Syllabi for
M.Tech in
Defence Technology
& Guidelines

2021 – 22

Directorate of Futuristic Technology Management (DFTM)
Government of India, Ministry of Defence
Defence Research & Development Organisation (DRDO)
New Delhi

In Collaboration with
All India Council for Technical Education (AICTE)
New Delhi

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M. Tech. (Defence Technology)

1. Introduction

DRDO has been pursuing basic and applied research in collaboration with academia, since last six decades. DRDO has been funding the research projects through various mechanisms to engage academia under its Grant-in-Aid scheme. In last five years, DRDO has given impetus to create Research Eco-system for Directed Research by establishing the Centres of Excellence within premier institutes and universities. DRDO is continuously taking efforts towards expanding the research base by engaging faculties, researchers, scientists, start-ups and industries for developing targeted emerging and futuristic technologies to accelerate the technological self-reliance in defence and security of the nation. DRDO has collaborated with AICTE for conducting the Regular M.Tech Course in Defence Technologies having 6 specialized streams and B.Tech (Elective Courses) in collaboration with All India Council for Technical Education (AICTE). The M.Tech. courses would infuse interest in students and motivate them to pursue their career in research and development for defence and security to join defence, PSUs and private defence industries.

2. Need for M.Tech. (Defence Technology)

DRDO has established very good connect with faculties and researchers of academia through research projects. So far the engineering education in the country do not have M.Tech courses, adapted to impart knowledge related to defence and security applications. Defence Institute of Advanced Technology (DIAT) Pune, CME Pune and select institutes and industries have been mainly providing required specialized knowledge related to defence and s ecurity to the students and armed forces personnel.

The M.Tech. in defence technology courses has been designed to produce Post Graduates who will have the necessary theoretical & experimental knowledge, skill and aptitude in various defence technologies areas and pursue them to carry out R&D in defence. The students will be provided valuable exposure & knowledge for various state of the art defence systems and contemporary technologies through class lectures & main thesis work. During the program, the students would be given valuable exposure by carrying out their main thesis work in DRDO labs, Defence PSUs & Private Defence Industries. This collaborative effort of DRDO, AICTE and Industries will provide required knowledge to the students and create job opportunities for them. The academic-industry trained workforce will immensely contribute in realizing GOI vision of Atmanirbhar Bharat.

3. Program Objectives

1. To develop Post Graduates who have the necessary theoretical & experimental knowledge, skill and aptitude in defence technologies and systems and can get recruited in the various defence laboratories, defence public sector & private industries, ordnance factories and other similar sectors of the economy at national and international level.
2. To contrive skilled manpower in the field of defence technologies.
3. To enhance students' interaction with the senior, experienced manpower engaged in defence labs and defence industries and have real time knowledge / experience in the technology development, technology deployment and defence systems.
4. To acquaint students for the needs of technologies related to defence & security of nation and to create zeal among students to pursue research and development for defence technologies.

4. Program Outcomes

S. No.	Program Outcome	Attributes
PO-01	Acquire technical competence, comprehensive knowledge and understanding the methodologies and technologies associated with land, air & naval defence systems. Apply knowledge to identify, formulate and analyse complex engineering problems.	Scholarship of Knowledge
PO-02	Having an ability to apply knowledge of science, mathematics, engineering & technology for development of defence technologies.	Critical Thinking
PO-03	Having an ability to design a component, subsystem or a system applying all the relevant standards and with realistic constraints, including operational and environmental.	Research Skill
PO-04	Acquire the skills for uses of contemporary techniques, resources and modern engineering and IT tools	Usages of Modern Techniques
PO-05	An ability to identify, investigate, understand and analyse complex problems, apply creativity, carry out research /investigation and development work to solve practical problems related to defence technological issues.	Design, Development & Solutions
PO-06	Ability to communicate effectively in both oral and written contexts in the form of technical papers, project reports, design documents and seminar presentations.	Communication
PO-07	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	Individual &Team Work

5. Program Structure

It is a 4 semester program with total 80 credits. It is having 2 specializations, as regard to the specializations, semester-1 will have common curriculum and semester 2 curriculum will be varied as per the specialization. Semester 3 & 4 includes dissertation and industrial training. The M.Tech. in Defence Technology will be having following specializations:

S. No.	Specialization
1.	Aerospace Technology
2.	Communication Systems & Sensors

- Semester-1 courses will be same for all specializations.
- Semester -2 courses will be as per the selected specialization.

6. Syllabi

(under AICTE Universities)

T : Tutorial; L : Lecture; P : Practical

Semester - 1

S. No.	Course Code	Course of study and scheme of examination	M.Tech			Branch Defence Technology
		Compulsory Courses	Periods/Week			Total Credits
			L	T	P	
1.	DT-01-01	Systems and warfare Platforms	4	-	-	4
2.	DT-01-02	Warfare Simulations & Strategies	4	-	-	4
3.	DT-01-03	Advanced Engineering Mathematics	4	-	-	4
4.	DT-01-L01	Systems and Platforms Lab	-	-	2	2
5.	DT-01-L02	Warfare Simulations & Strategies Lab	-	-	2	2
		Elective Courses				
6.		Elective 1	3	-	-	3
7.		Elective 2	3	-	-	3
8.		Seminar	-	-	1	1
		Total credits				23

Semester -1 Elective Courses

- Students are expected to select the Elective-I course of their choice, provided that at least a group of 7 students should opt for the similar elective course.

S. No.	Course Code	Course of study and scheme of examination	M.Tech Semester-1			
		Elective 1	Periods/Week			
			L	T	P	Total Credits
1.	DT-EL1-01	Rockets & Missiles Fundamentals	3	-	-	3
2.	DT-EL1-02	Advanced Thermal Engineering	3	-	-	3
3.	DT-EL1-03	Numerical methods for science & engineering	3	-	-	3
4.	DT-EL1-04	Communication Technology	3	-	-	3
5.	DT-EL1-05	Advanced Mechanical Engineering	3	-	-	3

S. No.	Course Code	Course of study and scheme of examination	M.Tech Semester-1			
		Elective 2	Periods/Week			
			L	T	P	Total Credits
1.	DT-EL2-01	Autonomy and Navigation Technology	3	-	-	3
2.	DT-EL2-02	Optimization theory & applications	3	-	-	3
3.	DT-EL2-03	Military Electronics System Engineering	3	-	-	3
4.	DT-EL2-04	System Engineering & Analysis	3	-	-	3

Semester - 2: Main Stream Defence Technology with following two specializations

S. No.	Main Stream Defence Technology
1.	Aerospace Technology
2.	Communication Systems & Sensors

1. Aerospace Technology

S. No.	Course Code	Course of study and scheme of examination	M.Tech Semester-2			Branch Defence Technology
		Compulsory Courses	Periods/Week			Total Credits
		Aerospace Technology	L	T	P	
1.	DT-AT-01	Aerospace System Configuration, Design & Simulation	4	-	-	4
2.	DT-AT-02	Guidance & control	4	-	-	4
3.	DT-AT-03	Aerospace Propulsion	4	-	-	4
4.	DT-AT-L01	Aerospace System Configuration, Design & Simulation Lab	-	-	2	2
5.	DT-AT-L02	Guidance & control Lab	-	-	2	2
		Elective Courses				
6.		Elective 1	3	-	-	3
7.		Elective 2	3	-	-	3
8.		Seminar	-	-	1	1
		Total credits				23

2. Communication Systems & Sensors

S. No.	Course Code	Course of study and scheme of examination	M.Tech Semester-2			Branch Defence Technology
		Compulsory Courses	Periods/Week			Total Credits
		Communication Systems & Sensors	L	T	P	
1.	DT-CSS-01	RadarTechnologies	4	-	-	4
2.	DT-CSS-02	Digital & satellite Communication and Navigation from Space	4	-	-	4
3.	DT-CSS-03	Tactical battlefield Communication & Electronic Warfare	4	-	-	4
4.	DT-CSS-L01	Radar Technologies Lab	-	-	2	2
5.	DT-CSS-L02	Digital & satellite Communication and Navigation from Space Lab	-	-	2	2
		Elective Courses				
6.		Elective 1	3	-	-	3
7.		Elective 2	3	-	-	3
8.		Seminar	-	-	1	1
		Total credits				23

Elective Courses offered for Semester 2

- Students are expected to select the Elective course of their choice, provided that at least a group of 7 students should opt for the similar elective course.

S. No.	Course Code	Course of study and scheme of examination	M.Tech Semester-2			
		Elective 3 (for all Specializations)	Periods/Week			
			L	T	P	Total Credits
1.	DT-EL3-01	Robotics (MSS, MCC)	3	-	-	3
2.	DT-EL3-02	EMI/EMC in Military Systems	3	-	-	3
3.	DT-EL3-03	Defence Electro-Optics and Imaging Systems	3	-	-	3
4.	DT-EL3-04	Structural Dynamics and Aero-elasticity	3	-	-	3
5.	DT-EL3-05	Safety, Health & Hazard Management	3	-	-	3
6.	DT-EL3-06	Fundamental of telemetry, telecomm and transponder	3	-	-	3
7.	DT-EL3-07	Jamming and ECM/ECCM technologies	3	-	-	3
8.	DT-EL3-08	Software defined Radios	3	-	-	3
9.	DT-EL3-09	Advanced Lightweight and Composite Structures	3	-	-	3
10.	DT-EL3-10	Test methodologies for DEW systems (Lasers & Microwave)	3	-	-	3
11.	DT-EL3-11	Advanced Analytical Techniques / Lab testing	3	-	-	3
12.	DT-EL3-12	Sonar System Engineering	3	-	-	3

S. No.	Course Code	Course of study and scheme of examination	M.Tech Semester-2			
		Elective 4 (for all Specializations)	Periods/Week			
			L	T	P	Total Credits
1.	DT-EL4-01	Unmanned Aerial Vehicle Design	3	-	-	3
2.	DT-EL4-02	Naval Ocean Analysis and Prediction	3	-	-	3
3.	DT-EL4-03	Modeling & simulation of Laser Matter Interaction	3	-	-	3
4.	DT-EL4-04	Computational Aerodynamics	3	-	-	3
5.	DT-EL4-05	Launch Vehicle Design & Analysis	3	-	-	3
6.	DT-EL4-06	Acquisition, Tracking & Pointing Technology	3	-	-	3
7.	DT-EL4-07	Data acquisition, tracking & post flight analysis	3	-	-	3
8.	DT-EL4-08	Air independent propulsion & batteries	3	-	-	3
9.	DT-EL4-09	Advanced digital modulation technologies & standards	3	-	-	3
10.	DT-EL4-10	Trajectories modeling & simulation	3	-	-	3
11.	DT-EL4-11	Sensor Technology	3	-	-	3

Semester - 3

S. No.	Course	Credit
1.	Project Dissertation- Phase 1	10
2.	Seminar/ Industrial training	4
	Total credits	14

Semester – 4

S. No.	Course	Credit
1.	Project Dissertation Phase-2	20
	Total credits	20

3. Procedure to approach DRDO Labs

Prospective institute may contact the DRDO Lab near its vicinity for conducting this program, e.g. prospective institute located in Hyderabad may seek help from DRDO Labs located inside or near the vicinity of Hyderabad. List of DRDO Labs is provided in Annexure A.

4. Eligibility criteria

Those who have pursued under graduation in following disciplines are eligible for taking up the M.Tech. Defence Technology courses:

1) Aerospace Engineering
2) Aeronautical engineering
3) Applied Electronics and Communication Engineering
4) Applied Electronics and Instrumentation Engineering
5) Chemical Technology
6) Chemical engineering
7) Computer Science & Engineering
8) Computer and Communication Engineering
9) Computer Engineering
10) Computer Engineering and Applications
11) Computer Networking
12) Computer Science and Information Technology
13) Computer Science and Technology
14) Computer Technology
15) Electrical and Computer Engineering
16) Electrical and Electronics Engineering
17) Electrical and Instrumentation Engineering
18) Electrical and Power Engineering
19) Electrical Engineering
20) Electronics engineering
21) Electrical, Electronics and Power Engineering
22) Electronics and Communication engineering
23) Instrumentation engineering
24) Electronics, Instrumentation and Control Engineering
25) Electronics, Science and Engineering
26) Electronics and Computer Engineering
27) Electronics and Communication Engineering
28) Electronics and Computer Science
29) Electronics and Control Systems
30) Electronics and Power Engineering
31) Electronics and Telecommunication
32) Electronics, Instruments and Control Engineering
33) Electronics System Engineering
34) Instrumentation and Electronics
35) Instrumentation Engineering
36) Marine Engineering
37) Marine Technology

38) Mechanical and Automation Engineering
39) Mechatronics Engineering
40) Mechanical engineering
41) Metallurgical and Materials Engineering
42) Military engineering
43) Optics and Opto-electronics
44) Power Electronics Engineering
45) Radio, Physics and Electronics
46) Software Engineering
47) Structural Engineering
48) Telecommunication Engineering

5. Guidelines

i. To begin the courses, it will be preferred to have institutes / universities in vicinity of DRDO/ PSU/private defence industries for effective conduction of courses.

ii. Keeping in view the uniqueness of the courses of this program, each course can be conducted on sharing basis, the faculty(s) from prospective institute / university can share the course to be conducted with the superannuated / working scientists from the DRDO labs located in the vicinity of the institute. On request by the institutions, the experts/ scientists for conducting the respective courses will be made available by DRDO lab provided that the prospective institution should plan the teaching assignment well in advance and communicate to the nearby DRDO lab for the meaningful. The institutes / university should cater for remuneration / funding to the mentioned lecturers for course activities as per university rules.

iii. The laboratory work mentioned in semester 1 & 2 can be held at respective DRDO labs / PSU/ private defence industries located in the vicinity on demand from the institution / university.

iv. There will be mentor from academic institute / university as well as from DRDO lab / Industries for conducting online/offline lab experiments.

v. M. Tech. Project phase 1 & 2 may be done in respective DRDO labs, DRDO established Center of Excellence, DIAT Pune, PSUs and private defence industries. As regard M.Tech dissertation based upon the topic of dissertation, the respective students will be placed appropriately to the various respective labs located all over countries.

vi. The model course structure has been provided for reference. The prospective institutions / universities can get it approved from the concerned bodies. Also the prospective institutions / universities may take approval of DRDO scientist to teach the courses on sharing basis.

vii. The prospective institution / universities can conduct the examination appropriately for theory, practical courses and dissertation. The dissertation examination can be conducted at DRDO lab as per the requirement of the dissertation topic, in case the developed product / system can not be taken out from the DRDO lab.

viii. The list of DRDO superannuated scientists along with contact details, willing to contribute for this program has been provided.

ix. Classes may be conducted online as well as offline as per need.

