AIAA Education Series.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	3	1	1	3	3	2	2	1
2	3	2	3	1	1	3	3	2	2	1
3	3	2	3	1	1	3	3	2	2	1
4	3	3	3	1	1	2	3	2	2	1
5	3	3	3	1	1	2	3	2	2	1

AV3005 FAULT TOLERANT CONTROL L T P C
3 0 0 3

UNIT I INTRODUCTION TO FAULT TOLERANCE 9

Principles of fault tolerance – redundancy – quantitative reliability – evaluation – exception handling. Application of fault tolerant systems in aircraft – reliability strategies – software fault tolerance-recovery block – Acceptance – tests – run-time Overheads -Fault Tolerant Processor – Hardware and software

UNIT II ERROR DETECTION AND ERROR RECOVERY 9

Measure for error detection – Mechanisms for error detection – Measures for damage confinement and damage assessment – Protection mechanisms – Protection in multi-level systems. Measures for error recovery – mechanisms for error recovery – check points and audit trials – the recovery cache – Concurrent processes – recovery for competing process – recovery for cooperating process – distributed systems – fault treatment – location and repair.

UNIT III ANALYTICAL REDUNDANCY CONCEPT 9

Additive faults and disturbance-Multiplicative faults and disturbance Residual generation-Detection property-Isolation property-Computational property-Design of Residual generation-Specification and implementation

UNIT IV DESIGN FOR DIRECTIONAL RESIDUAL 9

Parametric faults-Representation of parametric fault-Design for parametric fault and model errors-Robustness in residual generation-Perfect decoupling from disturbance.

UNIT V FAULT DIAGNOSIS 9

Fault diagnosis using Kalman filtering-Fault diagnosis using principle component analysis –Fault diagnosis using ANN and Fuzzy clustering, Case study: Aircraft fault detection.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Understand the importance of fault tolerance principles and procedures

CO2 Explain error detection and error recovery methods

CO3 Explain Analytical redundancy concepts.

CO4 Understand types of faults and detection procedures

CO5 Apply fault diagnosis procedures

REFERENCES:

1. Janos.J.Gertler, "Fault detection and diagnosis in engineering systems", second edition, Marcel Dekker, 1998.
2. Rami S.Mangoubi, "Robust Estimation and Failure detection", Springer-Verlag London, 1998.
3. Anderson and Lee, Fault tolerant principles and practice, Prentice – Hall, 1981
4. John. D. Musa, Anthony Jannino, Kzuhira, Okunito, Software reliability measurement, prediction and application, McGraw – Hill, 1989

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3					2	3	2		3
2	3	2				2	3	3		3
3	3	2	1			3	3	3		3
4	3	2	1			3	3	3		3
5	3	2	1			3	3	3		3

AV3006 REAL TIME EMBEDDED SYSTEM L T P C

3 0 0 3

UNIT I EMBEDDED SYSTEM ARCHITECTURE 9

Real Time System – Embedded Systems –Embedded System Architecture –Components of real time system, History of real time programming, Smart Cards – PIC Microcontrollers – ARM Processor – introduction to SoC - Real time Microcontrollers – Low power embedded systems.

UNIT II CONNECTIVITY 9

OSI Layers, RS232, RS 434, I2C, SPI, CAN, Wireless Connectivity - Bluetooth – WiFi -Protocols – IoT devices– LORON – Space Wires.

UNIT III EMBEDDED/REAL TIME OPERATING SYSTEM 9

Operating System Concepts: Processes, Threads, Interrupts, Events - Real Time Scheduling Algorithms – Task Management, Memory Management- Heap Memory Management – Dynamic Memory allotment, Overview of Operating Systems for Embedded, Kernel –Ubuntu, RT Linux Programming, Vx Works, Free RTOS, ROS and Gazebo.

UNIT IV SOFTWARE DEVELOPMENT FOR EMBEDDED APPLIATIONS 9

Software abstraction using Mealy-Moore FSM controller, Queue -Creation, Resource management priorities and dead line inversion, Synchronization, Coordination through election algorithm, Priority of messages- Introduction to real time system– DSP using ARM processor.

UNIT V CASE STUDIES WITH EMBEDDED CONTROLLER 9

STM32 MCUs, SEGGER debug tool, Programmable interface with A/D & D/A interface, IMU Interfacing, Basic multirotor Stabilization, PWM motor speed controller using timer interrupts, Data Fusion of Range Sensors, Digital servo.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the concepts of typical embedded systems.

CO2 Analyse a suitable choice of embedded processor for a given application.

CO3 Design the hardware and software for the embedded system.

CO4 Develop the real time kernel/operating system functions, task control block structure and analyze different task states.

CO5 Implement different types of inter task communication and synchronization techniques.

REFERENCES:

1. Krishna, C.M., Kang G. Shin, Real Time Systems, Mc-Graw Hill, 1997.
2. Prasad, K.V.K.K. Embedded/Real Time Systems: Concepts, Design and Programming, Dream Tech Press, Black Book, 2005.
3. Barnett, R, Cull, L. O., Cox, S. Embedded C Programming and the Microchip PIC, Thomson Learning, 2008.
4. Buhr, R.J.A, Bailey, D.L. An Introduction to Real-Time Systems, Prentice-Hall International, 1999.
5. David E-Simon, An Embedded Software Primer, Pearson Education, 2007.
6. Donald S. Reay. Digital Signal Processing Using the ARM Cortex M4,1st Edition, John Wiley and Sons Inc, 2016.
7. Douglass, B.P. Real Time UML", 2nd Edition, Addison-Wesley, 2000.
8. Sriram V Iyer, Pankaj Gupta, Embedded Real Time Systems Programming, Tata Mc-Graw Hill, 2004.
9. Wayne Wolf, Computers as Components. Principles of Embedded Computer System Design, Mergen Kaufmann Publisher, 2006.
10. Douglas Wilhelm Harder,Jeff Zaranett,Vajih Montaghami, Allyson Giannikouris , A practical introduction to real-times for Engineering.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2				3	3			3
2	3	2	2			2	3	1		3
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4	3	2	2			2	3	2		3
5	3	3	2			3	3	2		3

AV3007 MISSILE TECHNOLOGY L T P C

3 0 0 3

UNIT I MISSILE SYSTEM 9

Introduction - history - classification - missile system elements, missile ground systems - radars – launchers, coordinate frames – Coordinate transformation, Equations of Motion – basics of trajectory dynamics.

