CURRICULUM AND SYLLABI

FOR

COMPULSORY AND ELECTIVE COURSES

M. Tech. (Defence Technology)

FOR THE STUDENTS ADMITTED IN THE

ACADEMIC YEAR 2022-23 ONWARDS

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
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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 security 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 analysecomplex 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 allthe 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 theform 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 diverseteams, and in multidisciplinary settings.	Individual &TeamWork

1. Program Structure

It is a 4 semester program with total 80 credits. It is having 6 specializations, as regard to the specializations, semester -1 will have common curriculum and semester 2 curriculum will be variedas 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.	Communication Systems & Sensors
2.	High Energy Materials Technology

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

2. Syllabi

(under AICTE Universities)

1. 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.	22DT110	Systems and warfare Platforms	4	-	-	4
2.	22DT120	Warfare Simulations & Strategies	4	-	-	4
3.	22DT130	Advanced Engineering Mathematics	4	-	-	4
4.	22DT140	Systems and Platforms Lab	-	-	2	2
5.	22DT150	Warfare Simulations & Strategies Lab	-	-	2	2
		Elective Courses				
6.	22DTPX0	Elective 1	3	-	-	3
7.	22DTPX0	Elective 2	3	-	-	3
8.	22DTSA0	Seminar 1	-	-	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.	22DTPA0	Rockets & Missiles Fundamentals	3	-	-	3
2.	22DTPB0	Advanced Thermal Engineering	3	-	-	3
3.	22DTPC0	Numerical methods for science & engineering	3	-	-	3
4.	22DTPD0	Communication Technology	3	-	-	3
5.	22DTPE0	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.	22DTPP0	Autonomy and Navigation Technology	3	-	-	3
2.	22DTPQ0	Optimization theory & applications	3	-	-	3
3.	22DTPR0	Military Electronics System Engineering	3	-	-	3
4.	22DTPS0	System Engineering & Analysis	3	-	-	3

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

S. No.	Main Stream Defence Technology
1.	Communication Systems & Sensors
2.	High Energy Materials Technology

1. 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.	22DTC210	Radar Technologies	4	-	-	4
2.	22DTC220	Digital & satellite Communication andNavigation from Space	4	-	-	4
3.	22DTC230	Tactical battlefield Communication &Electronic Warfare	4	-	-	4
4.	22DTC240	Radar Technologies Lab	-	-	2	2
5.	22DTC250	Digital & Satellite Communication andNavigation from Space Lab	-	-	2	2
		Elective Courses				
6.	22DTRX0	Elective 1	3	-	-	3
7.	22DTRX0	Elective 2	3	-	-	3
8.	22DTCA0	Seminar 2C	-	-	1	1
		Total credits				23

2. High Energy Materials 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
		High Energy Materials Technology	L	T	P	
1.	22DTH210	High Energy Materials Modeling & Simulation	4	-	-	4
2.	22DTH220	Munitions and Target Response	4	-	-	4
3.	22DTH230	Manufacturing and Materials Propertiesof Explosives	4	-	-	4

4.	22DTH240	High Energy Materials Modeling & Simulation Lab	-	-	2	2
5.	22DTH250	Munitions and Target Response Lab	-	-	2	2
		Elective Courses				
6.	22DTRX0	Elective 1	3	-	-	3
7.	22DTRX0	Elective 2	3	-	-	3
8.	22DTHA0	Seminar-2H	-	-	1	1
		Total credits				23

Elective Courses offered for Semester 2

- 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 ofexamination	M.Tech Semester-2			
		Elective 1 (for all Specializations)	Periods/Week			
			L	T	P	Total Credits
1.	22DTRA0	Robotics (MSS, MCC)	3	-	-	3
2.	22DTRB0	EMI/EMC in Military Systems	3	-	-	3
3.	22DTRC0	Defence Electro-Optics and ImagingSystems	3	-	-	3
4.	22DTRD0	Structural Dynamics and Aero-elasticity	3	-	-	3
5.	22DTRE0	Safety, Health & Hazard Management	3	-	-	3
6.	22DTRF0	Fundamental of Telemetry, Telecomm andTransponder	3	-	-	3
7.	22DTRG0	Jamming and ECM/ECCM Technologies	3	-	-	3
8.	22DTRH0	Software Defined Radios	3	-	-	3
9.	22DTRJ0	Advanced Lightweight and CompositeStructures	3	-	-	3
10.	22DTRK0	Test Methodologies for DEW Systems(Lasers & Microwave)	3	-	-	3
11.	22DTRL0	Advanced Analytical Techniques / LabTesting	3	-	-	3
12.	22DTRM0	Sonar System Engineering	3	-	-	3