Course Contents

M.Tech. (Defence Technology)

Semester -1 Compulsory Course

Course Title : Systems and warfare Platforms
Course Code : DT-01-01
Teaching Scheme : L: 4, T: 0, P:0 Credits: 4

Course Objectives:

The main objective of the course is to provide knowledge to the students about various types of military platforms used in air, naval & land warfare. Students will also be apprised for weapon system and self-protection strategies and techniques.

Course Outcomes:

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

- Understand types of warfare platform used for Army, Air and Marine and their design fundamentals.
- Understand the weapon systems like guns, ordnance, missiles projectiles, mines/ countermines, lasers, undersea weapons, air-launched weapons, anti-aircraft, anti-ship and anti-submarine.

Course Content:

Unit	Contents	Contact Hrs.
1.	Types of platforms: land, sea, air; Lifecycle: concept, design, pre-production, production, operations, support.	7
2.	Ship design fundamentals: buoyancy, stability, ship resistance, survivability; damage control, NBCD, crew numbers, power requirements. Submarine design: buoyancy, stability, hull/tank design, air interdependence.	7
3.	Mechanics of flight: fixed and rotary wing, straight and level flight of aircraft, aircraft control and movement, aircraft control surfaces, aerodynamics, power requirements, range; speed, ceiling, survivability, payload.	7
4.	Military vehicle fundamentals: tracked, wheeled, A, B and C vehicles.	7
5.	Weapon systems: guns, ordnance, missiles, rockets, bombs, sub- munitions, projectiles, mines/ countermines, lasers, undersea weapons, air-launched weapons, anti-aircraft, anti-personnel, anti-ship, anti-submarine.	6
6.	Self defence and Protection systems: Armour, smoke, chaff, decoys; Introduction to instrumentation, lab tests and flight trials.	6
Total		40

References / Suggested Books:

1. "Light And Heavy Vehicle Technology ", by Nunney. Publisher Elsevier.
2. "Practical approach to motor vehicle engineering and maintenance", by Bon-nick Allan et. Al. Publisher: Yesdee.
3. "Automotive Vibration Control Technology: Fundamentals, Materials, Construction, Simulation, and Applications", by Trelleborg.
4. "An Introduction to Weapons Systems", by Yacov Bar-Shlomo. Publisher : Create Space Independent Publishing Platform.

5. "Heavy Vehicle Mechanics", by Ian Nicholson.Publisher : McGraw-Hill Educa-tion – Europe.
6. "Military Laser Technology for Defense: Technology for Revolutionizing 21st Century Warfare", by Alastair D. McAulay. Publisher : Wiley-Interscience; 1st edition.
7. Literature / books suggested by respective course Lecturers.

Course Title : Warfare Simulations & Strategies
Course Code : DT-01-02
Teaching Scheme : L: 4, T:0, P:0 Credits: 4

Course Objectives:

The main objective of the course is to provide knowledge to the students about warfare system and affluent them with combat modeling using mathematical modeling.

Course Outcomes:

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

- Understand the systems used in warfare scenario.
- Understand combat simulation & modelling
- Understand the war gaming simulation & modelling and human factor rep-resentation.

Course Content

Unit	Contents	Contact Hrs.
1.	Introduction to Warfare systems: air, surface, subsurface, littoral, electronic	7
2.	Military capabilities: air warfare, surface warfare, sub surface warfare, littoral warfare	7
3.	Introduction to the methods used in modeling combat and their application in support of defence decision making and training, Combat simulation.	7
4.	War gaming/interactive simulation, Lanchester's equations, Mathematical models of combat.	7
5.	War gaming and combat modeling in practice, manual war gaming.	6
6.	Human factors representation in war gaming and combat modeling.	6
Total		40

References / Suggested Books:

1. "Defense Modeling, Simulation, and Analysis: Meeting the Challenge". Publisher: National Academies Press (October 22, 2006).
2. "Introduction to Electronic Warfare Modeling and Simulation"by David L. Adamy". Publisher : Artech Print on Demand (October 31, 2002).
3. "Engineering Principles of Combat Modeling and Distributed Simulation", by Andreas Tolk (Editor), Old Dominion University. Publisher : John Wiley & Sons.
4. Literature / books suggested by respective course Lecturers.

Course Title : **Advanced Engineering Mathematics**
Course Code : **DT-01-03**
Teaching Scheme : **L: 4, T:0, P:0** **Credits: 4**

Course Objectives

The main objective of the course is to provide knowledge to the students of probability theory, algebra, solutions of Differential equations, Transform techniques, special functions & their applications in the areas with defence relevance.

Course Outcomes

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

- Know the methods for solving differential equations, generating functions.
- Understand basic concepts of Fourier Transform, Laplace Transforms and solve problems with periodic functions, step functions, impulse functions and convolution.
- Demonstrate MATLAB programming for engineering problems.
- Understand the utilization of mathematical methods for solving problems having relevance to defence applications.

Course Content:

Unit	Contents	Contact Hrs.
1.	Elements of Probability and Statistics, components of operations research, Linear Algebra	6
2.	Ordinary Differential equations, Numerical methods for ODE and P.D.E. Generating functions, recurrence relations	7
3.	Transform Techniques, Fourier series, Fourier Transform, Laplas Transform	7
4.	Special functions: Power series method, Frobenious method, Legendre equation, Legendre polynomials, Bessel equation, Bessel functions of first kind, Orthogonal property.	7
5.	Elements of Ramsey theory, theorems of Burnside and Polya, and balanced incomplete block designs.	7
6.	Application areas with defence relevance range from mathematics to computer science and operations research, applications in probability, game theory, network design, coding theory, and experimental design.	6
Total		40

References / Suggested Books:

1. "Advanced engineering mathematics", by Kreyszig. Publisher: Wiley.
2. "Advanced engineering mathematics",by Jain/Iyenger. Publisher: Narosa.
3. "Advanced engineering mathematics",byTaneja. Publisher: I K international
4. "Advanced engineering mathematics",by Alan Jeffery. Publisher: Academic Press.
5. "Advanced engineering mathematics",by Peter V. O'Neil. Publisher: Cengage Learning.
6. Literature / books suggested by respective course Lecturers.

Course title : Systems and Warfare Platforms Lab
Course Code : DT-01-L01
Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

Lab experiments will be added in consultation with DRDO labs considering the available facilities.

Course title : Warfare simulations & Strategies lab
Course Code : DT-01-L02
Teaching Scheme : L: 0, T: 0, P: 2 Credits: 2

Lab experiments will be added in consultation with DRDO labs considering the available facilities.

Semester 1, Elective-1 Courses

Course Title : Rockets & Missiles Fundamentals
Course Code : DT-EL1-01
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

The main objective of the course is to provide knowledge to the students about missile system, classification of missiles, aerodynamics of missiles, subsystems and missile trajectory.

Course Outcomes:

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

- Understand basics of missile physics as well as the engineering aspects of missile integration.
- Understand physics behind guided missiles and aero dynamics of missiles.
- Characterization of sub-systems used in missiles.

Course Content:

Unit	Contents	Contact Hrs.
1.	Basics of Missile Physics, Introduction to Guided Missiles, Classification of Missiles,	5
2.	Missile Aerodynamic Configurations, Introduction to Missile System, Interrelationship between various Missile Sub-Systems.	5
3.	Basic Characteristics of Guided Missile Systems, Missile System Reliability, Range dispersion and CEP Concept,	5
4.	Design, System Layout and integration of Sub-Systems,	7
5.	Coordinate Transformation, Transformation Matrices. Two, Three and Six DOF Equations of Motion, Ballistic Missile Trajectory,	7
6.	Effect of Curvature of Earth, Rotation of Earth, Variation of Gravity on Missile Trajectory.	7
Total		36

References / Suggested Books:

1. "Fundamentals of Guided Missiles",by S. R. Mohan. Publisher : Defence Re-search and Development Organisation.
2. "Estimation and Prediction of Ballistic Missile Trajectories" by Jeff ey A. Isaac-son, David R. Vaughan.Publisher : RAND (29 May 1996)
3. "Introduction to Modern Algebra and Matrix Theory", by O. Schreier, E. Sperner, Martin David, Melvin Hausner. Publisher : Dover Publications.
4. Literature / books suggested by respective course Lecturers.

Course Title : Advanced Thermal Engineering
Course Code : DT-EL1-02
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives

The main objective of the course is to provide knowledge to the students for the thermal management

requirements / problems of the defence systems and thermal system design & simulation for the various air, land & naval defence systems utilized under different environmental conditions.

Course Outcomes:

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

- Understand thermal design and simulations for system design.
- Carry out CFD simulations, design of heat exchangers, refrigeration.
- Understand the concept of thermal management requirement & design for defence systems.

Course Content:

Unit	Contents	Contact Hrs.
1.	System thermal design & Analysis, Tools for thermal design and simulation, Heat transfer analysis (conduction, convection & radiation),	7
2.	Computation fluid dynamics (CFD), Thermal Finite Element Analysis	7
3.	Heat Exchangers for: Heat Exchanger Network Design	6
4.	Refrigeration, Humidifiers, Air Washers and Cooling Towers	5
5.	Thermal management design of defence system (combat vehicles, missiles, aerial vehicles etc.)	6
6.	Thermal testing, thermal operation, and integration of thermal design into the defence systems.	5
Total		36

References / Suggested Books:

1. "Fundamentals of Heat and Mass Transfer", by Incropera and Dewitt. Publication: John Wiley.
2. "Convective Heat and Mass Transfer", by W M Kays and M E Crawford. Publisher: McGraw-Hill publishing Company.
3. "Thermal Radiation Heat Transfer" by J Siegel and R Howell. Publisher: Elsevier.
4. "Manohar Prasad, Refrigeration and Air Conditioning", 3rd Edition, New Age International, 2015.
5. "Computational Fluid Dynamics – The Basics with Applications", by John D Anderson. Publisher :1st Edition, McGraw Hill, 2012.
6. "Thermal System Design and Simulation", by P.L. Dhar, 1st Edition.
7. Literature / books suggested by respective course Lecturers.

Course Title : Numerical methods for science and engineering
Course Code : DT-EL1-03
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives

The main objective of the course is to provide knowledge to the students to develop numerical methods aided by technology to solve algebraic equations, calculate derivatives and integrals, curve fi and optimization techniques. The course will also develop an understanding of the fi e element analysis and computational fluid engineering.

Course Outcomes

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

- Use the numerical techniques (algorithms) to find the solution (approximate) algebraic equations and system of equations.
- Fit the data using interpolation technique and spline methods.
- Use to finite element analysis, interpretation of analysis results.
- Understanding of computational engineering process.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction, solution of non-linear equations, solution of linear systems.	5
2.	Introduction and polynomial approximation, curve fitting, Numerical applications & intergradations, numerical optimization.	5
3.	Matrices and types of linear systems, direct elimination methods, conditioning and stability of solutions,	5
4.	Introduction to Finite Element Analysis (FEA) simulation software, Pre- and Post-Processing, Free mesh and Mapped mesh techniques, Quality checks on nodes and elements, Boundary conditions,	7
5.	Introduction to computational fluid engineering, Fundamental equations, Computational Engineering Process.	7
6.	Fluid Simulation for Computer Graphics, Modelling techniques.	7
Total		36

References / Suggested Books:

1. "Numerical Methods for Scientifi and Engineering Computation", by M. K. Jain and S.R.K. Iyengar. Publisher : New Age International Publishers.
2. "Applied Numerical Analysis", by Gerald & Wheatley. Publisher Addison – Wesley.
3. "Introductory Methods of Numerical Analysis", by, S.S. Sastry. Publisher: PHI Pvt. Ltd., 5th Edition,New Delhi, 2009.
4. "Applied Numerical Methods Using MATLAB", by W.Y. Yang, W. Cao, T.S. Chung and J. Morris. Publisher: Wiley India Edn., 2007.
5. "Numerical Methods for Engineers with Programming and Software Applications", by Steven C. Chapra and Ra P. Canale. Publisher: Tata McGraw Hill, 2014 7th Edition.
6. "Finite Element Procedures", by K.J. Bathe, Prentice Hall of India.
7. "Finite Elements in Engineering", by Chandrupatla and Belegundu.
8. "Finite element Method", by J.N.Reddy.
9. Literature / books suggested by respective course Lecturers.

Course Title : Communication Technology
Course Code : DT-EL1-04
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives

The main objective of the course is to provide knowledge to the students about communication system design, calculation of bandwidth and signal-to-noise ratio of a signal, digital communication systems, performance evaluation, explain the concepts of link budget and multiple accesses as it applies to wireless communication.

Course Outcomes:

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

- Understand communication system design methodologies, communication system architecture,
  analogue & digital modulation techniques.
- Computation of data rates, bandwidth, BER.
- To carry out the link budget analysis.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction on Communication Systems, Basics of wireless channel behavior	6
2.	Digital data communication systems, digital signaling techniques	6
3.	Data rates and bandwidth calculation in digital data communication systems	5
4.	Probability of error and BER calculation, Modulation technologies (analogue & digital), Voice source coding, transmitter and receiver systems	7
5.	Communication system architectures, terminal design and performance, associated information systems	7
6.	Link budget calculations, telemetry and control and IO/IW implications. Antenna types and their impact on the communication systems	5
Total		36

References / Suggested Books:

1. "Fundamentals of communication systems," by Proakis and Salehi. Publisher: Pearson.
2. "Communication Systems", by Simon Haykin and Michael Moher. Publisher: Wiley.
3. "Modern digital and analog communication systems," by B.P. Lathi and Zhi Ding. Publisher: Oxford University Press.
4. Literature / books suggested by respective course Lecturers.

Course Title : Advanced Mechanical Engineering
Course Code : DT-EL1-05
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives:

The main objective of the course is to provide knowledge to the students about different methods of mechanical system analysis, mechanical simulation soft-ware and use of computational techniques for structural and fluid dynamics.

Course Outcomes

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

- Understand mechanical analysis software and carry out mathematical modeling for simulation of phenomena behind the structural and fluid dynamics.
- Carry out design & finite element analysis of components of systems and sub-systems.
- Carry out the CFD analysis.