UNIT II AERODYNAMICS 9

Missile aerodynamics- design methodology, aerodynamic prediction method, Drag estination – Aerodynamic loads & performance analysis, wind tunnel and flight testing of missile models and missile prototypes.

UNIT III PROPULSION 9

Principles of jet propulsion and rocketry, nozzle theory and performance parameters of solid rockets and ramjet and compound jet engines – Evaluation of flight performance - forces acting on vehicle - basic relations of motion - multi stage vehicles

UNIT IV NAVIGATION, GUIDANCE & CONTROL 9

Navigation - types - Inertial - GPS - Radar based terrain mapping, Guidance - explicit - PN –APN - beam riding – CLOS – Q Guidance, control – autopilot, and Actuation Systems – hydraulic, pneumatic, electromechanical – RCS.

UNIT V MISSILE TRAJECTORY CALCULATIONS 9

Vertical, inclined and gravity turn trajectories – determination of range and altitude- Two body problem - numerical computation of ballistic trajectories – Rocket dispersion.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Formulate the basic equations governing the rocket motion and compare different types of missiles.

CO2 Compare and select a suitable method of estimating aerodynamic forces and moments acting on the missile

CO3 Compare the different types of rocket propulsion and explain the importance of multi-staging.

CO4 Compare and select a suitable navigation, guidance and control scheme based on the requirements.

CO5 Formulate the expressions related to rocket motion to calculate range and velocity for different conditions.

REFERENCES:

1. Cornelisse,JW, “Rocket Propulsion and Space Dynamics”, J.W. Freeman & Co., Ltd., London, 1982.
2. Siouris, GM, “Missile Guidance and control systems”, Springer, 2004.
3. Chin, S.S. Missile Configuration Design, McGraw Hill, 1961.
4. Frederick White, J. Flight Performance Handbook for Powered Flight Operations, John Wiley & Sons, Inc., 1963.
5. Garnel, Guided Weapon Control Systems, 2nd Edition, Pergamon Press, 1980.
6. Merrill, G. Dictionary of Guided Missiles and Space Craft, D. Van Nostrand and Company, Inc,1959.
7. Paul Zarchan, “Tactical and Strategic Missile Guidance”, AIAA Education series,6th edition, 2013.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3				2	3	2		2
2	3	3				3	3	2		3

3	2		1	1		2	2	2		3
4	3	3		1		3	3	3		3
5	3	3		1		3	3	2		3

AV3008 UAV SYSTEM DESIGN **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO UAV 9

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

UNIT II BASICS OF AIRFRAME 9

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

UNIT III AVIONICS HARDWARE 9

Autopilot –AGL-pressure sensors-servos-accelerometer – gyros-actuators – power supply processor, integration, installation, configuration, and testing

UNIT IV COMMUNICATION PAYLOADS AND CONTROLS 9

Payloads-Telemetry-tracking-Aerial photography-controls-PID feedback-radio control frequency range –SAS- flight director-commands and videos-elements of control loops-flight computer sensor-displays-parameter settings-modems-memory system-simulation-ground test-analysis troubleshooting.

UNIT V PATH PLANNING AND MAV 9

Waypoints navigation-ground control software-Recent trends in UAV-Case Studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Differentiate UAV based on its physical dimension and weight
CO2 Design a suitable airframe according to the application requirements
CO3 Select the proper hardware, payload and communication method for the UAV
CO4 Design an UAV using the skills learned to satisfy the requirements
CO5 Explain the UAV terminologies and different certification standards

REFERENCES:

1. Armand J. Chaput, ―Design of Unmanned Air Vehicle Systems‖, Lockheed Martin Aeronautics Company, 2001
2. Jane‗s- Unmanned Aerial Vehicles and Targets, Jane‗s Information Group; ASIN: 0710612575, 1999.
3. Kimon P. Valavanis, Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy‖, Springer, 2007.
4. Paul G Fahlstrom, Thomas J Gleason, Introduction to UAV Systems‖, UAV Systems, Inc,1998.
5. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.
6. Said, R. and H. Chayeb, Power supply system for UAV‖, KTH, 2002.

7. Skafidas, Microcontroller Systems for a UAV‖, KTH, TRITA-FYS 2002:51 ISSN 0280-316 X. 34, 2002.
8. Swatton, P.J. Ground studies for pilots flight planning, Sixth edition, 2002

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	2	1				3	2	1		
2	3					2	3	3		
3	2					3	2	1		2
4	2					3	2	3		1
5	1		1			2	1			

AV3009 AIRCRAFT MODELING AND SIMULATION FOR AVIONICS ENGINEERS L T P C
3 0 0 3

UNIT I SYSTEM MODELS AND SIMULATION 9

Continuous and discrete systems, System modeling, Static models, Dynamic models, Principles used in modeling the techniques of simulation, Aircraft axis systems - Aircraft Equations of Motion – Longitudinal and Lateral Directional EOM- Kinematic Equations – Dynamic modeling of aircraft, Linearizing the EOM-Equations of longitudinal and lateral directional motion- Aircraft mathematical model- Analytical modeling of aircraft wing loads, Bending moment model

UNIT II PROBABILITY CONCEPTS IN SIMULATION 9

Stochastic Variables, Discrete probability functions, continuous probability function, Measure of Probability functions, Continuous uniformly distributed random number, Congestion in systems, Arrival patterns, various types of distribution, Simulation of Queuing systems

UNIT III SYSTEM SIMULATION 9

Discrete events, Representation of time, Generation of arrival patterns, Simulation Programming tasks, Gathering statistics, Counters and summary statistics, Simulation language. Continuous System models, digital analog simulators, Continuous system simulation language (CSSLs), Hybrid simulation, UAV and MAV simulation, Simulation of an autopilot, INS, autonomous landing systems, Interactive systems, AeroSim and Aerospace Blockset libraries for flight simulation

UNIT IV SYSTEM DYNAMICS AND MATHEMATICAL MODELS FOR FLIGHT SIMULATION 9

Historical background growth and decay models, System dynamics diagrams, Multi – segment models, Representation of time delays, The Dynamo Language Elements of Mathematical models, Equation of motion, Representation of aerodynamics data, Aircraft systems, Structure and cockpit systems, Motion system, Visual system, EXtended Reality (XR), Instructor‘s facilities.

UNIT V FLIGHT SIMULATOR AS A TRAINING DEVICE AND RESEARCH TOOL 9

Introduction, advantage of simulator, the effectiveness of Simulator, The user‘s role, Simulator Certification, Data sources, Validation, in- flight simulators - Interfacing Flight Gear Flight Simulator using AeroSim and Aerospace Blockset

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Develop equations governing the aircraft dynamics and apply the process of linearizing them.