S. No.	Course Code	Course of study and scheme ofexamination	M.Tech Semester-2			
		Elective 2 (for all Specializations)	Periods/Week			
			L	T	P	Total Credits
1.	22DTRP0	Unmanned Aerial Vehicle Design	3	-	-	3
2.	22DTRQ0	Naval Ocean Analysis and Prediction	3	-	-	3

3.	22DTRR0	Modeling & Simulation of Laser MatterInteraction	3	-	-	3
4.	22DTRS0	Computational Aerodynamics	3	-	-	3
5.	22DTRT0	Launch Vehicle Design & Analysis	3	-	-	3
6.	22DTRU0	Acquisition, Tracking & Pointing Technology	3	-	-	3
7.	22DTRV0	Data Acquisition, Tracking & Post FlightAnalysis	3	-	-	3
8.	22DTRW0	Air Independent Propulsion & Batteries	3	-	-	3
9.	22DTRX0	Advanced Digital Modulation Technologies & Standards	3	-	-	3
10.	22DTRY0	Trajectories Modeling & Simulation	3	-	-	3
11.	22DTRZ0	Sensor Technology	3	-	-	3

Semester - 3

S. No.	Course	Credit
1.	22DT310 Project Dissertation- Phase 1	10
2.	22DT320 Seminar/ Industrial training	4
	Total credits	14

Semester – 4

S. No.	Course	Credit
1.	22DT410 Project Dissertation Phase-2	20
	Total credits	20

22DT110	SYSTEMS AND WARFARE PLATFORMS

Category	L	T	P	Credit
PC	4	0	0	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

On the successful completion of the course students will 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.

Syllabus

Types of platforms: land, sea, air; Lifecycle: concept, design, pre-production, production, operations, support.

Ship design fundamentals: buoyancy, stability, ship resistance, survivability; damage control, NBCD, crew numbers, power requirements. Submarine design: buoyancy, stability, hull/tank design, air interdependence.

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.

Military vehicle fundamentals: tracked, wheeled, A, B and C vehicles.

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.

Self-defence and Protection systems: Armour, smoke, chaff, decoys; Introduction to instrumentation, lab tests and flight trials.

Learning Resources

- "Light And Heavy Vehicle Technology ", by Malcolm Nunney. Publisher Routledge 4th Edition 2006.
- "Practical approach to motor vehicle engineering and maintenance", by Bonnick Allan Derek Newbold Publisher: Routledge 2011
- "Automotive Vibration Control Technology: Fundamentals, Materials, Construction, Simulation, and Applications", by TrelleborgVibracoustic Publisher: Vogel Business Media GmbH 2015.
- "An Introduction to Weapons Systems", by Yacov Bar-Shlomo. Publisher: Create Space Independent Publishing Platform 2016.
- "Heavy Vehicle Mechanics", by Ian Nicholson.Publisher: McGraw-Hill Education – Europe 2001.
- "Military Laser Technology for Defense: Technology for Revolutionizing 21st Century Warfare", by Alastair D. McAulay. Publisher: Wiley-Interscience; 1st edition 2011.
- Literature / books suggested by respective course Lecturers.

22DT120	WARFARE SIMULATIONS & STRATEGIES

Category	L	T	P	Credit
PC	4	0	0	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 & modeling.
- Understand the war gaming simulation & modeling and human factor representation.

Syllabus

Types
Introduction to Warfare systems: air, surface, subsurface, littoral, electronic
Military capabilities: air warfare, surface warfare, sub surface warfare, littoral
Warfare Introduction to the methods used in modeling combat and their application in support of defence decision making and training, Combat simulation.
War gaming/interactive simulation, Lanchester's equations, Mathematical models of combat. War gaming and combat modeling in practice, manual war gaming.
Human factors representation in war gaming and combat modeling.