Course Content

Unit	Contents	Contact Hrs.
1.	Introduction to tools for mechanical design & analysis	5
2.	Stress engineering – theory & simulation, mechanics of solids	7
3.	Finite element methods in structural dynamics, Structural integrity	7
4.	Fluid mechanics	5
5.	Computational fluid dynamics	7
6.	Component design, Applied materials and corrosion	5
Total		36

References / Suggested Books:

1. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method " by H. Versteeg. Publisher : Pearson.
2. "Computational Fluid Dynamics the Basics with Applications", by John D. An-der Jr. Publisher : McGraw Hill Education (1 July 2017)
3. "Fluid Mechanics: Volume 2: Foundations and Applications of Mechanics (Cambridge-iisc)" by C. S. Jog. Publisher : Cambridge University Press.
4. " Fundamentals of Machine Component Design", by Robert C. Juvinall, Kurt M. Marshek. Publisher : John Wiley & Sons
5. Literature / books suggested by respective course Lecturers.

Semester 1, Elective-2 Courses

Course Title : Autonomy and Navigation Technology
Course Code : DT-EL2-01
Teaching Scheme : L: 3, T: 0, P: 0 Credits: 3

Course Objectives:

The main objective of the course is to provide knowledge to the students about technology of modern navigation systems, particularly satellite-based systems, UAV guidance systems, GPS, SLAM.

Course Outcomes:

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

- Describe the basic principle of operation of a global navigation satellite system
- Understand the navigation systems and derive the navigation equations.
- Carry out path planning the UGV / UAV.
- Solve the equations for calculating a position estimate from a given satellite constellation.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction on navigation and guidance systems, Guidance approaches: conventional guidance such as PN (Proportional Navigation)	6
2.	Geodetic fundamentals of navigation, positioning, reference- and coordinate systems and computational methods for navigation and positioning on the surface of the earth.	7
3.	Geometric guidance, path planning and following, and optimal guidance; path planning for UGV/UAV guidance systems	7
4.	Navigation approaches: navigation systems, Understanding the Global Positioning System (GPS)	5
5.	GNSS (Global Navigation Satellite System), terrain based navigation	6
6.	SLAM (Simultaneous Localization and Mapping); Cooperative guidance and collision avoidance.	5
Total		36

References / Suggested Books:

1. "Global Navigation Satellite Systems: Insights Into GPS", by Bhatta, B., Glonass, Galileo, Compass, and Others. Publisher : BS Publications, New Delhi 2010.
2. "Global Positioning Systems, Inertial Navigation, and Integration", by Grewal, M. S., Weill, L. R., Andrews, A. P., Publisher: John Wiley & Sons, New York, 2006.
3. "GNSS – Global Navigation Satellite Systems", by Verlag Wien. Hofmann-Wellenhof, B., Lichtenegger, H., Wasle, E.. Publisher: Springer 2008.
4. "Global Positioning System Theory and Practice", Hofmann-Wellenhof, B., Lichtenegger, H., Verlag Wien, Collins, J. Publisher: Springer 2001.
5. Literature / books suggested by respective course Lecturers.

Course Title : Optimization theory & applications
Course Code : DT-EL2-02
Teaching Scheme : L: 3, T:0 , P: 0 Credits: 3

Course Objectives

The main objective of the course is to provide knowledge to the students on the numerical optimization algorithms. The course objective is to cover the concepts of optimization methods and algorithms developed for solving various types of optimization problems. Apply the mathematical results and numerical techniques of optimization theory to various Engineering and Analytics problems and applications in both theoretical and applied research areas.

Course Outcomes

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

- Understand mathematical modeling and the formulation of optimization problems.
- Create programs based on different optimization algorithms using IT tools, such as MATLAB etc.
- Understand theory about linear programming, integer programming, and stochastic programming
- Understand the process of finalizing design of engineering systems by applying the numerical optimization.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction to optimization, classical optimization techniques.	6
2.	Linear programming & non linear programming and dimensional minimization methods.	7
3.	Non coordination optimization techniques, coordinated optimization techniques, coordinated programming.	7
4.	Dynamic programming, integer programming, stochastic programming.	6
5.	Solution of a variety of design problems in mechanical engineering, using numerical optimization techniques.	5
6.	Additional Topics: multi-objective, optimization, game theory, optical control theory.	5
Total		36

References / Suggested Books:

1. "Numerical Optimization", by Jorge Nocedal and Stephen J.Write. Publisher: Springer, 2006.
2. "Practical methods of Optimization" by R.Fletcher. Publisher : Wiley, 1987.
3. "Iterative method for optimization" by C. T. Kelley. Publisher : SIAM, 1999.
4. "Introduction to Nonlinear Optimization: Theory, Algorithm, and Application with MATLAB. MOS-SIAM Series on Optimization", by Amir Becker.
5. "Dynamic Programming and Optimal Control (VolumeI) "by Dimitri P. Bertsekas. Publisher : Athena Scientic, 2005.
6. "Optimization Theory and Applications", by SS Rao.
7. Literature / books suggested by respective course Lecturers.

Course Title : **Military Electronics System Engineering**
Course Code : **DT-EL2-03**
Teaching Scheme : **L: 3, T:0 , P: 0** **Credits: 3**

Course Objectives

The main objective of the course is to provide knowledge to the students about the learning of the electronics systems requirement for military environment, generation of system requirements, limitations of COTS equipment and radiation effects on the electronic systems.

Course Outcome

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

- Understand the military electronics systems.
- Generate system design requirements as per mission needs & operational requirements.
- To create digital simulation models.
- Understand the limitations of the COTS available electronics systems
- Evaluate the radiation effects on the performance of electronics systems

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction to electronics engineering concepts and methods for the design and integration of complex defense systems.	5
2.	Familiarity with the systems engineering process through case studies of representative defense systems.	5
3.	Introduction to methods used for determination of system requirements from mission needs and operational requirements.	6
4.	Digital simulation models, including those in current used in defence for determining engineering and performance trade-offs.	7
5.	Limitations of commercial-off-the-shelf (COTS) integrated circuits, thermal failure, electrostatic breakdown, noise in solid state devices, packaging reliability issues.	7
6.	Radiation effects due to space and nuclear environments, and the limited availability of military integrated circuit suppliers.	6
Total		36

References / Suggested Books:

1. "Introduction to Electronic Defense Systems", by Neri Filippo. Publisher: Artech House Publishers.
2. "Military Handbook of Electronic Reliability design", by US Department of Defence.
3. "Defence Electronics Standards and Quality Assurance", by Ray Tricker. Pub-lisher : Elsevier
4. "Handbook of Defence Electronics and Optronics: Fundamentals, Technologies and Systems", by Anil K. Maini. Publisher: John Wiley & Sons Ltd
5. "Digital Simulation Methods", by M.G. Hartley. Publisher : P.Peregrinus Ltd
6. "Analysis and Simulation of Noise in Nonlinear Electronic Circuits and Sys-tems", By Alper Demir. Publisher : Springer.
7. Literature / books suggested by respective course Lecturers.

Course Title : System engineering and analysis
Course Code : DT-EL2-04
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

The course is intended to provide knowledge to the students about the military systems engineering, system requirements, basics of system design, architecture, operational requirements, system reliability and management.

Course Outcome

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

- Understand the system design requirements, architecture, functional requirements
- Generate the system requirements documents as per the requirement analysis.
- Understand the system reliability, maintainability, usability issues.
- Carry out the system reliability analysis.

Course Content

Unit	Contents	Contact Hrs.
1.	Fundamentals of systems engineering and system architecting of weapon system, system engg. standards 15288, requirements analysis, functional analysis and allocation, preliminary system architecture.	7
2.	Systems analysis, system design, and the basics of test and evaluation, Introduction to combat systems,	6
3.	System development phases (Conceiving, Designing, Implementing, and Operating),	5
4.	Techniques of system design and assessment for operational feasibility, including reliability, maintainability, usability (including human factors and human performance).	7
5.	Supportability, and producibility, System cost assessment and effectiveness estimation.	4
6.	Reliability analysis and management (basic tools and methods of reliability for developing complex systems including electronic components, mechanical components, and software), redundancy, graceful degradation, fault tolerance, MTBF.	7
Total		36

References / Suggested Books:

1. "The Engineering Design of Systems: Models and Methods", by Buede D.M.2. Publisher: John Wiley & Sons Inc.
2. "Systems engineering fundamentals", by Defense Acquisition University Pressfort Belvoir, Virginia
3. "System Analysis Design and Development", by Charles S. Wasson. Publisher : Wiley Series in System Engineering and Management.
4. "Principles of Planned Maintenance", by Clifton R H. Publisher: McGraw Hill, New York.
5. "An introduction to Reliability and Maintainability Engineering", by Ebling CE. Tata Mc Graw Hill.
6. "Reliability Engineering", by Srinath L S. Publisher : Affiliated East-West Press Limited, New Delhi, 2002.
7. "Engineering Maintainability", by Dhillon B S. Publisher : Prentice Hall of India.
8. Literature / Literature / books suggested by respective course Lecturers.

Semester – 2
(Compulsory Courses)

AEROSPACE TECHNOLOGY

M.Tech
Courses
2021-22

M. Tech. in Defence Technology

at AICTE Affiliated Institutes / Universities

2. Aerospace Technology

Course Title : Aerospace System Configuration, Design and Simulation
Course Code : DT-AT-01
Teaching Scheme : L: 4, T:0, P:0 Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to the students about the process & techniques of aerospace system design, meeting the specified design requirements. They will also learn about carrying structural and aerodynamic analysis, performance evaluation of aircraft and stability analysis.

Course Outcomes:

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

- Understand the concept of missile system and its design requirements and process.
- Design an aerospace vehicle and articulate its benefits in written and verbal forms.
- Understand the methods for aero-elastic analysis, computational fluid analysis and advances in aero-dynamics.
- Understand the air to air, ground to air, air to ground weapon system, UAV mounted GW and UCAVs.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction (aero-elastic phenomena and design requirements), Introduction to missiles & systems, Design process.	6
2.	Structural requirement, Structural and aerodynamic stiffness, Static aero-elasticity: torsional divergence, Structural vibration and modal analysis.	6
3.	Aerodynamic loads on an oscillating lifting surface, Characteristics of flutter and important design parameters, Methods for aero-elastic analysis, Computational fluid dynamics, advances in aero dynamics (Hypersonic Flows and Aerodynamic Heating).	7
4.	Aircraft performance (cruising, climb, descent, takeoff, landing, maneuver, flight path).	7
5.	System's stability & control, aerodynamics control, Introduction to dynamic stability, first and second order responses, Equations of motion and modal characteristics.	7
6.	Introduction to air to air, ground to air, air to ground weapon systems, UAV mounted GW and UCAVs.	7
Total		40

References / Suggested Books:

1. "Aircraft design: a conceptual approach", by D. Raymer
2. "Flight Dynamics Principles", by Michael V. Cook
3. "Introduction to Structural Dynamics and Aeroelasticity", by Dewey H. Hodges, G. Alvin Pierce
4. "Airplane Aerodynamics and Performance", by Chuan Tau Edward Lan
5. "Fundamentals of Structural Dynamics", by Roy R. Craig Jr., Andrew J. Kurdila.
6. Literature / books suggested by respective course Lecturers.

Course Title : **Guidance & control**
Course Code : **DT-AT-02**
Teaching Scheme : **L: 4, T:0, P:0** **Credits: 4**

Course Objectives

The main objective of the course is to provide knowledge to the students about fundamental of satellite navigation, navigation mathematics, principles of radio navigation, INS/GNSS integration and missile control methods.

Course Outcome:

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

- Understand the principles of satellite navigation, inertial navigation, radio positioning.
- Understand various aspects of designing a navigation system.
- Develop mathematical model of missile dynamics.
- Carry out simulation for aircraft/missile using mathematical tools like MATLAB.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction to Navigation, Navigation Mathematics.	6
2.	GNSS: fundamentals, Signals, and Satellites: Fundamentals of Satellite Navigation, Inertial Navigation, Advanced satellite Navigation, Principles of radio Positioning, Terrestrial radio Navigation, Short-Range Positioning, Satellite Navigation Processing.	7
3.	Errors and Geometry, Dead Reckoning, Attitude, and Height Measurement, Feature matching, INS/GNSS Integration.	6
4.	Missile Control Methods: Aerodynamic and Thrust Vector Control, Polar and Cartesian Control.	6
5.	Mathematical Modeling of Missile Dynamics; Missile Actuators and Sensors. Roll and Roll Rate Stabilization.	8
6.	Design and Analysis of Lateral Autopilots, 6 DOF simulation for aircraft/missile using MATLAB	7
Total		40

References / Suggested Books:

1. "Modern Inertial Technology Navigation, Guidance, and Control", by Anthony Lawrence 2012. Publisher : Springer New York.
2. "The Global Positioning System & Inertial Navigation", by Jay Farrell. Publisher : McGraw-Hill Education (16 December 1998).
3. "MATLAB for Engineering Applications", by William Palm. Publisher : McGraw-Hill Education; 4th edition (February 6, 2018).
4. "Global Navigation Satellite Systems, Inertial Navigation, and Integration", by Grewal, M. S., Andrews, A. P., Bartone, C. G. (2013). Publisher: John Wiley and Sons Inc.
5. "Principles of GNSS, inertial and multi-sensor integrated navigation systems", by Groves, P. D. Publisher : Artech House.
6. "Optimal State Estimation", by Kalman, H Infi y.
7. "Nonlinear Approaches", by Simon, D. (2006). Publisher: Wiley-Interscience
8. Literature / books suggested by respective course Lecturers.

Course Title : Aerospace Propulsion
Course Code : DT-AT-03
Teaching Scheme : L: 4, T: 0, P: 0 Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to the students about different criteria for the selection and evaluation of different types of propulsion systems, analysis of propulsion systems and the thermodynamics behind the critical parts of Aerospace system.

Course Outcomes

At the end of the course the student will have:

- Knowledge about thermodynamics and fluid dynamics behind the aerospace system.
- Understanding of Rocket motor design
- Understanding of different design aspects related to propulsion systems used in aerospace.