CO2 Explain the probability concepts in simulation and flight simulators.

CO3 Test the guidance and control schemes using simulators

CO4 To compare the different system models, motion and visual systems

CO5 To select a suitable flight simulators and use it as training and research tool

REFERENCES:

1. Brian L. Stevens, Frank L. Lewis, Eric N. Johnson. 'Aircraft Control and Simulation', John Wiley & Sons, 2016.
2. David Allerton. 'Principles of Flight Simulation', John Wiley & Sons, 2009.
3. Gordon. G., System Simulation‖, Prentice – Hall Inc., 1992.
4. Marcello R. Napolitano. 'Aircraft Dynamics', John Wiley & Sons, 2011.
5. Stables, K.J. and Rolfe, J.M. Flight Simulation, Cambridge University Press, 1986.
6. Thomas R. Yechout, Steven L. Morris, David E. Bossert, Wayne F. Hallgren, James K. Hall—Introduction to Aircraft Flight Mechanics, AIAA Education series, 2014.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3			1	3	3	3	1	3
2	3	2			1	2	3	3	1	3
3	3	3			1	3	3	3	1	3
4	3	2			1	2	3	3	1	3
5	3	2			1	3	3	3	1	3

AV3010 LAUNCH VEHICLE DYNAMICS AND CONTROL L T P C

3 0 0 3

UNIT I INTRODUCTION 9

Introduction to Launch Vehicle, Types, operational environment to the vehicle system,Historical background – Coordinate Frame –celestial sphere and Ecliptic,Heliocentric Inertial reference frame, Earth Centered/Geocentric Inertial reference frame, Earth Centered reference frame-Kepler's Law,Newton laws and Newton law of gravitation and Two body problem.

UNIT II AUGMENTATION SYSTEMS 9

Need for automatic flight control systems, Stability augmentation, control augmentation Systems, Gain scheduling concepts, Compensator, Root Locus, Nyquist Plots and Bode plot.

UNIT III COORDINATE SYSTEMS AND EQUATION OF MOTION 9

Coordinate systems, Attitude dynamics and control, Rotational kinematics, Direction cosine matrix, Euler angles, Euler's Eigen axis rotation, Quaternions, Rigid body dynamics of launch vehicle, Angular momentum, Inertia matrix, Principal axes, Derivation of dynamic equations, Effect of aerodynamics.

UNIT IV STABILITY ANALYSIS OF LAUNCH VEHICLE 9

Effect of aerodynamics, structural dynamics and flexibility, propellant sloshing, Actuator dynamics, Gimbaled engine dynamics, External forces and moments, Linear model for Aero-structure-control-slosh interaction studies.

UNIT V MISSILE AND LAUNCH VEHICLE GUIDANCE 9

Homing guidance laws- short range, Medium range and BVR missiles, P Navigation, PN Navigation, Implicit guidance schemes, Explicit guidance, Q guidance schemes, Trajectory design and Flight sequence, Navigation guidance and control aspects.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Ability to understand aircraft equations of motion, linearisation and its dynamics.

CO2 To understand various stability augmentation and its schemes.

CO3 Define the various frame of references and its importance's in launch vehicle and its dynamics.

CO4 Analyse the oscillatory modes, disturbance and its remedial solutions

CO5 Analyse various guidance's laws and its requirements for Launch vehicles

REFERENCES:

1. K. J. Ball, G. F. Osborne, Space vehicle dynamics, Clarendon P., 1967
2. J.H.Blakelock, Automatic control of Aircraft and Missiles, Wiley India,1991.
3. A.L.Greensite, Control Theory Vol. II- Analysis and Design of Space Vehicle Flight Control Systems, Spartan Books, 1970
4. N V Kadam ,Practical design of flight control systems for launch vehicles and Missiles , Allied Publishers Pvt. Ltd., 2009
5. Brian L. Stevens, Frank L. Lewis, Aircraft Control and Simulation, Wiley, 2003
6. A. L. Greensite, Analysis and Design of Space Vehicle Flight Control Systems – Short Period Dynamics, Vol 1, NASA
7. A. L. Greensite, Analysis and Design of Space Vehicle Flight Control Systems, -- Trajectory Equations Vol 2, 1967, NASA
8. Garnel. P. & East. D. J, 'Guided Weapon control systems', Pergamon Press, Oxford, 1977.
9. B.N Suresh & K.Sivan, Integrated design for space transportation system', springer 2015.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3	1		2	3	3	3	2	3
2	3	3	1		2	2	3	3	2	3
3	3	2	1		2	2	3	3	2	3
4	3	2	1		1	3	3	3	1	3
5	3	3	1			3	3	3		3

AV3011 ELECTRONIC WARFARE **L T P C**
3 0 0 3

UNIT I ELECTRONIC WARFARE (EW) PRINCIPLES AND RADAR 9

Electronic Warfare taxonomy – Electromagnetic spectrum – Properties of electromagnetic waves – EW Mission and scenarios – Network centric operations – Basic principles of Radar – Radar Equations - Types – SAR – AESA

UNIT II ELECTRONIC SUPPORT MEASURE (ESM) RECEIVERS – ELECTRONIC COUNTER MEASURES (ECM) 9

Radar Warning Receivers (RWR) – Missile Approach Warning Receivers (MWR) – Passive direction finding and emitter location - Noise jamming – AESA Support Jammer System – Deception Electronic Counter Measures (DECM) – Modern ECM systems.

UNIT III RADAR AND ECM PERFORMANCE ANALYSIS 9

Introduction to stealth technology – Active and Passive stealth – Radar detection performance low RCS aircraft - ECM - Jamming equations - EW receiver sensitivity

UNIT IV EW SIGNAL PROCESSING 9

Signal environment - EM sensor subsystem - The receiver subsystem - The pre-processor the data servo loop - Mile parameter tracking - Advanced pulley power - Managed Jamming.