Learning Resources

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

22DT130	ADVANCED ENGINEERING MATHEMATICS

Category	L	T	P	Credit
PC	4	0	0	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

On the successful completion of the course students will 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.

Syllabus

Elements of Probability and Statistics, components of operations research, Linear Algebra
Ordinary Differential equations, Numerical methods for ODE and P.D.E. Generating functions, recurrence relations
Transform Techniques, Fourier series, Fourier Transform, Laplace Transform
Special functions: Power series method, Frobenius method, Legendre equation, Legendre polynomials, Bessel equation, Bessel functions of first kind, Orthogonal property.
Elements of Ramsey theory, theorems of Burnside and Polya, and balanced incomplete block designs.
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.

Learning Resources

- “Advanced Engineering Mathematics”, by Erwin Kreyszig. Publisher: Wiley 10th edition 2010.
- “Advanced Engineering Mathematics”, by Srk Iyengar and Rk Jain. Publisher: Narosa. 3rd edition 2007
- “Advanced Engineering Mathematics”, by HC Taneja. Publisher: I K international Volume 1,2 2013
- “Advanced Engineering Mathematics”, by Alan Jeffery. Publisher: Elseiver 1st Edition 2001.
- “Advanced Engineering Mathematics”, by Peter V. O’Neil. Publisher: Cengage Learning. 8th edition 2016.
- Literature / books suggested by respective course Lecturers.

22DT140	SYSTEMS AND WARFARE PLATFORMS LAB

Category	L	T	P	Credit
PC	0	0	2	2

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

22DT150	WARFARE SIMULATIONS & STRATEGIES LAB

Category	L	T	P	Credit
PC	0	0	2	2

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

22DTPA0	ROCKETS & MISSILES FUNDAMENTALS

Category	L	T	P	Credit
PE	3	0	0	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

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

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

Syllabus

Basics of Missile Physics, Introduction to Guided Missiles, Classification of Missiles,
Missile Aerodynamic Configurations, Introduction to Missile System, Interrelationship between various Missile Sub-Systems.
Basic Characteristics of Guided Missile Systems, Missile System Reliability, Range dispersion and CEP Concept,
Design, System Layout and integration of Sub-Systems,
Coordinate Transformation, Transformation Matrices. Two, Three and Six DOF Equations of Motion, Ballistic Missile Trajectory,
Effect of Curvature of Earth, Rotation of Earth, Variation of Gravity on Missile Trajectory.

Learning Resources

- “Fundamentals of Guided Missiles”, by S. R. Mohan. Publisher: Defence Re-search and Development Organisation, 2016.
- “Estimation and Prediction of Ballistic Missile Trajectories” by Jeffrey A. Isaac-son, David R. Vaughan. Publisher: RAND (29 May 1996)
- “Introduction to Modern Algebra and Matrix Theory”, by O. Schreier, E. Sperner, Martin David, Melvin Hausner. Publisher: Dover Publications, 2nd Edition 2011.
- Literature / books suggested by respective course Lecturers.

22DTPB0	ADVANCED THERMAL ENGINEERING

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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

Syllabus

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

Learning Resources

- "Fundamentals of Heat and Mass Transfer", by Incropera and Dewitt. Publication: John Wiley 2006.
- "Convective Heat and Mass Transfer", by W M Kays and M E Crawford. Publisher: Graw-Hill Company, 4th edition 2017.
- "Thermal Radiation Heat Transfer" by J Siegel and R Howell. Publisher: Elsevier. 7th edition 2020.
- "Manohar Prasad, Refrigeration and Air Conditioning", 3rd Edition, New Age International, 2015.
- "Computational Fluid Dynamics – The Basics with Applications", by John D Anderson. Publisher:1st Edition, McGraw Hill, 2012.
- "Thermal System Design and Simulation", by P.L. Dhar, 1st Edition 2017.
- Literature / books suggested by respective course Lecturers.

22DTPC0	NUMERICAL METHODS FOR SCIENCE AND ENGINEERING

Category	L	T	P	Credit
PC	3	0	0	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 fitting and optimization techniques. The course will also develop an understanding of the finite element analysis and computational fluid engineering.