Course Content

Unit	Contents	Contact Hrs.
1.	Classification & mode of operation of various propulsion systems, basis thermodynamics & fluid Dynamics.	7
2.	Rocket motor design & analysis, Gas Turbine Engine design, GT engine efficiency, GT engine heat transfer & cooling.	8
3.	Aircraft performance, jet engine performance.	6
4.	Jet engine control (compressor performance, axial turbine performance, Fuel systems & pumps, airframe fuel systems, hydro-mechanical fuel metering, Electronics engine control)	7
5.	System integration	6
6.	Computational fluid dynamics (flow modelling strategies, physical modelling, finite difference equations, etc.)	6
Total		40

References / Suggested Books:

1. "Rocket Propulsion Elements", by George Paul Sutton and Oscar Biblarz. Pub-lisher: John Wiley & Sons
2. "Modern Engineering for Design of Liquid-Propellant Rocket Engines: Progress in Astronautics and Aeronautics Series" by Dieter K. Huzel, David H. Huang.
3. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method" by H. Versteeg. Publisher : Pearson; 2nd edition.
4. "Computational Fluid Dynamics the Basics with Applications" by John D. An-derson, Jr. Publisher : McGraw Hill Education (1 July 2017)
5. " Fluid Mechanics: Volume 2: Foundations and Applications of Mechanics", by C. S. Jog. Publisher : Cambridge University Press; 3rd edition.
6. "Parallel Processing for Jet Engine Control"' by Thompson, Haydn A, Publisher: Springer- Verlag London
7. "Fundamentals of Machine Component Design", by Robert C. Juvinall, Kurt M. Marshek. Publisher : John Wiley & Sons.

8. "Gas Turbines for Electric Power Generation",by S. Can Gülen.
9. "Gas Turbine Theory ", by H.I.H. Saravanamuttoo, Prof G.F.C. Rogers , H. Co-hen. Publisher : Prentice Hall.
10. "Elements of Propulsion: Gas Turbines and Rockets" by Jack D. Mattingly, Keith Boyer. Publisher : American Institute of Aeronautics & Astronautics.
11. Literature / books suggested by respective course Lecturers.

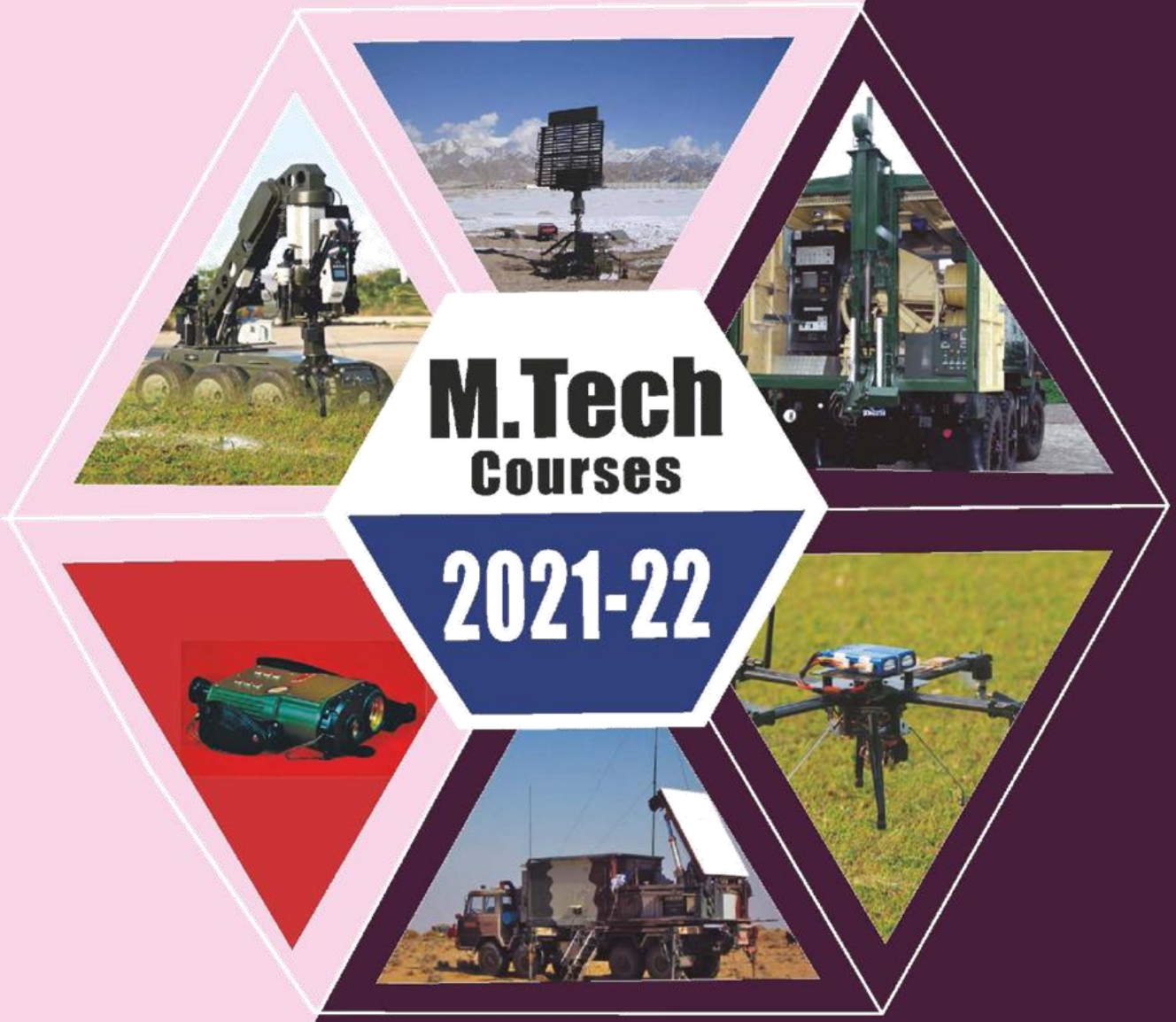
Course title : Aerospace system configuration, Design & simulation Lab
Course Code : DT-AT-L01
Teaching Scheme : L: 0, T: 0, P: 2 Credits: 2

Lab experiments will be added in consultation with DRDO labs considering the available facilities.

Course title : Guidance & Control lab
Course Code : DT-AT-L02
Teaching Scheme : L: 0, T:0 , P: 2 Credits: 2

Lab experiments will be added in consultation with DRDO labs considering the available facilities.

COMMUNICATION SYSTEMS & SENSORS



M.Tech Courses

2021-22

M. Tech. in Defence Technology

at AICTE Affiliated Institutes / Universities

2. Communication Systems and Sensors

Course Title : Radar Technologies
Course Code : DT-CSS-01
Teaching Scheme : L: 4, T: 0, P:0 Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to the students about learning on the radar systems, radar parameters, radar environment, theory of detection and design of radar elements, different types of radars & their application.

Course Outcomes

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

- Understand the design of radar systems, solve range equations.
- Apply appropriate mathematical and computer models relevant to radar systems to calculate system performance, and assess the limitations of particular cases
- Understand the major components of a modern radar system
- Learn basic radar signal processing techniques.
- Understand advanced radar techniques.
- Know the major functions and applications of a modern radar systems.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction to RADAR, Radar parameters/definitions, radar equations.	6
2.	Radar cross section (RCS) & Theory of detection, Clutter.	6
3.	Atmospheric propagation, Surveillance and Tracking Radar, Radar Designs.	6
4.	Radar elements Design, Radar Transmitter design, Radar antenna design, Duplexer/TR switch & Radar Receiver.	7
5.	Radar signals and networks, Radar signal processing chain, Pulse compression and micro-doppler processing, Tracking algorithms	7
6.	Phased array radar, Data processing for phased array radar, Airborne radar, imaging radar, Synthetic aperture radar, inverse synthic aperture radar, adaptive array processing.	8
Total		40

References / Suggested Books:

1. "Introduction to Radar Systems",by M.I. Skolnik. Publisher: Tata Mcgraw hill edition, 2001.
2. "Radar Systems Analysis and Design using MATLAB",by B.R.Mahafza. Publisher CRC Press, 2013.
3. "Monopulse Principles and Techniques", by S.M.sherman and D.K.Barton. Publisher : Artech house, 2011
4. "Fundamentals of Radar Signal Processing", by M.A.Richards. Publisher Tata Mcgraw hill.
5. "Ground Penetrating Radar: Theory and Applications",by, Editor: H.M. Jolt. Publisher: Elsevier.
6. "Radar, Sonar And Navigation Engineering", by K. K Sharma. Publisher: S K Kataria& Sons.
7. Literature / books suggested by respective course Lecturers.

Course Title : Digital & Satellite Communication and Navigation from Space
Course Code : DT-CSS-02
Teaching Scheme : L: 4, T: 0, P:0 Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to the students on the analogue and digital communication systems, optical communication, satellite communications systems, modulations techniques, signal propagation effects, navigation techniques.

Course Outcomes:

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

- Understand the communication techniques
- Evaluate the performance of communication systems
- Design the analogue and digital communication systems
- Understand and analyse the signal transmission effects
- Understand the different types of navigation techniques

Course Content

Unit	Contents	Contact Hrs.
1.	Elements of a communications system and their relationship to system performance.	6
2.	Free space optical communication, Fiber optics communication, Wireless/cellular communications.	7
3.	Fundamental concepts such as current/voltage relationships, time and frequency domains, power spectral density, random signals, Communications system components and functions, analog and digital communications systems,	7
4.	Modulation transmission and reception; baseband and passband digital modulation; system, noise, transmission lines, waveguides and antennas, FEC techniques for mitigating channel errors.	7
5.	Propagation effects on signal transmission; end-to-end path calculations for wire/coax, and RF systems including terrestrial ground links and satellite communications, Spread spectrum, conecpt of frequency hoping.	7
6.	Navigation techniques from space regarding functioning of GPS, GLONASS, IRNSS & Galileo	6
Total		40

References / Suggested Books:

1. "Satellite communication", by T. Pratt, C. W. Bostian, J. E.Allnut. Publisher: John Willey and sons
2. "Satellite Communications Systems: systems, techniques and technology", by G. Maral, M. Bousquet, Z. Sun. Publisher:John Willy and sons
3. "Digital Communications: Fundamentals and Applications", B. Sklar . Prentice-Hall, Inc.
4. "Understanding of GPS/GNSS: Principles and Applications",by E. Kaplan and C. Hegarty. Publisher: Artech House Publishers.
5. Literature / books suggested by respective course Lecturers.

Course Title : **Tactical Battlefield Communication & Electronic Warfare**
Course Code : **DT-CSS-03**
Teaching Scheme : **L: 4, T:0, P: 0** **Credits: 4**

Course Objectives

The main objective of the course is to provide knowledge to the students on the techniques for setting up intercept and jamming links for Electronic Warfare (EW) against ground to ground enemy communication signals, UAV command and data links, cell phone links and weapon control links, techniques for predicting intercept and jamming performance.

Course Outcomes:

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

- Understand the nature of tactical battlefield communication
- Calculate communication link performance
- Calculate the requirements for interception of tactical communication
- Calculate the requirements for emitter location, intercept and jamming of tactical comm. signals including weapon control link, UAV links, Cell phone links.
- Use various tools to perform electronic warfare calculations

Course Content:

Unit	Contents	Contact Hrs.
1.	Radiometry and power calculation, signature generation, atmospheric effects.	6
2.	Radar ES operational use, radar/ES detection battle, quiet radar, jamming techniques & strategies, jamming of SAR systems.	6
3.	Introduction to radar waveform interception, Technology and operational characteristics of electronic warfare, Signal processing statics & analysis, statistics & noise, analogue & digital signal processing.	7
4.	Decision theory- hypothesis testing, probabilities of false alarm and detection, Bayesian systems, error probability and bit error rate, receiver operating.	7
5.	UAV Payload/link Issues, cell phone issues, Intercept links, Frequency hopping and other LPI threats;Special techniques for jamming LPI signals	7
6.	Introduction to electronic counter measures and counter-counter measures.	7
Total		40

References / Suggested Books:

1. "Tactical Battlefield Communications Electronic Warfare", by David Adamy 2008
2. "Military Communications in the Future Battlefield ", by Marko Suojanen.
3. "Electronic Warfare for the Digitized Battlefield ", by Michael Frater, Michael Ryan.
4. Literature / books suggested by respective course Lecturers.

Course title : Radar Technologies Lab
Course Code : DT-CSS-L01
Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

Lab experiments will be added in consultation with DRDO labs considering the available facilities.

Course title : Digital & Satellite Communication and Navigation from Space
Course Code : DT-CSS-L02
Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

Lab experiments will be added in consultation with DRDO labs considering the available facilities.

Semester 2, Elective-3 Courses

Course Title : Robotics (MSS, MCC)
Course Code : DT- EL3-01
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

The course is intended to provide learning on the basic concepts of robotics by exposing students to a broad range of topics with emphasis on basics of manipulators, coordinate transformation and kinematics, trajectory planning, control techniques, sensors and devices, robot applications and economics analysis.

Course Outcomes:

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

- Use matrix algebra and Lie algebra for computing the kinematics of robots.
- Calculate the forward kinematics and inverse kinematics of serial and paral-lel robots.
- Calculate the Jacobian for serial and parallel robot.
- To do the path planning for a robotic system.
- To use software tools for analysis and design of robotic systems.

Course Content:

Unit	Contents	Contact Hrs.
1.	Fundamentals of land-based robotic systems covering the areas of locomotion, manipulation, grasping, sensory perception, and teleoperation.	7
2.	Kinematics, dynamics, manipulability, motion/force control, real-time programming, controller architecture, motion planning, navigation, and sensor integration, Control system design.	5
3.	Transformation of coordinates, Kinematics and inverse kinematics, Jacobians.	4
4.	Modelling Control, Proportional (P), Proportional-Integral (PI), Proportional-Integral-Derivative (PID) and Model Based Predictive Controller (MPC)	7
5.	Feedback Control System, Motion and path planning, Collision avoidance and navigation	7
6.	Fundamental of AI, Programming methods for robotics, Human-Robot interaction.	6
Total		36

References / Suggested Books:

1. Text Book: Introduction to Robotics by S.K. Saha (Tata McGraw-Hill, New Delhi, India 2008, 1st Reprint 2009)
2. “Introduction to Robitcs: Mechanics and Control”, by Craig, J.J. Publisher : Pear-son, Delhi.
3. “Fundamentals of Robotics: Analysis and Control”, by Schilling Robert J. Pub-lisher : Prentice-Hall, 1990.
4. “An Introduction to Robotics Analysis, Systems, Applications”, by Niku Saeed B. Publisher: Prentice-Hall, 2001.
5. Stuart Russell and Peter Norvig, Publisher: Prentice Hall
6. Literature / books suggested by respective course Lecturers.

Course Title : **EMI/EMC in Military Systems**
Course Code : **DT-EL3-02**
Teaching Scheme : **L: 3, T:0, P:0** **Credits: 3**

Course Objectives:

The course is intended to provide learning on the basic concepts of EMI/EMC design, techniques for prevention of electronic equipment through good EMI/EMC design techniques – grounding, shielding, cable management, and power interface design, troubleshooting techniques, EMI/EMC standards.