UNIT V ELECTRONIC COUNTER - COUNTER MEASURES (ECCM) 9

Radar applications in weapon systems - Radar types and characteristics, EW Technology and Future Trends – Directed Energy Weapons – Antenna Technology - ECM transmitter power source technology - EW receiver technology - EW at millimeter Wavelength - Low Observability EW technology.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain and Classify the tasks involved in electronic warfare and types of radar

CO2 Explain the different methods of Electronic Support Measures and Electronic Counter Measures

CO3 Develop jamming equations for analysing of Radar and ECM performance

CO4 Compare and select a suitable method of signal processing based on the information requirements

CO5 Compare the different methods of ECCM

REFERENCES:

1. Curtis Schleher. D. — 'Introduction to Electronic Warfare', Artech House Inc., U.S.A., 1986
2. Mario De Archnaelis, —Electronic War from Battle of Osushima to the Falklands and Lebanon Conflicts, Ritana Books, New Delhi, 1990.
3. Sen, A.K. Bhattacharya, A.B. —Radar Systems & Radar Aids to Navigation, Khanna Publishers,1988
4. David L. Adamy, 'EW101: A First Course in Electronic Warfare', Artech House Publishers, 2001.
5. David L. Adamy, 'EW 102: A Second Course in Electronic Warfare', Artech House Publishers, 2004.

6. David L. Adamy, 'EW 103: Communications Electronic Warfare', Artech House Publishers, 2001.
7. David L. Adamy, 'EW 104: Electronic Warfare Against a New Generation of Threats', Artech House Publishers, 2015.
8. David L. Adamy, 'Introduction to Electronic Warfare Modeling and Simulation', Artech House Publishers, 2002.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	1	1	1		3	3	1		3
2	3	1				3	3	1		3
3	3	3				3	3	3		3
4	3	2				2	3	2		3
5	3	2	2			2	3	2		3

AV3012 SPACECRAFT COMMUNICATION SYSTEMS **L T P C**
3 0 0 3

UNIT I ELEMENTS OF SATELLITE COMMUNICATIONS 9

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.

UNIT II TRANSMISSION, MULTIPLEXING, MULTIPLE ACCESS AND CODING 9

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

UNIT III SATELLITE LINK DESIGN 9

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

UNIT IV SATELLITE TELEMETRY, TRACKING AND TELECOMMAND 9

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.

UNIT V APPLICATIONS 9

VSAT-VSAT Technologies, Networks MSS-AMSS, MMSS

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Understand the importance satellite communication system and its parameters
CO2 Explain about various types of Multiple access techniques
CO3 Explain about importance of Link budget in SATCOM
CO4 Explain the procedures of telemetry, tracking and telecommand systems
CO5 Apply SATCOM procedures in real applications

REFERENCES:
1. Wilbur L. Pritchard and Joseph A.Sciulli, Satellite Communication Systems Engineering, Prentice Hall, New Jersey, 1986.
2. Timothy Pratt and Charles W.Bostain, Satellite Communications, John Wiley and Sons, 1986.
3. Tri T Ha, Digital Satellite Communication, Macmillan Publishing Company, 1986.
4. Kadish, Jules E, Satellite Communications Fundamentals, Artech House, Boston 2000
5. Lida,Takashi ed.,Satellite communications:System and its design technology, Ohmsha Tokyo 2000 6.
6. Maral, Gerard,Satellite communications systems: Systems, techniques and technology, John Wiley, Newyork 2002.
7. Elbert, Bruce R, Satellite communication applications handbook, Artech house Boston 2004.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3					2	3	2		3
2	3	2				2	3	3		3
3	3	2	1			3	3	3		3
4	3	2	1			3	3	3		3
5	3	2	1			3	3	3		3

AV3013 GEOSPATIAL DRONE DATA PROCESSING L T P C
3 0 0 3

UNIT I REMOTE SENSING TECHNOLOGY 9

Principles of Observation, Remote Sensing Types & Resolution, Earth Observation sensors, Spectral Signature, Image/Video Interpretation, Definition of GIS, Application of GIS and Remote Sensing.

UNIT II DRONE SURVEY AND MAPPING 9

Principles of Data acquisition, Comparison of Tradition survey with Advanced Survey Techniques, Challenges in Data Capturing, Data Capturing Methodology, DGPS – GCP Importance, GCS Overviews, Flight Plan, Auto Mission, Advantages and limitation of Drones in Mapping.

UNIT III GEOSPATIAL DATA BASE CREATION 9

Introduction to Photogrammetry, Challenges in Drone Photogrammetry, Drone Data Processing Methodology, Cluster computing Process, Data Products Generation - Point Cloud, - DSM, - DEM, - DTM, - Orthomosaic, Secondary Product Generation.

UNIT IV GEOSPATIAL DATA ANALYSIS 9

Introduction of Analysis Software, Input spatial data into GIS, Conversion of Data, Accuracy Assessment, Analysis of 2D and 3D Data Products, Importance of Data Analysis, Data Management, Case Study on Drone Data Analysis, WebGIS.

UNIT V CASE STUDIES 9

Drones in Disaster, Agriculture, Mining, Urban Planning, Construction and Infrastructure, Environmental Mapping, Archaeological, Rehabilitation and reconstruction - Drones in Future Mapping Applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the Remote Sensing Technology.

CO2 Execute Drone flight plan, data capturing and its challenges

CO3 Explain the Advanced Drone data processing

CO4 Describe the Drone Data Interpretation

CO5 Develop Drone based Applications and Impacts

REFERENCES:

1. Lillesand, T.M. and Kiefer, R.W.,"Remote sensing and Image Interpretation", John Wiley, 1987.
2. Frazier, A., & Singh, K. (Eds.) "Fundamentals of Capturing and Processing Drone Imagery and Data (1st ed.)", CRC Press, 2021.
3. Daniel Tal, John Altschuld "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", John Wiley & Sons, Inc, 2021
4. "Drone Technology: Future Trends and Practical Applications", Scrivener Publishing LLC, 2023
5. Jean Doumit, "From drones to geospatial analysis", Scientific edition polygraph Center Kuban State University, 2018.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	1		2			3	1	1		1
2	1		1		1	3	2	2	1	
3	1		1			2	1	1		2
4	1	1				2	2	2		2
5	1	1	2			3	1	2		1

AV3014 DIGITAL FLY BY WIRE CONTROL L T P C

3 0 0 3

UNIT I INTRODUCTION TO FLY-BY-WIRE CONTROL 9

Advanced Control concepts - Need for FBW systems – FBW Flight Control Features and Advantages - Evolution of FBW – Evolution – Development - Historical perspectives in design Programs-Douglas Long Beach Programs, WPAFB B 47 In House Program, LTV IAP, Sperry Phoenix Programs, CAS and SAS,

UNIT II ELEMENTS OF DFBW CONTROL 9

Description of various elements of DFBW systems – Control Laws - Design – Airdata Gain scheduling - Handling Qualities – PIOs – Digital implementation of FBW - Advantages of Digital Implementation - Digital Data Problems – Software - Failure Modes and Effects Analysis

UNIT III DFBW ARCHITECTURES 9

Need for redundant architecture, discussion on triplex vs. quadruplex architecture for DFBW system, Concept of redundancy and failure survival capabilities – Common mode failures - Fault coverage and redundant architecture. - Concept of cross-strapping, Actuator command voting and servo force voting etc.