Course Outcomes

On the successful completion of the course students will 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.

Syllabus

Introduction, solution of non-linear equations, solution of linear systems.

Introduction and polynomial approximation, curve fitting, Numerical applications & intergradations, numerical optimization.

Matrices and types of linear systems, direct elimination methods, conditioning, and stability of solutions,

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,

Introduction to computational fluid engineering, Fundamental equations, Computational Engineering Process.

Fluid Simulation for Computer Graphics, Modelling techniques.

Learning Resources

- "Numerical Methods for Scientific and Engineering Computation", by M. K. Jain and S.R.K.Iyengar. Publisher : New Age International Publishers 3rd edition 2007
- "Applied Numerical Analysis", by Gerald & Wheatley. Publisher Addison – Wesley.
- "Introductory Methods of Numerical Analysis", by, S.S. Sastry. Publisher: PHI Pvt. Ltd., 7th Edition, New Delhi, 2009.
- "Applied Numerical Methods Using MATLAB", by W.Y. Yang, W. Cao, T.S. Chung and J. Morris. Publisher: Wiley India Edn., 2007.
- "Numerical Methods for Engineers with Programming and Software Applications", by Steven C. Chapra and Ra P. Canale. Publisher: Tata McGraw Hill, 2014 7th Edition.
- "Finite Element Procedures", by K.J. Bathe, Prentice Hall of India, 1996
- "Finite Elements in Engineering", by Chandrupatla and Belegundu, Pearson; 4th edition, 2011.
- "Finite element Method", by J.N.Reddy, McGraw hill 3rd Edition 2005.
- Literature / books suggested by respective course Lecturers.

22DTPD0	COMMUNICATION TECHNOLOGY

Category	L	T	P	Credit
PC	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

Introduction on Communication Systems, Basics of wireless channel behavior
Digital data communication systems, digital signalling techniques
Data rates and bandwidth calculation in digital data communication systems
Probability of error and BER calculation, Modulation technologies (analogue & digital), Voice source coding, transmitter and receiver systems
Communication system architectures, terminal design and performance, associated information systems
Link budget calculations, telemetry and control and IO/IW implications. Antenna types and their impact on the communication systems.

Learning Resources

- "Fundamentals of Communication Systems," by Proakis and Salehi. Publisher: Pearson 2nd edition 2014.
- "Communication Systems", by Simon Haykin and Michael Moher. Publisher: Wiley 5th edition 2009.
- "Modern Digital and Analog communication systems," by B.P. Lathi and Zhi Ding. Publisher: Oxford University Press, 4th Edition 2017.
- Literature / books suggested by respective course Lecturers.

22DTPE0	ADVANCED MECHANICAL ENGINEERING

Category	L	T	P	Credit
PC	3	0	0	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 software and use of computational techniques forstructural and fluid dynamics.

Course Outcomes

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

- Understand mechanical analysis software and carry out mathematical modelling 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.

Syllabus

Introduction to tools for mechanical design & analysis
Stress engineering – theory & simulation, mechanics of solids
Finite element methods in structural dynamics, Structural integrity
Fluid mechanics
Computational fluid dynamics
Component design, Applied materials and corrosion.

Learning Resources

- “An Introduction to Computational Fluid Dynamics: The Finite Volume Method “ by H. Versteeg. Publisher: Pearson.2nd edition 2007.
- “Computational Fluid Dynamics the Basics with Applications”, by John D. Ander Jr. Publisher: McGraw Hill Education (1 July 2017)
- “Fluid Mechanics: Volume 2: Foundations and Applications of Mechanics (Cambridge-IISC)” by C.S. Jog. Publisher: Cambridge University Press 2015.
- “Juvinall's Fundamentals of Machine Component Design: SI Version”, by Robert C. Juvinall, Kurt M. Marshek. Publisher: John Wiley & Sons 2018
- Literature / books suggested by respective course Lecturers.

22DTPP0	AUTONOMY AND NAVIGATION TECHNOLOGY

Category	L	T	P	Credit
PC	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

Introduction on navigation and guidance systems, Guidance approaches: conventional guidance such as PN (Proportional Navigation)

Geodetic fundamentals of navigation, positioning, reference- and coordinate systems and computational methods for navigation and positioning on the surface of the earth.