Course Outcomes:

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

- Understand the concept of EMI / EMC protection of equipment
- Identify and prevent the common EMI/EMC problems in military systems.
- Understand the Design impact (by requirement) of military EMC specifications.
- Understand EMI/EMC troubleshooting tips and techniques.
- Learn generate EMI/EMC requirements document.

Course Content

Unit	Contents	Contact Hrs.
1.	Basic Concepts: Definition of EMI/EMC and EMP, Classification of EMI/EMC, Sources of EMI, EMI coupling modes, ESD Phenomena and effects, Transient phenomena and suppression,	6
2.	EMC requirements for electronic systems, Non-ideal Behaviors of Components; EMI Measurements: Basic principles of EMI measurements, EMI measuring instruments;	6
3.	EMI Control Methods: Conducted and radiated emissions and susceptibility, Crosstalk and shielding, Grounding, Bonding, Filtering, EMI gasket, Isolation transformer, opto isolator; Faraday cage, isolation of shelters	6
4.	EMC Standard and Regulations: National and Intentional standardizing organizations, Frequency assignment, Spectrum conversation;	5
5.	EMC Design and Interconnection Techniques: Cable routing and connection, Component selection and mounting, PCB design (Trace routing, Impedance control, decoupling, Zoning and grounding);	7
6.	EMC analysis and detection techniques: Using tools for signal integrity analysis, Study eye diagrams for communication systems.	6
	Total	36

References / Suggested Books:

1. "EMI/EMC Computational Modeling Handbook", by brucearchambeault, Omar M. Ramahi, et al.
2. "EMI/EMC Computational Modeling Handbook: 630 (The Springer International Series in Engineering and Computer Science)", by Bruce R. Archambeault, Omar M. Ramahi, et al.
3. "A practical approach to electromagnetic compatibility", by Chetan Kathalay
4. Literature / books suggested by respective course Lecturers.

Course Title : **Defence Electro-Optics and Imaging Systems**
Course Code : **DT-EL3-03**
Teaching Scheme : **L: 3, T:0, P:0** **Credits: 3**

Course Objectives:

The aim of the course is to provide an introduction to the principles of wide range of current and future electro-optic and imaging devices. Course will also to enable students to light on application of electro-optics and imaging system in defence ap-plication.

Course Outcomes:

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

- Understand the technology and principles underpinning electro-optic devices and systems.
- Apply their knowledge to practical electro-optic design and acquisition prob-lems.
- Understand the trade-offs in electro-optic systems design.

Course Content

Unit	Contents	Contact Hrs.
1.	Principles of radiometry, The human eye, Visible band optical sighting systems.	6
2.	Camera systems, Image intensifiers, Missile seekers.	6
3.	Electro-optic countermeasures.	6
4.	Thermal imagers, II cameras, Hyper-spectral imaging, Digital image processing.	7
5.	EO sensors for Lasers and laser DEW	5
6.	Electro-optic protection measures.	6
Total		36

References / Suggested Books:

1. "Systems engineering analysis of electro-optical and Infra red system", by William Wolfgang Arrasmith.
2. "Introduction to Infrared and Electro-Optical Systems", by Author Ronald G. Driggers Ronald G. Driggers.
3. "Handbook of Defence Electronics and Optronics: Fundamentals, Technologies and Systems", by Author(s): Anil K. Maini
4. "Building Electro-Optical Systems: Making It all Work", by Author Philip C. D. Hobbs.
5. "Electro-Optical Instrumentation: Sensing and Measuring with Lasers", by Author Silvano Donati.
6. "Electro-optical systems design, Analysis and testing", by Author Michael C. Dudzik.
7. Literature / books suggested by respective course Lecturers.

Course Title : Structural Dynamics and Aero-elasticity
Course Code : DT-EL3-04
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

The course is intended to provide learning on the mathematics behind the computational analysis, Different methods of analysis, Mathematical modeling of the various phenomena related to vibration analysis, various failure criteria and theory related to elastic fracture.

Course Outcomes:

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

- Understand vibrations and fluid dynamics behind the aerospace system.
- Understand of different design aspects related to loading in aerospace system.
- Do the system dynamic analysis using finite element methods.

Course Content:

Unit	Contents	Contact Hrs.
1.	Principles and methods of computational structural dynamics and vibration analysis.	6
2.	Introduction to dynamic analysis using the finite element method, Calculation of modal parameters.	6
3.	System dynamic response via mode superposition, frequency response, model reduction, and structural synthesis techniques, Fatigue analysis.	7
4.	Introduction to aero-elasticity, Aerodynamic Loading, Bending Moment, Sectional properties of Aerofoil, V-n Diagram,	6
5.	Basic theory of linear elastic fracture mechanics; strain energy release rate;	6
6.	Applications to delamination crack growth in polymer composite laminates, Damage tolerance issues in composites	5
Total		36

References / Suggested Books:

1. "Elements of vibration analysis", by Leonard Meirovitch. Publisher : McGraw-Hill Inc.,US; 2nd edition (1 March 1986)
2. "Finite Element Analysis Theory And Application With ANSYS", by Moaveni Publisher : Pearson Education; 3rd edition (1 January 2011)
3. "Mechanical Vibrations | SI Edition | Sixth Edition", by Singiresu S. Rao. Publisher: Pearson
4. "Elements of Fracture Mechanics", by Prashant Kumar. Publisher : McGraw Hill Education.
5. "Introduction to Structural Dynamics and Aeroelasticity", by Dewey H. Hodges and G. Alvin Pierce. Publisher: Cambridge University Press.
5. Literature / books suggested by respective course Lecturers.

Course Title : **Safety, Health & Hazard Management**
Course Code : **DT-EL3-05**
Teaching Scheme : **L: 3, T:0, P: 0** **Credits: 3**

Course Objectives:

The main objectives of the course will be to inculcate a holistic approach towards safety health and hazard management. The course will provide understanding on the safety & hazard management of the toxic chemicals, gases, explosives etc.

Course Outcomes:

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

- Understand chemical safety standards, fire safety, hazard management.
- Handle toxic liquids & gases, explosives.
- Understand the NBC warfare safety, health & environment safety.

Course Content

Unit	Contents	Contact Hrs.
1.	Chemical Safety: Standards and regulations of chemical safety in Industries or Laboratories, Storage of hazardous chemicals, Compatibility and classification codes, Chemical risk analysis and management	6
2.	Fire triangle and Handling of Toxic, Industrial Gases	4
3.	Hazard Management: HAZOP and HAZAN techniques, Hazard in manufacture, Hazard prevention measures, Disposal of hazardous materials;	7
4.	Warfare: Classifications of explosives based on hazards, Nuclear, biological and chemical warfare safety;	7
5.	Health: Assessment of human factors, Health & Environment safety	6
6.	Nano materials safety (Toxicology study)	6
Total		36

References / Suggested Books:

1. "Occupational Health and Safety Management A Practical Approach", by Charles D. Reese. Publisher : CRC Press.
2. "Occupational and Environmental Safety and Health", Arezes, P.M., Baptista, J.S., Barroso, M.P., Carneiro, P., Cordeiro, P., Costa, N., Melo, R.B., Abreu dos Santos Baptista, J.M., Perestrelo, G. (Eds.). Publisher : Springers, 2019
3. "Handbook of Occupational Safety and Health", by S. Z. Mansdorf. Publisher : Wiley.
4. "Institution of Chemical Engineers", by Trevor Kletz"Hazop and Hazan
5. "Handbook Of Toxicology Of Chemical Warfare Agents", by Ramesh C. Gupta 2nd Edition Elsevier, 2015
6. "Nanomaterials Safety Toxicity And Health Hazards", by Shyamasree Ghosh De Gruyter.
7. "Hazardous Chemicals Handbook", by Phillip Carson, Clive Mumford Butterworth-Heinemann.
8. Literature / books suggested by respective course Lecturers.

Course Title : Fundamental of telemetry, telecommand& transponder
Course Code : DT-EL3-06
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

The main objectives of the course will be to provide knowledge of the students about the satellite communication, telemetry, modulation techniques, target tracking, signal processing of communication systems.

Course Outcomes:

The students will have in depth knowledge on:

- Satellite communication and related technologies.
- Overall control of satellites through collection, processing, and transmission of data.
- Determination of the satellite's exact location through the reception, processing, and transmitting of ranging signals.
- Proper control of satellite through the reception, processing, and implementation of commands transmitted from the ground.

Course Content:

Unit	Contents	Contact Hrs.
1.	Fundamental of satellite communication, different modulation and multiplexing schemes.	6
2.	Satellite Telemetry, Tracking and Tele-command, Multiple Access Techniques Telemetry, Data Transmission, Methods of Modulation, Time Division and Frequency Division Multiplexing, FDMA, TDMA, CDMA and DAMA, Coding Schemes.	6
3.	Satellite Packet Communications, Tracking and Telemetry.	6
4.	Doppler and Electro-Optical methods of tracking, Airborne Missile.	6
5.	Signal Processing: Processing of Signal, Data Acquisition and Reduction.	6
6.	Introduction to satellite communication, transponders.	6
Total		36

References / Suggested Books:

- "Spacecraft TT&C and Information Transmission Theory and Technologies", by, Jiaxing Liu. Publisher : Springer, 2014
- "Introduction to PCM Telemetering Systems", by Stephen Horan. Publisher: CRC Press
- "Satellite Communications Systems: Systems, Techniques and Technology", by Gerard Maral, Michel Bousquet, Zhili Sun. Publisher : Wiley, 2020
- "Satellite Communications", by Timothy Pratt, Jeremy E. Allnutt, 3rd Edition Publisher : Wiley.
- "Principles of Modern Communication Systems", by Samuel O. Agbo , Matthew N. O. Sadiku 2017
- Literature / books suggested by respective course Lecturers.

Course Title : Jamming and ECM/ECCM technologies
Course Code : DT-EL3-07
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives:

The course is intended to provide learning on the concept of jamming, frequency matching, continuous interference, factors affecting ECM, basic principle of noise jamming, different types of jamming systems, ECM techniques, and ECCM.

Course Outcomes:

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

- Understand the concept of electronic attacks.
- Understand the principles and the practical applications of current and evolving electronic jamming technology
- Understand the different types of electronics counter measures and counter – counter measures.

Course Content

Unit	Contents	Contact Hrs.
1.	Principals of Electronic Attack (EA), Jamming-to-Signal Ratio, Jamming Types Burn-Through, Cover Jamming, Range Deceptive Jamming, Inverse Gain Jamming.	7
2.	Repeater Jamming Equations, Noise Jamming vs. Deception, Repeater vs. Transponder, Side lobe Jamming vs. Main lobe Jamming.	6
3.	Stand-Off Jamming, Escort Jamming, Self-Protection Jamming, ECM techniques, On-Board ECM Systems, Off-Board ECM Systems.	5
4.	Infrared Countermeasures (IRCM), Off-Board ECM Systems, Communications Countermeasures (COM-ECM), Electro-Optic Counter Measure (EOCM) Systems.	6
5.	Airborne Tactical Jamming System, Shipboard Self-Defense System, EA/Susceptibility against Weapon Systems. Search Radar Counter-Countermeasures, Tracking Radar.	6
6.	Counter-Countermeasures, Infrared Counter-Countermeasures, Communications Counter-Countermeasures.	6
Total		36

References / Suggested Books:

1. "Electronic Countermeasure and Electronic Counter-Countermeasure", by Bahman Zohuri.
2. "Fundamentals of Electronic Warfare 2001", by S.A. Vakin , L.N. Shustov, R.H. Dunwell.
3. "Communications, Radar and Electronic Warfare by Adrian Graham 2010
4. "Electronic Warfare & Radar Systems Engineering Handbook" 2013, Naval Air Warfare Center Weapons Division.
5. "EW 101: A First Course in Electronic Warfare (Artech House Radar Library)", 1st Edition
6. Literature / books suggested by respective course Lecturers.

Course Title : Software defined Radios
Course Code : DT-EL3-08
Teaching Scheme : L: 3, T:0 , P:0 Credits: 3

Course Objectives:

The course is intended to provide understanding of the fundamental of software defined radios, different aspects of SDRs, practical scenarios along with knowledge of different SDR hardware and software.

Course Outcomes:

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

- Understand the concept, application of SDRs.
- Understand of analog RF components as front end block in implementation of SDR.
- Gain knowledge of digital hardware architectures and its development techniques.
- Gain knowledge of software development for embedded wireless systems.

Course Content:

Unit	Contents	Contact Hrs.
1.	SDR introduction, major standards, SDR architecture, SDR enablers, advantage / disadvantages, Applications.	6
2.	Waveform platform bifurcation, red – black separation, digital modulation- advanced linear and non-linear bandwidth efficient modulations. Bandwidth and power efficiency, peak to average power, error vector magnitude and error probability.	6
3.	SDR Hardware, super-heterodyne architecture, homodyne architecture, advantages & disadvantages, Software for SDR, Processing architecture for SDR.	6
4.	RF channels, receiver channel equalization, multiple access techniques Frequency, time and code division techniques as well as carrier sensing, Wireless sensor networks and beam steering in azimuth and elevation, receiver analogue signal processing, receiver digital signal processing..	6
5.	Source and channel coding (Source and channel coding, sampling, entropy, data compression, voice coding, block and convolution coding, turbo coding, space-time coding and trellis coding).	7
6.	Case studies in software radio design, Introduction and a Historical perspective	5
	Total	36

References / Suggested Books:

1. "Software Radio, (A modern approach to radio engineering)", by Jeffery H.Reed Publisher : PHI PTR.
2. "RF and Digital Signal Processing for Software Defined Radio", by John J. Rouphael. Publisher : Elesiver.
3. "Digital Techniques in Frequency Synthesis", by B.G.Golderg. Publisher: McGraw-Hill.
4. "Multirate Signal Processing", by N.J.Fliege. Publisher: John Wiley and sons.
5. Literature / books suggested by respective course Lecturers.

Course Title : Advanced Lightweight and Composite Structures
Course Code : DT-EL3-09
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

The main objectives of this course is to impart thorough knowledge of advanced composite materials, their manufacturing techniques and to develop mathematical models & design structures made of composites. Basic understanding of structures used in airborne systems like missiles and aircrafts& their performance under static and dynamic loading, including crash and bird strike will also be covered.

Course Outcomes:

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

- Understand the design of advanced structures and lightweight materials for aerospace materials.
- Understand the numerical and analytical skills in structural mechanics for both composite and metallic components.
- Apply knowledge to solve real engineering problems.