UNIT IV REQUIREMENTS FOR DFBW SYSTEM DESIGN 9

Survivable Flight control System programs, ADP Phases-Simplex package Evaluation -FBW without Mechanical Backup-Survivable Stabilator Actuator package, Reliability requirements and their relevance to DFBW system design, redundant power supply requirements, Environmental and weight, volume constraints, Built-in-test features, Software development, Redundancy management, Issues of digital control laws

UNIT V RECENT TRENDS IN DFBW 9

Thrust Vectoring - Fly-By-Light – Control Configured Vehicle (CCV) and Active Control Technology (ACT) concepts – MIL-F 9490-D Guidelines - Helicopter FBW Flight Control Systems - Testing and Case Studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1 Explain the basic concepts of Fly-by-wire and provide the necessary mathematical knowledge that are needed in understanding modern aircraft control strategies.

CO2 Design the control law for lateral and longitudinal axis with the necessary mathematical knowledge that are needed in creating modern aircraft control strategies.

CO3 Explain on various topics such as evolution of FBW, Elements, architecture, design and design issues of DFBW.

CO4 Deploy these skills effectively in the analysis and understanding of Survivable Control System

CO5 Explain the advanced concepts of Digital Fly-by-wire and the recent trends

REFERENCES:

1. Vernon R. Schmitt, James W Morris and Gavin D Jenny, Fly By Wire- A Historical Perspective‖, SAE International, 1998.
2. Collinson R.P.G, 'Introduction to Avionics Systems', Springer Publisher, 3rd Edition 2011.
3. Gibson, J.G. Handling qualities and the fly-by-wire airplane. Proceedings of the AGARD flight mechanics symposium o stability and control AGARD CP-260, 1978.
4. McRuer, Duane T, Donald E.J and Thomas T.M. A Perspective on Super augmented Flight control: Advantages and Problems, Active Control Systems - Review, Evaluations and Projections, AGARD-CP-384, 1985.
5. Mooij, H.A- Flight experience with an experimental electrical pitch-rate-command/attitude hold flight control system, AGARD-CP-137, Advances in Control systems, 1974.
6. Peter. G. Hamel. In Flight Simulators and Fly-by-Wire/ Light demonstrators, Springer, 2017.

COs	POs						PSOs			
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2	3	3	3		2	3	3	3		3

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AV3015 IMAGE ANALYSIS AND MACHINE VISION FOR AEROSPACE APPLICATIONS

L T P C
3 0 0 3

UNIT I FUNDAMENTALS OF IMAGE PROCESSING 9

Introduction – Elements of visual perception, Steps in Image Processing Systems – Image Acquisition – Sampling and Quantization – Pixel Relationships – Colour Fundamentals and Models, Image File Formats - Geometric Spatial Transformations, Introduction to the Mathematical tools – Image Acquisition-Imaging Sensors

UNIT II IMAGE SEGMENTATION AND FEATURE ANALYSIS 9

Detection of Discontinuities – Edge Operators – Edge Linking and Boundary Detection – Thresholding – Region Based Segmentation – Color Image Segmentation, Motion Segmentation, Feature Analysis and Extraction, Template Matching methods

UNIT III MULTI RESOLUTION ANALYSIS 9

Multi Resolution Analysis: Image Pyramids – Multi resolution expansion – Wavelet Transforms, Fast Wavelet transforms, Wavelet Packets.

UNIT IV AI IN MACHINE VISION 9

Object Identification -Decision-Making Methods - Statistical Classification and Neural Networking-Image Analysis- Pattern Recognition- Applications to robotics; intelligent interaction of machines with their environment.

UNIT V AEROSPACE APPLICATIONS 9

Image Recognition - Image Classification – Content-based image retrieval- Image Fusion – Image Analysis–Colour Image Processing - Vision based navigation algorithms–Computer Vision Algorithms for Unmanned Aerial Vehicles- Object detection – Tracking, Visual motion analysis – Optical Flow.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the mathematics behind image processing, point operations and colour image enhancement and restoration.
CO2 Perform image processing using Feature Analysis, Feature Extraction and Template Matching methods.
CO3 Perform Image enhancement, Wavelet transforms, multi-resolution analysis
CO4 Perform Object detection, Pattern Recognition and application of AI in Machine Vision
CO5 Deploy these skills effectively in vision based navigation and control.

REFERENCES:

1. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Third Edition, Pearson Education, 2008.

2. Anil K. Jain, Fundamentals of Digital Image Processing, Prentice-Hall India, 2007
3. Rafael C. Gonzalez, Richard E. Woods and Steven L. Eddins, Digital Image Processing Using MATLAB, First Edition, Pearson Education, 2004.
4. Alexander Hornberg, Handbook of Machine Vision, First Edition, 2006
5. Madhuri A. Joshi, Digital Image Processing: An Algorithmic Approach, Prentice-Hall India, 2006. .
6. Ron Graham, Alexander Koh, Digital Aerial Survey: Theory and Practice, Whittles Publishing; First edition, 2002.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3		2		3	3	3		3
2	3	3		2		2	3	3		3
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5	3	3		2		2	3	3	2	3

AO3016 SPACECRAFT ATTITUDE AND CONTROL L T P C
3 0 0 3

UNIT I ATTITUDE SENSORS 9
Relative Attitude sensors – Gyroscopes, Motion reference Units, Absolute Attitude sensors – Horizon sensor, Orbital Gyrocompass, Earth sensors, sun sensors –types-, star sensor, Magnetometer

UNIT II CONTROL ACTUATORS 9
Thrusters, Momentum Wheel, Control Moment Gyros, Reaction wheel, Magnetic Torquers, Reaction Jets, Ion Propulsion, Electric propulsion, solar sails

UNIT III ATTITUDE DYNAMICS , ATTITUDE AND ORBITAL DISTURBANCES 9
Rigid Body Dynamics, Flexible body Dynamics, Slosh Dynamics, Drag, Solar radiation Pressure, Disturbances due to Celestial bodies