Geometric guidance, path planning and following, and optimal guidance; path planning for UGV/UAV guidance systems

Navigation approaches: navigation systems, Understanding the Global Positioning System (GPS)

GNSS (Global Navigation Satellite System), terrain-based navigation

SLAM (Simultaneous Localization and Mapping); Cooperative guidance and collision avoidance.

Learning Resources

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

22DTPQ0	OPTIMIZATION THEORY & APPLICATIONS

Category	L	T	P	Credit
PC	3	0	0	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

- On the successful completion of the course students will be able to
- Understand mathematical modelling 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.

Syllabus

Introduction to optimization, classical optimization techniques.
Linear programming & non-linear programming and dimensional minimization methods.
Non coordination optimization techniques, coordinated optimization techniques, coordinated programming.
Dynamic programming, integer programming, stochastic programming.
Solution of a variety of design problems in mechanical engineering, using numerical optimization techniques.
Additional Topics: multi-objective, optimization, game theory, optical control theory.

Learning Resources

- “Numerical Optimization”, by Jorge Nocedal and Stephen J.Write. Publisher: Springer, 2006.
- “Practical methods of Optimization” by R.Fletcher. Publisher: Wiley, 2009.
- “Iterative method for optimization” by C. T. Kelley. Publisher: SIAM, 1999.
- “Introduction to Nonlinear Optimization: Theory, Algorithm, and Application with MATLAB. MOS- SIAM Series on Optimization”, by Amir Becker 2014.
- “Dynamic Programming and Optimal Control (Volume-I) “by Dimitri P. Bertsekas. Publisher: Athena Scientific, 2005.
- “Optimization Theory and Applications”, by SS Rao. Second Edition, 1984.
- Literature / books suggested by respective course Lecturers.

22DTPR0	MILITARY ELECTRONICS SYSTEM ENGINEERING

Category	L	T	P	Credit
PC	3	0	0	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 Outcomes

On the successful completion of the course students will 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.

Syllabus

Introduction to electronics engineering concepts and methods for the design and integration of complex defence systems.

Familiarity with the systems engineering process through case studies of representative defence systems.

Introduction to methods used for determination of system requirements from mission needs and operational requirements.

Digital simulation models, including those in current used in defence for determining engineering and performance trade-offs.

Limitations of commercial-off-the-shelf (COTS) integrated circuits, thermal failure, electrostatic breakdown, noise in solid state devices, packaging reliability issues.

Radiation effects due to space and nuclear environments, and the limited availability of military integrated circuit suppliers.

Learning Resources

- “Introduction to Electronic Defence Systems”, by Neri Filippo. Publisher: Artech House Publishers. 1991.
- “Military Handbook of Electronic Reliability design”, by US Department of Defence.
- “Defence Electronics Standards and Quality Assurance”, by Ray Tricker. Publisher: Butterworth-Heinemann, 2014
- “Handbook of Defence Electronics and Optronics: Fundamentals, Technologies and Systems”, by Anil K. Maini. Publisher: John Wiley & Sons Ltd. 2018
- “Digital Simulation Methods”, by M.G. Hartley. Publisher: P. Peregrinus Ltd
- “Analysis and Simulation of Noise in Nonlinear Electronic Circuits and Systems”, By Alper Demir. Publisher: Springer 1998.
- Literature / books suggested by respective course Lecturers.

22DTRS0	SYSTEM ENGINEERING AND ANALYSIS

Category	L	T	P	Credit
PC	3	0	0	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 Outcomes

On the successful completion of the course students will 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.

Syllabus

Fundamentals of systems engineering and system architecting of weapon system, system engineering standards 15288, requirements analysis, functional analysis and allocation, preliminary system architecture.

Systems analysis, system design, and the basics of test and evaluation, Introduction to combat systems,

System development phases (Conceiving, Designing, Implementing, and Operating),

Techniques of system design and assessment for operational feasibility, including reliability, maintainability, usability (including human factors and human performance).

Supportability, and producibility, System cost assessment and effectiveness estimation.

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.