Course Content:

Unit	Contents	Contact Hrs.
1.	Review of Strength of Materials, Introduction to Aerospace Materials – Metal Alloys and Fiber Reinforced Composite	6
2.	Introduction to different types of constructions: Monocoque, Semi-Monocoque, Truss, and Corrugated shell	7
3.	Introduction to Aircraft and Missile Structural Components: Spars; Ribs; Stringer; Longerons	6
4.	Analysis of stress; Analysis of strain	7
5.	Material Constitutive Relations	5
6.	Failure Theories; Fatigue theory	5
Total		36

References / Suggested Books:

1. "Composite Structures Safety Management", by Dr. Bjorn Backman. Publisher : Elsevier Science.
2. "Composite Structures: Design, Mechanics, Analysis, Manufacturing and Testing", by Manoj Kumar Buragohain. Publisher : CRC Press.
3. "Lightweight Composite Structures in Transport: Design, Manufacturing, Analy-sis and Performance", by James Njuguna Woodhead Publishing, 2016
4. "Structural and Stress Analysis", by T.H.G. Megson. Publisher: Butterworth-Heinemann.
5. Literature / books suggested by respective course Lecturers.

Course Title : Test Methodologies for DEW Systems (Lasers & Microwave)
Course Code : DT-EL3-10
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

The course is intended to provide learning on the testing requirements, characterization, system performance testing procedures, test setups, safety standards, safety tools of laser and microwave based DEW systems.

Course Outcomes:

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

- Understand the characterization and testing requirements of DEW systems.
- Carry out the indoors & outdoors system performance testing.
- Understand the safety issues, safety standards, handling high power sources.

Course Content:

Unit	Contents	Contact Hrs.
1.	Testing requirements of DEW system, types of testing, laser effect testing on target, system output testing.	6
2.	System performance testing, System outdoor test & measurement instruments.	7
3.	Laser testing issues, Laser safety, Laser safety standards, laser safety tools.	5
4.	Microwave system testing Impedance measurement, S-Parameters and the Smith Chart.	5
5.	Power Measurement, Noise Figure and Phase Noise measurement, Frequency measurements (Spectrum Analysis), Gain Compression and Intermodulation, Network Analysis,	7
6.	Microwave subsystem / system characterization techniques. HPM safety tools, safety standards.	6
Total		36

References / Suggested Books:

1. "An Introduction to Microwave Measurements", by Ananjan Basu.
2. Literature / books suggested by respective course Lecturers.

Course Title : Advanced Analytical techniques/Lab testing
Course Code : DT-EL3-11
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

The main objective of the course is to impart an in-depth knowledge of material characterization by all the conventional well established techniques used worldwide. The course provides understanding on the material characterization, having main focus on polymeric techniques, chromatography and Spectroscopy.

Course Outcomes:

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

- Understand different characterization techniques.
- Applyappropriateanalyticaltechniqueforaparticularmaterialorganic/ inorganic/ nanomaterial/ polymer etc.

Course Content:

Unit	Contents	Contact Hrs.
1.	Instrumental Analysis: Qualitative analysis	4
2.	Genesis of instrumental analysis, hyphenated techniques	4
3.	Polymeric Techniques: Rheology Techniques, Molecular weight determination; Thermal Techniques: Thermo Gravimetry (TG), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC)	8
4.	Chromatographic Techniques: Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Thin Layer Chromatography (TLC), Ion chromatography	8
5.	Spectroscopy: Ultra Violet-Visible Spectroscopy UV-VIS, Infra-Red spectroscopy (IR), Nuclear Magnetic Resonance (NMR), Mass spectroscopy, Atomic Absorption Spectroscopy (AAS)	8
6.	XRD and SEM techniques, Sensitivity studies.	4
Total		36

References / Suggested Books:

1. "Fundamentals of molecular spectroscopy" by C. N. Banwell. Publisher : McGraw Hills.
2. "Introduction to Spectroscopy" by Donald L. Pavia, Gary M. Lampman, and George S. Kriz. Publisher: Cengage Learning, 2014.
3. "Chromatography: Concepts and Contrasts" by James M. Miller. Publisher : Wiley.
4. "Chromatography: Principles and Instrumentation", by Mark F. Vitha. Publisher: Wiley.
5. "Elements of X-Ray Diff action" by B.D. Cullity Deceased, S.R. Stock. Publisher : Pearson.
6. "Electron Microscopy: Principles and Fundamentals" by S. Amelinckx, Dirk van Dyck, J. van Landuyt, Gustaaf van Tendeloo. Publisher : Wiley.
7. "Polymer Characterization: Physical Techniques", by Dan Campbell, Richard A. Pethrick, Jim R. White 2nd Edition. Publisher CRC Press.
8. Literature / books suggested by respective course Lecturers.

Course Title : SONAR System Engineering
Course Code : DT-EL3-12
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

The objective of the course is to provide an in-depth understanding of underwater acoustic principles, sonar technology and applications, hardware and software design engineers new to sonar system design.

Course Outcomes:

After the successful completion of the course student should be able to

- Know the basic building blocks of a radar system.
- Have an in-depth knowledge on different types of signals that are used.
- Know about the ambiguity function and its significance in radar signal processing.
- Know the physics behind sound propagation in water and principle of operation of sonar.
- Apply the knowledge acquired in this course in real time applications.

Course Content

Unit	Contents	Contact Hrs.
1.	Mathematical development and discussion of fundamental principles that pertain to the design and operation of passive and active sonar systems critical to naval operation.	6
2.	Topics from complex aperture theory, array theory.	6
3.	Signal processing	5
4.	Introduction to undersea warfare and engineering acoustics	6
5.	Principles of optimal signal processing techniques for detecting signals in noise, maximum likelihood, Bayes risk.	7
6.	Neyman-Pearson and min-max criteria and calculations of their associated error probabilities (ROC curves)	6
Total		36

References / Suggested Books:

1. "Fundamentals of Radar, Sonar and Navigation Engineering", by K. K. Sharma.
2. "Principles of Modern Radar: Advanced techniques", by editor William L. Mel-vin.
3. "An Introduction to Sonar Systems Engineering", by Lawrence J. Ziomek.
4. "Sonar for practicing engineers", by A. D. Waite.
5. "Underwater Acoustics: Analysis, Design and Performance of Sonar", by Rich-ard P. Hodges.
6. Literature / books suggested by respective course Lecturers

Semester 2, Elective – 4 Courses

Course Title : Unmanned Aerial Vehicle Design
Course Code : DT-EL4-01
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives:

The course is intended to provide the understanding of the initial designing and sizing process for rapidly growing fi ed – wing UAV technology, integrated with its performance and stability analysis, air-safety issues, airworthiness and prototype testing.

Course Outcomes:

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

- Understand the design requirements, design parameters of UAV.
- Perform the aerodynamic analysis, performance and stability analysis.
- Understand the performance testing of the UAVs.
- Understand the airworthiness and safety requirements of UAV.

Course Content:

Unit	Contents	Contact Hrs.
1.	UAV design Requirements, design parameters, design algorithms, Certification approaches: aircrafts and UAVs. Airworthiness of aircrafts and UAVs.	6
2.	Air safety issues. Handling qualities. Maneuverability requirements. Aircraft design; UAV system design. UAV system identification	6
3.	UAV aerodynamics, structures and propulsion, performance and stability analysis.	7
4.	UAV project life cycles. Stages of Aircraft design. Initial sizing: aircrafts and of UAVs.	6
5.	Ground control systems. Ground and flight testing of UAVs. UAV guidance and Navigation. Design for reliability.	5
6.	Wind Tunnel Testing, Aerodynamic Characterization through Wind Tunnel Testing.	6
Total		36

References / Suggested Books:

1. "Introduction to Flight", by John D. Anderson
2. "Performance, Stability, Dynamics, and Control of Airplanes", by Bandu N. Pamadi.
3. "Aircraft performance and design", by John D. Anderson.
4. "Unmanned Aircraft Design A review of fundamentals", by Mohammad H. Sadraey.
5. "Aircraft Design : A Conceptual Approach", by Daniel P. Raymer.
6. "Unmanned Aircraft Systems : UAVs Design Development and Deployment", by Reg Austin.
7. "Small Unmanned Fixed-wing Aircraft Design: A Practical Approach", by Andrew J. Keane and James P. Scanlan.
8. Literature / books suggested by respective course Lecturers.

Course Title : Naval Ocean Analysis and Prediction
Course Code : DT-EL4-02
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

The course is intended to provide understanding of the science and art of Naval Ocean. They will learn methods of analysis of ocean data, to model Naval ocean, to generate global ocean circulation prediction system, Shallow Water Analysis and Forecast System (SWAFS).

Course Outcomes:

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

- Understand and develop the Navy Ocean modeling and prediction program.
- Understand the need to evaluate ocean models and prediction systems for operational and tactical applications.
- Understand and predict environmental conditions in the coastal ocean.

Course Content:

Unit	Contents	Contact Hrs.
1.	Advanced knowledge of the Indian Navy ocean analysis and prediction systems.	6
2.	Naval Ocean Modeling Program (NOMP), Naval ocean data systems.	5
3.	Atmospheric forcing systems, data assimilation systems.	6
4.	Optimal Thermal Interpolation System (OTIS), Thermal Ocean Prediction Systems (TOPS).	6
5.	Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface layer, and bulk formula for estimating air-sea fluxes.	7
6.	The global ocean circulation prediction system, Shallow Water Analysis and Forecast System (SWAFS), Knowledge of ocean eddies.	6
Total		36

References / Suggested Books:

1. Indian Navy: Ocean of opportunities (Defence Series Books) Author: by PRANAV ZOPE
2. Elements of Ocean Engineering. Author Robert E. Randall
3. Ocean Modelling for Beginners - Using Open-Source Software. Author Jochen Kaempf.
4. Literature / books suggested by respective course Lecturers.

Course Title : Modeling &Simulation of Laser Matter Interaction
Course Code : DT-EL4-03
Teaching Scheme : L: 3, T: 0, P: 0 Credits: 3

Course Objectives:

The course is intended to provide understanding on the high power laser beam interaction with metals and composite materials, physics based models for the lethality modeling, damage mechanism & damage threshold measurement techniques and performance evaluation of high power laser systems.

Course Outcomes:

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

- Understand of the laser matter interaction.
- Develop physics-based model for evaluation of effect of laser on metals and composites.
- Understand the laser parameter measurement techniques.
- Analyze the performance of high-power laser systems.

Course Content:

Unit	Contents	Contact Hrs.
1.	Laser beam characteristics, Laser lethality modeling & simulation with metal targets & composite materials.	5
2.	Physics based models for vulnerability assessment, Effect of laser on metals & composite materials.	7
3.	Measurement and Characterization of Damage Thresholds, Mechanisms of Damage, Exposure Limits and Their Interpretation.	7
4.	Analysis Tools for the Estimation of Hazards, Laser parameters measurement techniques.	6
5.	Tools to analyze and predict Laser System performance under different conditions like land, sea air, etc.	5
6.	Introduction of full scale end to end modeling of laser system performance.	6
Total		36

References / Suggested Books:

1. "High Power Laser-Matter Interaction", by Mulser, Peter, Bauer, Dieter. Publisher : Springer.
2. Literature / books suggested by respective course Lecturers.

Course Title : Computational Aerodynamics
Course Code : DT-EL4-04
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

The course is intended to provide learning on the computational aerodynamics, numerical methods for solving systems of equations, numerical modelling of fluids, CFD analysis, turbulence modelling.

Course Outcomes:

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

- Understand the CFD analysis, fluid mechanics, heat transfer analysis, numerical modelling of fluids.
- Generate numerical model related to fluid dynamics
- To do the pre and post processing of CFD analysis.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction to fluid mechanics & heat transfer,	5
2.	Introduction to numerical analysis, Discretisation approaches: finite difference, finite volume, finite element and spectral methods,	6
3.	Numerical methods for algebraic equations/systems of equations, Numerical schemes for hyperbolic, parabolic and elliptic systems and for fluid dynamics,	6
4.	CFD analysis	7
5.	Numerical modeling of compressible & in-compressible flow, turbulence modeling,	6
6.	Grid generation/CAD, data analysis and uncertainties.	6
	Total	40

References / Suggested Books:

1. "A Textbook of Heat Transfer Paperback", by S.P. Sukhatme. Publisher: Univer-sities Press.
2. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", by H. Versteeg. Publisher : Pearson.
3. "Computational Fluid Dynamics the Basics with Applications", by John D. An-derson, Jr. Publisher : McGraw Hill Education.
4. "Fluid Mechanics: Volume 2: Foundations and Applications of Mechanics (Cambridge-iisc)", by C. S. Jog. Publisher : Cambridge University Press; 3rd edi-tion.
5. "Numerical Modeling and Computer Simulation", Edited by DraganCvetković, publisher intechopen.
6. Literature / books suggested by respective course Lecturers.

Course Title : Launch Vehicle Design & Analysis
Course Code : DT-EL4-05
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

The course is intended to provide learning on the launch vehicle design and analysis, components and subsystems of the launch vehicle, propulsion systems.

Course Outcomes:

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

- Understand the launch vehicle requirements, its functioning.
- Design and analysis of launch vehicles.
- Understand the propellant requirement for launch vehicles.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction to propulsion for launch vehicles, beginning with mission energy requirements and an overview of current and proposed launch propulsion devices.	6
2.	Performance analysis, operating characteristics and propellant selection criteria for air breathing and solid	5
3.	Liquid and nuclear rocket motor propulsion systems.	7
4.	Advanced cycles and concepts are presented. Design of components and subsystems	7
5.	FE modelling: Idealization, Discretization, Meshing and Post Processing,	6
6.	Tracking and controlling errors, Nonlinear analysis in FEM, Launch dynamic analysis.	5
	Total	36

References / Suggested Books:

1. "Design of Rockets and Space Launch Vehicles", by Don Edberg, Willie Costa. Publisher : American Institute of Aeronauti cs & Ast. (August 21, 2020)
2. "Modern Engineering for Design of Liquid Propellant Rocket Engines (Progress in Astronautics and Aeronautics)", by Dieter K Huzel, David H Huang. Publish-er : AIAA (American Institute of Aeronautics & Astronautics); Revised, Subse-quent edition.
3. "Fundamentals of Astrodynamics 1st Edition", by Roger R. Bate, Donald D. Mueller. Publisher: The American Design Ethic, MIT, USA.
4. "Commercial Launch Vehicle Design", by Nickolay Mykola Zosimovych. Pub-lisher: Lap Lambert Academic Publishing.
5. "Space Vehicle Design, Second Edition", by Michael D. Griffi and James R. French. Publisher The American Institute of Aeronautics and Astronautics, Inc.
6. Literature / books suggested by respective course Lecturers.