UNIT IV ATTITUDE STABILIZATION SCHEMES & ORBIT MANEUVERS 9
Spin, Dual spin, Gravity gradient, Zero momentum system, Momentum Biased system, Reaction control system, Single and Multiple Impulse orbit Adjustment, Hohmann Transfer, Station Keeping and fuel Budgeting

UNIT V LAUNCH VEHICLE GUIDANCE 9
Operating principles and design of guidance laws, homing guidance laws- short range, Medium range and BVR missiles, Launch Vehicle- Introduction, Mission requirements, Implicit guidance schemes, Explicit guidance, Q guidance schemes

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, Students will be able to
CO1 Understand the importance of Spacecraft sensors
CO2 Explain Spacecraft Actuator principles and operations

CO3 Explain RBD theory
CO4 Understand stabilisation techniques and orbit transfer
CO5 Design LV guidance laws

REFERENCES:

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

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3					3	3	2		3
2	3	2				3	3	3		3
3	3	2	1			2	3	3		3
4	3	2	1			2	3	3		3
5	3	2	1			3	3	3		3

AV3016 DRONES FOR DISASTER MANAGEMENT L T P C
3 0 0 3

UNIT I DRONES IN DISASTER MANAGEMENT 9

Brief History of UAVs in DM, Importance of UAV in DM, Framework for Disaster Risk reduction, Overview of Disaster Phases, Usage of UAS in India for DM, Exemption required from Drone Rules for DM applications.

UNIT II DISASTER CATEGORIES VS UAVS AND PAYLOADS/SENSOR 9

Types of Disaster, List of UAVs and Payloads for DM, Payload Selection, Terrain Based Drones Selection , Limitations for drone flying, Limitation in Techniques/ Technology.

UNIT III USES OF DRONES IN DIFFERENT PHASES FOR DM 9

Drones in Pre –Disaster, During Disaster, Post- Disaster, SOP for Operation of Drone in DM, BVLOS Operations, UTM Services, Case Studies on Various Real-time disaster applications

UNIT IV DISASTER RESPONSE OPERATIONS 9

Sudden & Expected events, Site Assessment, Preparation Plan, Search & Rescue Operations, Building Partnerships, Identifying the Stake holders, Roles and Responsibility of Stake Holders and Partners, Preparing for Disaster Response Operations

UNIT V CURRENT UAS TECHNOLOGICAL TRENDS IN DM 9

Swarm UAVs, Live Mapping for Disaster Rescue, UAV with AI & ML Technology, Drone Taxi, Aerial Cargo UAV, Collaboration of UAV and UGV, Integration of 5G, Wireless communications, Powering of Drone

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the importance of Drone in DM.

CO2 Explain the Various type of drones, Payloads, Disaster Phases.

CO3 Get knowledge on Procedure to Operate Drones in DM.

CO4 Learn to Assist in a disaster with drones.

CO5 Develop New things in DM using drones.

REFERENCES:

1. Mihoko Sakurai, Rajib Shaw, “Emerging Technologies for Disaster Resilience”, Springer, 2021
2. Bart Custers, “The Future of Drone Use”, Springer, 2016
3. Christopher J. Schloe, “Drones - UAS for Emergency Response Services”, 2017
4. Zhi Liu, Kaoru Ota, “Smart Technologies for Emergency Response and Disaster Management”, IGI Global, 2017
5. Dr. R. K. Dave, “Disaster Management in India: Challenges and Strategies”, Prowess Publishing, 2018

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	1	1	1	2	2	3	1		2	
2	2	2	2			3	2			
3			2			2	2	2		
4			1	1		3	2			3
5	3	1	2			2	3	3		2

AV3017 ACTIVE CONTROL TECHNOLOGY L T P C

3 0 0 3

UNIT I ACTIVE CONTROL FUNCTIONS 9

Introduction-active control technology concepts-control configured vehicle-Design Philosophy, Aerodynamics: Relaxed static stability, Automatic Configuration management, side force control. Structures, Manoeuvre load control, Gust load alleviation, Ride smoothing, fatigue alleviation, Flutter-mode control, Propulsion and Flight Control Integration Technology (PROFIT)

UNIT II ACTIVE CONTROL DESIGN CONSIDERATIONS 9

Stability augmentation, Command augmentation, Control of aircraft center of gravity, Elastic mode stabilization, and Gust load control, Reliability, redundancy

UNIT III FLY-BY-WIRE TECHNOLOGY 9

Fly-By-Wire concepts. Primary and secondary electrical flight control system, Redundancy and architecture trade studies - analog and digital FBW Systems - Typical fly-by-wire flight control system elements - Application of fly-by-wire technology to civil and military aircraft.

UNIT IV FLYING QUALITIES 9

Definition, Cooper - Harper rating scale - flying qualities requirements - Relaxed static stability flying qualities requirements - Lower order equivalent systems criteria Neal - Smith criteria.

UNIT V CONTROL MODES OF COMBAT AIRCRAFT 9

Pitch rate Command - Attitude hold system - Carefree maneuvering - spin-stall prevention and similar limiting concepts - Combat
maneuvers.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Understand the importance of Active control technology

CO2 Explain ACT design procedures

CO3 Explain the importance of Fly by wire techniques

CO4 Understand the handling qualities of fighter crafts

CO5 Explain various control modes of fighter crafts

REFERENCES:

1. AGARD-AG-234, ‘Active controls aircraft Design’, 1978.
2. AGARD-CP-157, ‘Impact of active control technology in aircraft design’, 1975.
3. AGARD-CP-260, ‘Stability and control’, 1978.
4. AGARD-CP-137, ‘Advance in Control systems’, 1974.
5. AGARD-CP-228, ‘Structural aspects of active Controls’, 1977.
6. AGARD-IS-89, ‘Task oriented flight control Systems’, 1977.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3					3	3	2		3
2	3	2				3	3	3		3
3	3	2	1			2	3	3		3
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5	3	2	1			3	3	3		3

AV3018 THEORY OF DETECTION AND ESTIMATION OF DIGITAL SIGNALS L T P C

3 0 0 3

UNIT I REVEIW OF PROBABILITY AND STOCHASTIC PROCESS 9

Conditional Probability, Bayes' Theorem, Random Variables, Conditional Distributions and Densities, moments and distribution of random variables., Stationary Processes Cyclostationary Processes Averages and Ergodicity Autocorrelation Function Power Spectral Density Discrete-Time Stochastic Processes, Spatial Stochastic Processes Random Signals, Relationship of Power Spectral Density and Autocorrelation Function.