Learning Resources

- “The Engineering Design of Systems: Models and Methods”, by Buede D.M.2. Publisher: John Wiley & Sons Inc 2009.
- “Systems engineering fundamentals”, by Defence Acquisition University Pressfort Belvoir, Virginia .
- “System Analysis Design and Development”, by Charles S. Wasson. Publisher: Wiley Series in System Engineering and Management 2006.
- “Principles of Planned Maintenance”, by Clifton R H. Publisher: McGraw Hill, New York 1974.
- “An introduction to Reliability and Maintainability Engineering”, by Ebling CE. Tata Mc Graw Hill. 2017.
- "Reliability Engineering", by Srinath L S. Publisher: Affiliated East-West Press Limited, New Delhi, 2005.
- “Engineering Maintainability”, by Dhillon B S. Publisher: Prentice Hall of India. 1999
- Literature / Literature / books suggested by respective course Lecturers.

Semester – 2

(Compulsory Courses)

Communication Systems and Sensors

22DTC210	RADAR TECHNOLOGIES

Category	L	T	P	Credit
PC	4	0	0	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

On the successful completion of the course students will 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.

Syllabus

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

Learning Resources

- “Introduction to Radar Systems” ,by M.I. Skolnik. Publisher: Tata Mcgraw hill edition, 2002.
- “Radar Systems Analysis and Design using MATLAB” ,by B.R.Mahafza. Publisher CRC Press, 2013.
- “Monopulse Principles and Techniques”, by S.M.sherman and D.K.Barton. Publisher: Artech house, 2011
- “Fundamentals of Radar Signal Processing”, by M.A.Richards. Publisher Tata Mcgraw hill 2014.
- “Ground Penetrating Radar: Theory and Applications”, Editor: H.M. Jolt. Publisher: Elsevier 2008.
- "Radar, Sonar and Navigation Engineering", by K. K Sharma. Publisher: S K Kataria & Sons 2013.
- Literature / books suggested by respective course Lecturers.

22DTC220	DIGITAL & SATELLITE COMMUNICATION AND NAVIGATION FROM SPACE

Category	L	T	P	Credit
PC	4	0	0	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

On the successful completion of the course students will 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.

Syllabus

Elements of a communications system and their relationship to system performance.
Free space optical communication, Fiber optics communication, Wireless/cellular communications.
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,
Modulation transmission and reception; baseband and passband digital modulation; system, noise, transmission lines, waveguides and antennas, FEC techniques for mitigating channel errors.
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, concept of frequency hoping.
Navigation techniques from space regarding functioning of GPS, GLONASS, IRNSS & Galileo.

Learning Resources

- “Satellite communication”, by T. Pratt, C. W. Bostian, J. E.Allnut. Publisher: John Willey and sons 2nd edition, 2006
- “Satellite Communications Systems: systems, techniques and technology”, by G.Maral, M. Bousquet, Z. Sun. Publisher: John Willy and sons. 5th edition 2009
- “Digital Communications: Fundamentals and Applications”, B. Sklar. Prentice-Hall, Inc.2nd edition. 2001
- “Understanding of GPS/GNSS: Principles and Applications”, by E. Kaplan and C. Hegarty. Publisher: Artech House Publishers. 3rd edition. 2017
- Literature / books suggested by respective course Lecturers.

22DTC230	TACTICAL BATTLEFIELD COMMUNICATION & ELECTRONIC WARFARE

Category	L	T	P	Credit
PC	4	0	0	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

On the successful completion of the course students will 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.

Syllabus

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

Learning Resources

- “Tactical Battlefield Communications Electronic Warfare”, by David Adamy. Publisher: Artech House 2008
- “Military Communications in the Future Battlefield”, by Marko Suojanen. Publisher: Artech House 2018.
- “Electronic Warfare for the Digitized Battlefield”, by Michael Frater, Michael Ryan. Publisher: Artech House 2018 2001.
- Literature / books suggested by respective course Lecturers

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22DTC240	RADAR TECHNOLOGIES LAB

Category	L	T	P	Credit
PC	0	0	2	2

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

22DTC250	DIGITAL & SATELLITE COMMUNICATION AND NAVIGATION FROM SPACE LAB

Category	L	T	P	Credit
PC	0	0	2	2

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

Semester – 2 (Compulsory Courses)

High Energy Materials Technology

22DTH210	HIGH ENERGY MATERIALS MODELING & SIMULATION

Category	L	T	P	Credit
PC	4	0	0	4

Course Objectives

The main objective of the course is to provide knowledge to the students about high-energy materials from theoretical and practical standpoints. This course also includes detailed formulations and reactions presented with thermochemical calculations to aid understanding to the theory and chemical types ofexplosives.