Course Title : Acquisition, Tracking & Pointing Technology
Course Code : DT-EL4-06
Teaching Scheme : L: 3, T: 0, P: 0 Credits: 3

Course Objectives:

The course is intended to provide learning on the acquisition, tracking & pointing technologies, development of tracking algorithms, design and analysis of tracking systems.

Course Outcomes:

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

- Understand the concepts and basic systems requirements tracking systems.
- Understand the system configurations and critical component characteristics required in the design of stabilized pointing and tracking systems, along with an introduction to some more advanced concepts.
- Understand the control system and algorithm techniques and practices com-monly utilized in the design of tracking systems.

Course Content:

Unit	Contents	Contact Hrs.
1.	Acquisition, tracking, and pointing (ATP) design for military systems	6
2.	Target tracking and related mathematics, SNR requirement, the Johnson criteria, probability of estimation, detection criteria	6
3.	Tracking algorithms, track filters, multi target tracking,	6
4.	Electronic countermeasures against modern target tracking radars	7
5.	multiplatform-multi-sensor-multi target tracking	6
6.	Doppler and Electro-Optical methods of tracking	5
Total		36

References / Suggested Books:

1. "Acquisition, Tracking, Pointing, and Laser Systems Technologies XXI (Pro-ceedings of SPIE)" 30 October 2007 by Steven L. Chodos (Editor), William E. Thompson (Editor).
2. "Acquisition, Tracking, and Pointing, January 2017 In book: Free Space Optical Communication", by Hemani Kaushal, Vk Jain and SubratKar. Publisher: Springer India.
3. Literature / books suggested by respective course Lecturers.

Course Title : Data acquisition, tracking & post flight analysis
Course Code : DT-EL4-07
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

The course is intended to provide learning on the various aspects of flight trials, measurements & calibration, Generation & analysis of Data.

Course Outcomes:

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

- Understand the interfaces used in data acquisition and standalone instruments to real-world signals.
- Understand the Sensors and transducers, Data acquisition hardware and data acquisition software
- Carry out post flight analysis.

Course Content:

Unit	Contents	Contact Hrs.
1.	Importance of Flight Trials in Missile Development, Facilities, Safety Requirements	4
2.	Methods of Measurement, Introduction to Measuring Instruments: Functional elements of an instrument	6
3.	Static and Dynamic Characteristics, Zero, First and Second order of Instruments and their response	6
4.	Calibration of Instruments	5
5.	Sensors and Transducers: Passive and Active types, their uses in measurement of acceleration, angle, vibration, pressure, flow and temperature, strain etc.,	8
6.	Methods for post flight data analysis.	7
Total		36

References / Suggested Books:

1. "Advances in Missile Guidance, Control, and Estimation: 47 (Automation and Control Engineering)", by editors S.N. Balakrishnan, A. Tsourdos, B.A. White.
2. "Calibration Handbook of Measuring Instruments 1st Edition", by Alessandro Brunelli. Publisher : International Society of Automation.
3. "Calibration Book", by Janne Kivilaakso, Antero Pitkäkoski Jori Valli, Mike Johnson, Nobuo Inamoto Arja Aukia Masaki Saito. Publisher: VaisalaOyj.
4. "Sensors and Transducers", by Patranabis D. Publisher : Prentice Hall India Learning Private Limited.
5. "Sensors And Transducers Paperback", by Ian Sinclair. Publisher : Elsevier.
6. Literature / books suggested by respective course Lecturers.

Course Title : Air Independent Propulsion and Batteries
Course Code : DT-EL4-08
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objective

The course is intended to provide learning on the air independent propulsion systems, hybrid electric vehicles, power requirement of the vehicles, energy storage systems.

Course Outcome:

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

- Understand the requirements of air independent propulsion systems.
- Design and analysis of hybrid electric drive trains.
- Design and analysis Energy storage systems for hybrid electric vehicles.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction to Hybrid Electric Vehicles: Impact of modern drive-trains on energy supplies;	6
2.	Hybrid Electric Drive-trains: hybrid traction, various hybrid drive-train topologies, power flow control, fuel efficiency analysis;	7
3.	Electric Drive-trains: electric traction, electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis;	7
4.	Electric Propulsion unit: electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives, drive system efficiency;	6
5.	Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles,	6
6.	Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.	6
Total		36

References / Suggested Books:

1. "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", by Chris Mi, M. Abul Masrur. Publisher: Wiley.
2. "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Second Edition (Power Electronics and Applications Series)", by Mehrdad Ehsani, YiminGao, Ali Emadi, Publisher : Standards media.
3. Literature / books suggested by respective course Lecturers.

Course Title : Advanced digital modulation technologies & standards
Course Code : DT-EL4-09
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

The objective of this course is to provide knowledge on the engineering principles, theories and practices of a digital communication system. The course will deal with the design principles of transmitter and receiver so as to establish a reliable communication link.

Course Outcomes:

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

- Understand the design digital communication systems.
- Understand the transmitter, receiver communications system models, voice source coding– pulse code modulation, delta modulation and vocoders.
- Understand the requirement of cellular communication.

Course Content:

Unit	Contents	Contact Hrs.
1.	Design of digital communication system, transmitter and receiver communications system model	6
2.	Voice source coding– pulse code modulation, delta modulation, vocoders	6
3.	Digital modulation – Amplitude-shift, Frequency-shift, Phase-shift, differential phase-shift, Quadrature phase-shift, Quadrature phase-shift, and Minimum-shift keying, Quadrature amplitude modulation	8
4.	Communications channel – Multipath effects, fading and diversity, models of Egli and Murphy	6
5.	Receivers – super heterodyne systems, balanced and unbalanced mixers, frequency synthesizers, Link budget analysis	5
6.	Introduction to cellular communication – CDMA, OFDM, MIMO, Introduction to digital modulation standards.	5
Total		36

References / Suggested Books:

- "Communication Systems", by, Haykin, S. Publisher : John Wiley & Sons.
- "Modern Digital and Analog Communication Systems", by, Lathi, B.P. and Ding, Z. Publisher: Oxford University Press.

- "Signal Processing for Wireless Communication Systems", by H. Vincent Poor, Lang Tong, Publisher : Springers.
- "Digital Communication: Fundamentals and Applications", by Sklar, B., and Ray, P.K. Dorling Kindersley.
- "Communication Systems: An Introduction to Signals and Noise in Electrical Communication", by Carlson, A.B., Crilly, P.B. and Rutledge, J.C Publisher: McGraw-Hill.
- "Detection, Estimation and Modulation Theory Part I", by Van Trees, H.L. Publisher : Wiley Inter science.
- "Information Theory, Coding and Cryptography", by Bose, R. Tata McGraw-Hill.
- "Digital Communication", by Barry, J.R., Lee, E.A. and Messerschmitt, D.G.Kluwer.
- "Principles of Digital Transmission: Wireless Applications", by Benedetto, S. and Biglieri, E. Publisher : Springer.
- Literature / books suggested by respective course Lecturers.

Course Title : Trajectories modelling& simulation
Course Code : DT-EL4-10
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

The course is intended to provide the understanding of flight dynamics, trajectory design analysis, flight performance analysis and practical implications of trajectory planning.

Course Outcomes:

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

- Understand the flight trajectories design requirements.
- Evaluate and predict the flight performance for different trajectories.
- Understand the practical implications while trajectory design.
- Carry out MATLAB based simulation for trajectory modelling.

Course Content:

Unit	Contents	Contact Hrs.
1.	Flight Dynamics, Flight envelope limitations. Aerodynamic sizing-equations of motion. Accuracy of simplified equations of motion, orbital mechanics.	6
2.	Role of rocket propulsion in orbital trajectories and maneuvers, Maximizing missile flight performance. Benefits of flight trajectory shaping.	7
3.	Flight performance prediction of boost, climb, cruise, coast, steady descent, ballistic, maneuvering, divert, and homing flight.	7
4.	Practical implementation of integrated trajectory planning, Agility in maneuvering trajectories.	5
5.	Multiplier theory and its use in solving practical problems covered from a real-time computational viewpoint, No-fly zones and engineering requirements, formulation as a mathematical mixture of state and decision-variable constraints.	5
6.	Extensive MATLAB-based mini-projects.	6
Total		36

References / Suggested Books:

1. "Flight Dynamics", by Robert F. Stengel. Publisher : Princeton University Press.
2. Literature / books suggested by respective course Lecturers.

Course Title : Sensor Technology
Course Code : DT-EL4-11
Teaching Scheme : L: 3, T: 0, P: 0 Credits: 3

Course Objectives:

The main objective of the course is to provide learning on the basic physical principles and characteristic features in sensor technology, design, function and applications of different sensors.

Course Outcomes:

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

- Understand the basic principles of sensor systems required for satellites and tactical aircraft.
- Understand the atmospheric propagation and its impact on the performance of sensors
- Troubleshoot, repair/replace a faulty sensor in optimize process efficiency.

Course Content:

Unit	Contents	Contact Hrs.
1.	Physical principles underlying the sensor systems needed for satellites and tactical aircraft, as well as limitations imposed by the atmosphere and operating environment on these systems and their communication links,	6
2.	Phased array and pulsed compressed radars, imaging synthetic aperture and inverse synthetic aperture radars	5
3.	Atmospheric propagation of signal. Noise resources and thermal radiation	5
4.	Principles of semiconductor devices. Optical and infrared imaging detector systems.	8
5.	Detector resolution limitations and bandwidth requirements, Relationship between signals and noise.	6
6.	The characteristics of critical sensor functions (including detection, estimation, imaging, and tracking).	6
Total		36

References / Suggested Books:

1. "Handbook of Modern Sensors", by Jacob Fraden. Publisher : Springer.
2. "Micro sensors, Principles and Applications", by J. W. Gardner. Publisher : Wiley.
3. "Semiconductor Sensors", by S. M. Sze. Publisher : Wiley.
4. Literature / books suggested by respective course Lecturers.

* The communication has been done with the DRDO Laboratory for getting the details of laboratory work under semester 1 &2. The document will be amended once the details of laboratory work are finalized.

Annexure A

List of DRDO Labs

Sl No	DRDO Labs	Location
1.	Aerial Delivery Research & Development Establishment (ADRDE)	Agra
2.	Vehicle Research & Development Establishment (VRDE)	Ahmadnagar
3.	Naval Materials Research Laboratory (NMRL)	Ambernath
4.	Combat Vehicles Research & Development Establishment (CVRDE)	Avadi
5.	Integrated Test Range (ITR)	Balasore
6.	Aeronautical Development Establishment (ADE)	Bengaluru
7.	Centre for Air Borne System (CABS)	Bengaluru
8.	Centre for Artificial Intelligence & Robotics (CAIR)	Bengaluru
9.	Centre for Military Airworthiness & Certification (CEMILAC)	Bengaluru
10.	Defence Avionics Research Establishment (DARE)	Bengaluru
11.	Electronics & Radar Development Establishment (LRDE)	Bengaluru
12.	Microwave Tube Research & Development Centre (MTRDC)	Bengaluru
13.	Gas Turbine Research Establishment (GTRE)	Bengaluru
14.	Advanced Systems Laboratory (ASL)	Bengaluru
15.	Centre for Advanced Systems (CAS)	Bengaluru
16.	Centre for High Energy Systems and Sciences (CHESS)	Bengaluru
17.	Defence Electronics Research Laboratory (DLRL)	Bengaluru
18.	DGRE	Chandigarh
19.	Defence Metallurgical Research Laboratory (DMRL)	Bengaluru
20.	Defence Research & Development Laboratory (DRDL)	Bengaluru
21.	Research Centre Imarat (RCI)	Bengaluru

22.	Terminal Ballistics Research Laboratory (TBRL)	Chandigarh
23.	Naval Physical & Oceanographic Laboratory (NPOL)	Cochin
24.	Defence Electronics Applications Laboratory (DEAL)	Dehradun
25.	Instruments Research & Development Establishment (IRDE)	Dehradun
26.	Advanced Numerical Research & Analysis Group (ANURAG)	Hyderabad
27.	Advanced Systems Laboratory (ASL)	Hyderabad
28.	Centre for Advanced Systems (CAS)	Hyderabad
29.	Centre for High Energy Systems and Sciences (CHESS)	Hyderabad
30.	Defence Electronics Research Laboratory (DLRL)	Hyderabad
31.	Defence Metallurgical Research Laboratory (DMRL)	Hyderabad
32.	Defence Research & Development Laboratory (DRDL)	Hyderabad
33.	Research Centre Imarat (RCI)	Hyderabad
34.	Defence Materials & Stores R&D Establishment (DMSRDE)	Kanpur
35.	Defence Research and Development Establishment (DRDE)	Gwalior
36.	Centre for Millimeter Wave Semiconductor Devices & Systems (CMSDS)	Kolkata
37.	High Energy Materials Research Laboratory (HEMRL)	Pune
38.	Armament Research & Development Establishment (ARDE)	Pune
39.	Research & Development Establishment (Engrs) [R&D (Engrs)]	Pune
40.	Naval Science & Technological Laboratory (NSTL)	Visakhapatnam

* The communication has been done with the DRDO Laboratories for getting the contact details of nodal contact point. The information received from the DRDO labs will be provided soon.

Annexure B

M.Tech. (Defence Technology)
Provisional List of Superannuated Scientists from DRDO Labs

Following is the provisional list of the superannuated senior scientists from DRDO labs who are interested in taking the teaching assignments / guest lectures for the M.Tech. (Defence Technology). The list will be updated as more willing working / superannuated scientist interested for taking lectures are identified. The academic institute may also create a pool of willing faculties to take lecturers for the mentioned courses.