UNIT II SINGLE AND MULTIPLE SAMPLE DETECTION 9

Hypothesis Testing and the MAP Criterion, Bayes Criterion, Minimax Criterion, Neyman-Pearson Criterion, Sequential Detection, The Optimum Digital Detector in Additive Gaussian Noise, Performance of Binary Receivers in AWGN.

UNIT III FUNDAMENTALS OF ESTIMATION THEORY 9

Formulation of the General Parameter Estimation Problem, Relationship between Detection and Estimation Theory, Types of Estimation Problems, Properties of Estimators, Bayes Estimation, Minimax Estimation, Maximum-Likelihood Estimation, Comparison of Estimators of Parameters.

UNIT IV WIENER AND KALMAN FILTERS 9

Orthogonality Principle, Autoregressive Techniques, Discrete Wiener Filter, Continuous Wiener Filter, Generalization of Discrete and Continuous Filter Representations, Linear Least-Squares Methods, Minimum-Variance Weighted Least-Squares Methods, Minimum-Variance, Least Squares, Kalman Algorithm - Computational Considerations, Signal Estimation, Continuous Kalman Filter, Extended Kalman Filter.

UNIT V APPLICATIONS 9

Detector Structures in Non-Gaussian Noise, Examples of Noise Models, Receiver Structures, and Error-Rate Performance, Estimation of Non-Gaussian Noise Parameters Fading Multipath Channel Models, Receiver Structures with Known Channel Parameters, Receiver Structures without Knowledge of Phase, Receiver Structures without Knowledge of Amplitude or Phase, Receiver Structures and Performance with No Channel Knowledge.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the concepts of detection, estimation and various types of detection theory
CO2 Apply the theory behind various estimation techniques.
CO3 Analyse detection and estimation theory to solve communication problems.
CO4 Apply probability and stochastic process concepts in detection and estimation.
CO5 Design Wiener and Kalman filters to solve problems in estimation process.

REFERENCES:

1. Thomas Schonhoff, "Detection and Estimation Theory", Prentice Hall, NewJersy,2007.
2. Steven M. Kay, "Fundamentals of Statistical Processing, Volume I: Estimation Theory", Prentice Hall Signal Processing Series, Prentice Hall, PTR, NewJersy, 1993.
3. Harry L. Van Trees, "Detection, Estimation and Modulation Theory", Part I John Wiley and Sons, New York, 2001.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3					3	3	2		3
2	3	2				2	3	3		3
3	3	2	1			3	3	3		3
4	3	2	1			2	3	3		3
5	3	2	1			3	3	3		3

AV3019 MISSILE GUIDANCE AND CONTROL **L T P C**
3 0 0 3

UNIT I MISSILE SYSTEMS INTRODUCTION 9

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

UNIT II MISSILE AIRFRAMES, AUTOPILOTS AND CONTROL 9

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

UNIT III MISSILE GUIDANCE LAWS 9

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

UNIT IV STRATEGIC MISSILES 9

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

UNIT V WEAPON DELIVERY SYSTEMS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Develop a generalized missile equations of motion and identify different components of a missile.

CO2 Design a suitable control law by estimating the aerodynamic forces and moments for the given configuration.

CO3 Compare different missile guidance laws and select a suitable law based on the type of threat.

CO4 Compare strategic and conventional missiles and explain the concepts of ballistic and cruise missiles.

CO5 Compare and select a suitable method of weapon delivery based on the requirements.

REFERENCES:

1. Blakelock, JH, "Automatic Control of Aircraft and Missiles", 2nd edition, John Wiley & Sons, 1991.
2. Siouris, GM, "Missile Guidance and control systems", Springer, 2004.

3. Fleeman, Eugene L, “Tactical Missile Design”, 2nd edition, AIAA Education series, 2006.
4. Garnell, P, “Guided Weapon Control Systems”, 2nd Edition, Pergamon Press, 1980.
5. Joseph Ben Asher and Isaac Yaesh, “Advances in Missile Guidance Theory” AIAA Education series, 1998.
6. Paul Zarchan, “Tactical and Strategic Missile Guidance”, AIAA Education series,6th edition, 2013.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2				3	3	2		3
2	3	3				2	3	3		3
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4	3	2				3	3	2		3
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AV3020 DRONES FOR CIVIL AND MILITARY APPLICATIONS L T P C
3 0 0 3

UNIT I TYPES OF DRONES IN CIVIL APPLICATIONS 9
Brief History of UAVs in civil domain, - Importance of UAV in civil applications, - Rotary wing, - fixed wing, - hybrid UAVs.

UNIT II TYPES OF DRONES IN MILITARY APPLICATIONS 9
Drones used by Indian Agencies, - Types of Drones Used, - Classifications, - Target decoys, - Combat missions, - High altitude surveillance UAVs.

UNIT III PAYLOADS AND GCS 9
Payload Selection, - LWIR, - MWIR, - SWIR, - LRF, - Lidar, - Drones in Pre- and post-assessment, - GCS , - RVT, - Command and control stations , - Telemetry.

UNIT IV OPERATIONS CASE STUDY 9
- UAVs Real-Time action, - kamikaze operations, - counter drone Operations, - Drone attack.

UNIT V CURRENT UAS TECHNOLOGICAL TRENDS IN MILITARY 9
Swarm UAVs, - UAV with AI & ML Technology, - Logistics Drone, - Aerial Cargo UAV, - Collaboration of UAV and UGV, - Hermes-450, - Baykar Bayraktar TB2, - TAI Anka, - General Atomics MQ-9 Reaper, - Rustom - Tactical Airborne Platform for Aerial Surveillance.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, Students will be able to
CO1 Develop knowledge on the importance of Drone.
CO2 Differentiate Various type of drones, Payloads, Military missions.
CO3 Get knowledge to Execute Operations of Drone in civil and military applications.
CO4 Learn how to Assist in a post-strike with drones.
CO5 Learn to implement IOT.

REFERENCES:
1. Paul G. Fahlstrom, Thomas J. Gleason, “Introduction to UAV Systems”, Springer, 2012
2. Daniel R. Faust · 2015, Military Drones.

3. Paul J. Springer · 2013, Military Robots and Drones
4. Drone Warfare: Killing by Remote Control Medea Benjamin,2021

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	1		1			3	1			2
2	1	1	1			3	2			
3						3	1	1		2
4					1	2	1	2	1	3
5	1	2	1			2	2	2		

AO3055 ELECTRIC PROPULSION SYSTEMS L T P C
3 0 0 3

UNIT I PHYSICS OF IONIZED GAS 9

Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas Electrical conductivity of an ionized gas - Kinetic Theory – Application of ionized gas flows.
Particle collision in ionized gas-Electron Atom collision, Electron ion collision, Electron –Electron and ion-Ion collision, Atom-Atom collision and ion atom collision.