Course Outcomes

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

- Formulate the basis for evaluating competitive and alternative high energy material systems.
- Understand the theory and methods of simulations and applications of high energy materials.
- Understand the usage of tools for carrying out modeling & simulation of high energy materials for using them for creating defence related systems.

Syllabus

Understanding of high energy materials from theoretical and practical standpoints, to formulate the bases for evaluating competitive and alternative high energy material systems
High energy materials physics and chemistry
Molecular energetic of the high energy materials molecule including molecular orbital and valence bonding and resonance stabilization
Concepts and practical implications of sensitivity and energy potential, oxygen balance and thermodynamic, reaction rate theory, hot-spot theory, shock physics and detonation theory
Tools for high energy materials modeling & simulation
Overview high energy materials modeling using FEM technique.

Learning Resources

- “Chemistry of High-Energy Materials”, by Thomas M. Klapötke, 4th Edition Gruyter, 2017
- “Shock Waves Science and Technology Library, Detonation Dynamics- Vol. 6,” by Editor: Zhang F. Publisher: Springer 2012.
- Physics of Shock Waves and High-Temperature Hydrodynamic Phenomena (Dover Books on Physics) by Zel'dovich & Raizer. 2002
- “The Chemistry of Explosives”, by Jacqueline Akhavan 4th Edition RSC Publishing.2011
- “Handbook of Materials Modeling : Applications: Current and Emerging Materials” by Andreoni Wanda, Yip Sid-ney. Publisher: Springer, 2020.
- Literature / books suggested by respective course Lecturers.

22DTH220	MUNITIONS AND TARGET RESPONSE

Category	L	T	P	Credit
PC	4	0	0	4

Course Objectives

The main objective of the course is to provide knowledge to students about warheads, ammunition andarmour design, and the underlying wound ballistics and human vulnerability. The course will also cover characterization of high energy materials for different properties.

Course Outcomes

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

- Design warheads, ammunition, and armours.
- Understand fragmentation theory, small arms, and cannon ammunition.
- Understand the characterization of high energy materials.

Syllabus

Introduction to warheads and ammunition, Introduction to armour design

Wound ballistics and human vulnerability, Fragmentation theory and warheads, small arms and cannon ammunition, Shell, and projectile design

Target penetration and shock events covering subsonic to hydrodynamic regimes, Shaped charge, and Explosively Formed Penetrator (EFP) warhead design, Kinetic Energy (KE) ammunition and penetrator design

Mine threat and damage mechanisms, Complex armour, spacing, obliquity, disposition, and failure mechanisms

Characterization and testing of materials for high strain rate loading

Blast effects, blast-structure interactions including internal detonations, Terminal ballistics demonstration.

Learning Resources

- “A Comprehensive Guide to Munitions: Bullets, Bombs, Artillery, Mines, Missiles & Explosives” 2016”, by Paul F. Kisak. Createspace.
- “Ammunition: Small Arms, Grenades and Projected Munitions”, by Ian V. Hogg. Publisher: Greenhill Books. 1998.
- “MILITARY SMALL ARMS: Design Principles and Operating”, by Derek Allsop Brassey's (UK) (1997)
- “Armour: Materials, Theory, and Design”, by Paul J. Hazell. Publisher: CRC Press, 2015.
- Literature / books suggested by respective course Lecturers.

22DTH230	MANUFACTURING AND MATERIALS PROPERTIES OF EXPLOSIVES

Category	L	T	P	Credit
PC	4	0	0	4

Course Objectives

The main objective of the course is to provide knowledge to students about synthesis of high energy materials such as Lead Azide/Styphnate, TNT, RDX, NC, NG etc. Various properties of high energy materials, filling processes of high energy materials, plant design, and safety issues will be covered.

Course Outcomes

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

- Understand the basic chemistry of nitration for the synthesis of high energy material molecules
- Have environmental awareness Engineering of the manufacturing of high energy materials.
- Understand physics of high energy materials: Detonation theory, Shocks physics, Explosives train.