Semester -1 (Compulsory Courses)

S. No.	Subjects	Name & Designation	Contact Details	Associated DRDO Lab	Location
1.	Systems and Platforms	Dr Vikas Kumar (Naval)	9849597942	DMRL	Hyderabad
		Sh C. Govindarajan (Combat Vehicles)	9962022929	CVRDE	Chennai
		Sh Srikumar P (Aero)	09448231455	ADE	Bangalore
		Sri. Bhave SM (Naval)	9440858537	NSTL	Vizag
		Sh. K Sreethar (Artillery)	9841323414	CVRDE	Chennai
		Sh. K B Satyanarayana (Combat vehicles)	8500305996	CHESS	Hyderabad
		Sh. Mukesh Chand (Aero)	9490956151	DRDL	Hyderabad
		Sh. Sharma Rakesh Kumar (Aero)	9989157000	DRDL	Hyderabad
		Sh. Karthikeyan S	09482479046	SEMILAC	Bangalore
		Sh. P C Verma (Instrumentation)	94410319061	IRDE	Dehradun
		Sh. U Solomon (Combat Vehicles)	9445040353 / 9629952303	CVRDE	Chennai
		Sh. Suranjan Pal (Laser)	9868240545	HQ	Delhi
		Sh. KSS Rao (Laser)	9885031113	DLRL	Hyderabad
2.	Warefare,Simulations & Strategies	Dr. R N Pralhad (Ballistic, modeling, simulation)	9764157707	DG(ACE)	Pune
		Sh. S T Shah (Armaments)	9422005720	ARDE	Pune
		Sh. P Raghevendra Rao (Warfare)	9490792715	DLRL	Hyderabad
		Prof. G Kumaraswami Rao (Warfare)	9347611184 / 9440881501	DLRL	Hyderabad
3.	Advanced Engineering Mathematics	Sh. Subbukutti S	09448011201	ADE	Bangalore
		Dr. K K Chand (System analysis & modeling)	9437453842 / 9437026085	PXE	Balasore
		Course can be taken by Institute Faculty.			

Semester-1 Elective 1

S. No.	Subjects	Name & Designation	Contact Details	Associated DRDO Lab	Location
1.	Rockets& Missiles Fundamentals	Dr. Vijay Govund Borkar	9441282985, 040-29552985	RCI	Hyderabad
		Dr. Gadgil SB		RCI	Hyderabad
		Sh. Mukesh Chand	9490956151 mcag2009@ gmail.com	DRDL	Gaziabad
2.	Advanced Thermal Engineering	N Venkateswaran	9444947188 kasven1985@ gmail.com	CVRDE	Chennai
		Course can be taken by Institute Faculty.			
3.	Numerical methods for Science & Engineering	Dr. K K Chand	9437453842, 9437026085 kkchandpxe@ hotmail.com	PXE	Balasore
		Sh. Subbukutti S	9448011201	ADE	Bangalore
		Course can be taken by Institute Faculty.			
4.	Communication Technology	Mrs. Sekhar Sellammal	9910011797	HQ_DER&IPR	Delhi
		Sh. L Gnana Michael	9448365755 lgmprakasam@ gmail.com	LRDE	Bangalore
		Sh. G Kumaraswamy Rao	9347611184 9440881501	DLRL	Hyderabad
		Sh. Hemant Gupta	9811378026	HQ_DFTM	Delhi
		Dr. R J Mukhedkar	9423012225	ARDE	Pune
		Sh. K Ramesh	9448380617	CAIR	Bangalore
		Course can be taken by Institute Faculty.			
5.	Advanced Mechanical Engineering	Dr Kumar S Sai	09490956638	DRDL	Hyderabad
		Shri Murthy JK	09490166633	RCI	Hyderabad
		Course can be taken by Institute Faculty.			

Semester-1 Elective 2

S. No.	Subjects	Name & Designation	Contact Details	Associated DRDO Lab	Location
1.	Autonomy and Navigation Technology	K Ramesh	9448380617	CAIR	Bangalore
		R Regunathan	9448383361	CAIR	Bangalore
		Dr. N Rama Murhty	9449346693	CAIR	Bangalore
		Sh. S Varadarajan	9448324568 varad1950@ gmail.com	LRDE	Bangalore
		Sh. L Gnana Michael	9448365755 lgmprakasam@ gmail.com	LRDE	Bangalore
		Sh. G Kumaraswamy Rao	9347611184 9440881501	DLRL	Hyderabad
		Course can be taken by Institute Faculty.			
2.	Optimization Theory & Applications	In process of selection / identification of lecturers. Course can also be taken by Institute Faculty.			
3.	Military Electronics System Engineering	Sh. Sangamkar AK	9490956850	DRDL	Hyderabad
		Course can be taken by Institute Faculty.			
4.	System Engineering & Analysis	Dr. K K Chand (System analysis & modeling)	9437453842 / 9437026085	PXE	Balasore
		Sh. B Bhaskar Rao (System Eng. & Analysis)	9483775480	DLRL	Hyderabad
		Sh. B V Nityanand (System Eng. & Analysis)		DLRL	Hyderabad
		Sh. C Chandrasekharan (QC, Management)	9444703314	CVRDE	Chennai
		Sh. Aga Mirkhushal (Reliability)	8788869930	GTRE	Bangalore
		Dr. Shivpal Singh Panwar (Reliability)	9440125067	DRDL	Hyderabad
		Course can be taken by Institute Faculty.			

Semester 2 – Aerospace Technology (Compulsory Course)

S. No.	Subjects	Name & Designation	Contact Details	Associated DRDO Lab	Location
1.	Aerospace System Configuration, Design & Simulation	Shri Srikumar P	09448231455 psrikumar@nias@res.in	ADE	Bangalore
		Shri Thakur DN	09490956181	DRDL	Hyderabad
		Shri Mukesh Chand	09490956151	DRDL	Hyderabad
		Shri Sharma Rakesh Kumar	09989157000	DRDL	Hyderabad
		Dr Satyanarayana A	09490956232	DRDL	Hyderabad
		Shri Prabhakaran V	09449649186	ADE	Bangalore
2.	Guidance & control	Air Commode P Banerjee	9674279119	ITR	Balasore
		Dr. A K Sarkar	9490748628	DRDL	Hyderabad
		Sh. Mahendra Jha	9423009850	ARDE	Pune
3.	Aerospace Propulsion	Sh. K Jana	9437754489	ITR	Balasore
		Sh. Kamal Sagarmail Jain	9049872281 jainkamalsa@gmail.com	VRDE	Pune
		Dr. R N Pralhad	9403321102 / 9764157707	ARDE	Pune
		Sh. Y S Dhoke	9673145127	ARDE	Pune
		Dr. R J Mukhedkar	9423012225	ARDE	Pune
		Sh. V Sundararajan	9741012514	GTRE	Bangalore
		Sh. T Venkatakrishnaiah	9902919644	GTRE	Bangalore
		Shri Chandramouli G	09848347443	DRDL	Hyderabad

Semester 2 – Communication Systems & Sensors (Compulsory Course)

S. No.	Subjects	Name & Designation	Contact Details	Associated DRDO Lab	Location
1.	Radar Technologies	Sh. S Varadarajan	9448324568 varad1950@gmail.com	LRDE	Bangalore
		Dr. D C Pandey	9449048858 pande.dc@gmail.com	LRDE	Bangalore
		Sh. L Gnana Michael	9448365755 lgmprakasam@gmail.com	LRDE	Bangalore
		Sh. G Kumaraswamy Rao, Sc 'H'	9347611184 9440881501	DLRL	Hyderabad
		Dr. M Lakshminarayana	9440805818	DLRL	Hyderabad
		Dr. B Rama Krishna Rao	9949418424	DLRL	Hyderabad
		Sh. T V Prakash Rao	9845662650	DLRL	Hyderabad
		Course can be taken by Institute Faculty.			
2.	Digital & satellite Communication and Navigation from Space	K Ramesh	9448380617	CAIR	Bangalore
		R Regunathan	9448383361	CAIR	Bangalore
		Dr. N Rama Murhty	9449346693	CAIR	Bangalore
		Sh. S Varadarajan	9448324568 varad1950@gmail.com	LRDE	Bangalore
		Sh. L Gnana Michael	9448365755 lgmprakasam@gmail.com	LRDE	Bangalore
		Sh. G Kumaraswamy Rao, Sc 'H'	9347611184 9440881501	DLRL	Hyderabad
		Dr. M Lakshminarayana	9440805818	DLRL	Hyderabad
		Course can also be taken by Institute Faculty.			

3.	Tactical battlefield Communication & Electronic Warfare	Sanjay Burman	9845244674	CAIR	Bangalore
		Dr. M Lakshminarayana	9440805818	DLRL	Hyderabad
		Dr. B Rama Krishna Rao	9949418424	DLRL	Hyderabad
		Sh. P Raghevendra Rao (Warfare)	9490792715	DLRL	Hyderabad
		Dr. Ashwani Kumar	9441286216	DLRL	Hyderabad
		Sh. B V Nityananda	9483775480	DLRL	Hyderabad
		Sh. T V Prakash Rao	9845662650	DLRL	Hyderabad

Semester 2 – Elective 3

S. No.	Subjects	Name & Designation	Contact Details	Associated DRDO Lab	Location
1.	Robotics	In process of selection / identification of lecturers. Course can also be taken by Institute Faculty.			
2.	EMI/EMC in Military Systems	Dr. DC Pande	9449048858 pande.dc@gmail.com	LRDE	Bangalore
		Sh. B Bhaskar Rao	9483775480	DLRL	Hyderabad
		Sh. B V Nityananda		DLRL	Hyderabad
		Course can also be taken by Institute Faculty.			
3.	Defence Electro-Optics and Imaging Systems	Sh. Varadarajan V	9448975626	O/o DG (ECS)	Bangalore
		Sh. Nagi SS	9412915391	IRDE	Dehradun
		Sh. A K Sahay	9410394305	IRDE	Dehradun
		Sh. Amitava Ghosh	9410394308	IRDE	Dehradun
		Sh. Tyagi Rameshwar P	9411106584	IRDE	Dehradun
4.	Structural Dynamics and Aero-Elasticity	Dr. K Ramachandra	9448077779	GTRE	Bangalore
		Dr. D N Khatri	9868266493	ISSA	Delhi
		Course can be taken by Institute Faculty.			
5.	Safety, Health & Hazard Managment	In process of selection / identification of lecturers. Course can also be taken by Institute Faculty.			
6.	Fundamental of telemetry, telecommand & transponder	Sh. R Reghunathan	9448383361	CAIR	Bangalore
		Sh. L Gnana Michael Prakasam,	9448365755 lgmprakasam@gmail.com	LRDE	Bangalore
		Sh. G Kumaraswamy Rao	9347611184 9440881501	DLRL	Hyderabad
		Dr. N Rama Murthy	9449346693	CAIR	Bangalore
		Course can be taken by Institute Faculty.			

7.	Jamming and ECM/ECCM technologies	Sh. G Kumaraswamy Rao	9347611184 9440881501	DLRL	Hyderabad
		Dr. M Lakshminarayana	9440805818	DLRL	Hyderabad
		Sh. P Raghevendra Rao	9490792715	DLRL	Hyderabad
8.	Software Defined Radios	In process of selection / identification of lecturers.			
9.	Advanced Lightweight and Composite Structures	Sh. Anil	9449811240	ADE	Bangalore
		Sh. Prabhakaran V	9449649186	ADE	Bangalore
		Dr. Vijay Kumar Varma	9449078557 varmavij@gmail.com	DRDL	Hyderabad
		Dr. S B Singh	9412054196 sbs50@rediffmail.com	VRDE	Pune
		Course can be taken by Institute Faculty.			
10.	Test methodologies for DEW systems (Lasers & Microwave)	Dr N S Vasan	9456512916	IRDE	Dehradun
		Sh. Suranjan Pal	9868240545	HQ	Delhi
		Sh. KSS Rao	9885031113	DLRL	Hyderabad
		Sh. P Raghevendra Rao (Warfare)	9490792715	DLRL	Hyderabad
11.	Advanced Analytical Techniques / Lab testing	Dr. S N Asthana	7588026160	HEMRL	Pune
		Dr. R V Singh	6306142342	HEMRL	Lucknow
		Dr. A K Sikadar	9420496646	HEMRL	Pune
		Dr. R K Pandey	9423572521	HEMRL	Pune
		Dr. Mehilal	9923331983	HEMRL	Pune
		Dr. (Mrs) U R Nair	9923800038	HEMRL	Pune
		Dr. Javaid Athar	9423585986	HEMRL	Pune
12.	Sonar System Engineering	Sh. Reddy KP	9966455778	NSTL	Vizag
		Sh. Shiakumar N	9446416689	NPOL	Kochi

Semester 2 – Elective 4

S. No.	Subjects	Name & Designation	Contact Details	Associated DRDO Lab	Location
1.	Unmanned Aerial Vehicle Design	In process of selection / identification of lecturers. Course can also be taken by Institute Faculty.			
2.	Naval Ocean Analysis and Prediction	In process of selection / identification of lecturers.			
3.	Modeling & simulation of Laser Matter Interaction	Dr. Arvind Bharti	8527266969	HQ_DCC	Delhi
		Dr. N S Vasan	9456512916	IRDE	Dehradun
		Sh. Suranjan Pal	9868240545	CHESS	Gurgaon
4.	Computational Aerodynamics	Sh. Mukesh Chand	9490956151 mcag2009@gmail.com	DRDL	Hyderabad
		Sh. T Venkatakrishnaiah	9902919644	GTRE	Bangalore

5.	Launch Vehicle Design & Analysis	In process of selection / identification of lecturers.			
6.	Acquisition, Tracking & Pointing Technology	Sh. S Varadarajan	9448324568 varad1950@ gmail.com	LRDE	Bangalore
		Sh. Suranjan Pal	9868240545	CHESS	Gurgaon
7.	Data acquisition, tracking & post flight analysis	Sh. K S Ramprasad		GTRE	Bangalore
		Sh. B K Paltasing	9437011267	ITR	Balasore
		Dr. S N Banerjee	9861261136 / 9078689820 drsnbano@ gmail.com	ITR	Balasore
8.	Air independent propulsion & batteries	Sh. Rajsekharan Nair KV	9847472936	NPOL	Kochi
		Sh. Chandramouli G	9848347443	DRDL	Hyderabad
9.	Advanced digital modulation technologies & standards	Sh. S Varadarajan	9448324568 varad1950@ gmail.com	LRDE	Bangalore
		Sh. L Gnana Michael	9448365755 lgmprakasam@ gmail.com	LRDE	Bangalore
		Sh. G Kumaraswamy Rao	9347611184 9440881501	DLRL	Hyderabad
		Dr. M Lakshminarayana	9440805818	DLRL	Hyderabad
		Course can be taken by Institute Faculty.			
10.	Trajectories modelling & simulation	Sh. M V Bhaskarachary	9437297128 mvbc57@ gmail.com	ITR	Balasore
11.	Sensor Technology	Sh. G Kumaraswamy Rao	9347611184 9440881501	DLRL	Hyderabad
		Dr. B Rama Krishna Rao	9949418424	DLRL	Hyderabad
		Dr. Ashwani Kumar	9441286216	DLRL	Hyderabad
		Sh. T V Prakash Rao	9845662650	DLRL	Hyderabad
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