UNIT II BASIC PHYSICS OF ELECTRIC PROPULSION 9

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

UNIT III ELECTRO-THERMAL ACCELERATION 8

One dimensional model - Enthalpy of high temperature gases - Frozen flow efficiency – Resisto jets - Electrical discharges – Arc jets - Operation and Analysis - Materials - advantages and Disadvantages.

UNIT IV ELECTROSTATIC ACCELERATION 8

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

UNIT V ELECTROMAGNETIC ACCELERATION 11

The Lorentz force – Magneto gas dynamic channel flow - Ideal steady flow acceleration - Thermal and viscous losses - Geometry considerations - Self-induced fields - Sources of the conducting gas - The magneto plasma dynamic arc - Magneto- plasma dynamic (MPD) thrusters - Pulsed plasma acceleration - Pulsed plasma thrusters (PPT) - Quasi steady acceleration - Pulsed inductive acceleration - Travelling wave acceleration, Circuit analysis of pulsed acceleration, coaxial guns and pulsed acceleration.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be

CO1 Able to classify and describe the electric thrusters for space applications.

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

REFERENCES:

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

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
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2	2		2		2	3	3		3	
3	2	3	1		2	3	3		3	
4	1	3				2	3	1	3	
5	1	3		2	2	2	3	1	3	

AO3052 MISSILE AND LAUNCH VEHICLE AERODYNAMICS L T P C
3 0 0 3

UNIT I BASICS OF HIGH SPEED AERODYNAMICS 9
Compressible flows-Isentropic relations-mathematical relations of flow properties across shock and expansion waves-fundamentals of Hypersonic Aerodynamics

UNIT II LAUNCH VEHICLE CONFIGURATIONS AND DRAG ESTIMATION 9
Types of Rockets and missiles-various configurations-components-forces on the vehicle during atmospheric flight-nose cone design and drag estimation

UNIT III BASICS ASPECTS OF MISSILE AERODYNAMICS 9
Classification of missiles-Aerodynamics characteristics and requirements of air to air missiles, air to surface missiles and surface to air missiles-Missile trajectories

UNIT IV AERODYNAMICS OF SLENDER AND BLUNT BODIES 9
Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles- determination of aeroelastic effects.

UNIT V STABILITY AND CONTROL OF MISSILES 9
Forces and moments acting on missiles-Lateral, rolling and longitudinal moments-missile dispersion-stability aspects of missile configuration-Aerodynamic control methods-Jet control methods-Stability derivatives.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able
CO1 To apply the concepts of high speed aerodynamics on missiles and launch vehicles

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

REFERENCES:

1. Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., New York 1999.
2. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 1985.
3. Anderson, J.D., "Hypersonic and High Temperature Gas Dynamics", AIAA Education Series.
4. Charles D.Brown, "Spacecraft Mission Design", AIAA Education Series, Published by AIAA, 1998
5. Chin SS, Missile Configuration Design, Mc Graw Hill, New York, 1961.
6. Elements of Space Technology for Aerospace Engineers", Meyer Rudolph X, Academic Press, 1999
7. Nielson, Jack N, Stever, Gutford, "Missile Aerodynamics", Mc Graw Hill, New York, 1960.

COs	POs						PSOs			
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3	2	2			2	3	3			
4	3	3	1		1	2	3	2	2	1
5	3	3	1	2		3	3	2	2	1

AV3021 THRUST VECTOR CONTROL TECHNOLOGY **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9

Nozzle flow-ideal and real nozzle-losses due to two phase flow, types of nozzle, fixed nozzle, movable nozzle, submerged nozzle, extendible nozzle, blast-tube mounted nozzle, unconventional nozzle, expansion deflection nozzle, aero-spike nozzle, dual bell nozzle, shock-cell structures under-expansion, over-expansion, Nozzle thrust ,Thrust vectoring, application, methods of thrust vectoring, 2-D, 3-D thrust vectoring.

UNIT II GIMBALED EENGINES AND NOZZLES 9

Gimbaled engine(s) or nozzle(s)- Thrust vectoring in liquid propellant engine, , Moving of combustion chamber, moving of the entire engines, solid propellant engine-Nozzle deflection. Instrumentations for the gimbaled engines thrust vectoring.

UNIT III REACTIVE FLUID INGECTION 9

Reactive fluid injection-Injection system-Components –working principle, Combustion of the injected fluid with exhaust-Thrust production-exhaust plume modification-Net force calculation, Instrumentations for Reactive fluid injection-Injection thrust vectoring.

UNIT IV AUXILIARY VERNIER THRUSTERS 9

Auxiliary Vernier thrusters- Components-Working principle-attitude control system, reaction control system-Components-working principle, Instrumentations for Auxiliary thrust vectoring.

UNIT V JET VANES 9

Exhaust vanes, also known as jet vanes-jet tabs, actuators, Jet control –vortex generators – resultant thrust-Auxiliary thrust control-Cant nozzle, Instrumentations for thrust vectoring by jet-vanes.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able

CO1 Have an Idea about thrust vector control techniques used in rockets and missiles
CO2 Be able to modify the existing methods to control the thrust in an efficient manner.
CO3 Have an ability to solve numerical problems associated with the direction of resultant thrust
CO4 Be capable of arriving at new methods to control the nozzle thrust
CO5 Have knowledge on developing numerical codes for practical engineering thrust control problems in rockets and missiles.

REFERENCES:

1. Sutton,GP "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2016.
2. Ramamurthi,K, "Rocket Propulsion", Laxmi Publications Private Limited, 1st edition, 2016.
3. B. H. Prescott and M. Macocha, "Nozzle Design," pp. 177-186 in Chapter 6 of G. E. Jensen and D. W. Netzer (Eds.), Tactical Missile Propulsion, Vol. 170 in Progress in Astronautics and Aeronautics, American Institute of Aeronautics and Astronautics, 1996.
4. J. H. Blakelock, Automatic Control of Aircraft and Missiles, 2nd ed., John Wiley & Sons, New York, 1991, 656 pages.
5. S. R. Wassom, L. C. Faupel, and T. Perley, "Integrated Aerofin/Thrust Vector Control for Tactical Missiles," Journal of Propulsion and Power, Vol. 7, No. 3, May-June 1991, pp. 374-381.

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