Syllabus

Chemistry of the synthesis of high energy material molecules: Basic chemistry of nitration, Synthesis examples of Lead Azide/Styphnate, TNT, RDX, NC, NG, Basic stability/ compatibility

Material science of high energy materials: Basic hazard/performance properties, Crystal properties, Binder properties, Mechanical properties,

Environmental awareness, Engineering of the manufacturing of high energy materials

Filling processes of high energy materials, Plant design, safety, Quality control

Physics of high energy materials: Detonation theory, Shocks physics, Explosives train.

Learning Resources

- Detonation: Theory and Experiment", by Wildon Fickett. Publisher: Dover Publications Inc, unabridged edition, 2003.
- "Organic Chemistry of Explosives", Jai Prakash Agrawal, Robert Dale Hodgson, Publisher: Wiley and sons, 2006
- "High explosives and propellants", by S. Fordham,2nd edition,2013.
- "Demystifying Explosives: Concepts in High Energy Materials", by Sethurama Sharma Venugopalan,1st edition,2015.
- "Chemistry and Physics of Energetic Materials", by Bulusu, S.N. Publisher: Springer, 1990th edition.
- "High Energy Materials: Propellants, Explosives and Pyrotechnics", by Jai Prakash Agrawal. Publisher: Wiley, 1st edition, 2015.
- Literature / books suggested by respective course Lecturers.

22DTH240	HIGH ENERGY MATERIALS MODELING & SIMULATION LAB

Category	L	T	P	Credit
PC	0	0	2	2

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

22DTH250	MUNITIONS AND TARGET RESPONSE LAB

Category	L	T	P	Credit
PC	0	0	2	2

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

Semester 2, Elective-1 Courses

22DTRA0	ROBOTICS (MSS, MCC)

Category	L	T	P	Credit
PE	3	0	0	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 manipu-lators, coordinate transformation and kinematics, trajectory planning, control tech-niques, sensors and devices, robot applications and economics analysis.

Course Outcomes

On the successful completion of the course students will 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 parallel 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.

Syllabus

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

Learning Resources

- Text Book: Introduction to Robotics by S.K. Saha (Tata McGraw-Hill, New Delhi, India 2008, 1st Reprint 2009)
- “Introduction to Robotics: Mechanics and Control”, by Craig, J.J. Publisher : Pear-son, Delhi,3rd edition,2004.\
- “Fundamentals of Robotics: Analysis and Control”, by Schilling Robert J. Publisher : Prentice- Hall, 1990.
- “An Introduction to Robotics Analysis, Systems, Applications”, by Niku Saeed B. Publisher: Prentice-Hall, 2001.
- Stuart Russell and Peter Norvig, Publisher: Prentice Hall,3rd edition,2010.
- Literature / books suggested by respective course Lecturers

22DTRB0	EMI/EMC IN MILITARY SYSTEMS

Category	L	T	P	Credit
PE	3	0	0	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 standard.

Course Outcomes

On the successful completion of the course students will 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.

Syllabus

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,

EMC requirements for electronic systems, Non-ideal Behaviors of Components; EMI Measurements: Basic principles of EMI measurements, EMI measuring instruments;

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

EMC Standard and Regulations: National and Intentional standardizing organizations, Frequency assignment, Spectrum conversation;

EMC Design and Interconnection Techniques: Cable routing and connection, Component selection and mounting, PCB design (Trace routing, Impedance control, decoupling, Zoning and grounding);

EMC analysis and detection techniques: Using tools for signal integrity analysis, Study eye diagrams for communication systems.

Learning Resources

- “EMI/EMC Computational Modeling Handbook”, by Bruce Archambeault, Omar M. Ramahi, et al.
- “EMI/EMC Computational Modeling Handbook: 630 (The Springer International Series in Engineering and Computer Science)”, by Bruce R. Archambeault, Omar M. Ramahi, et al, 2013.
- “A practical approach to electromagnetic compatibility”, by Chetan Kathalay,2nd edition,2019.
- Literature / books suggested by respective course Lecturers.

22DTRC0	DEFENCE ELECTRO-OPTICS AND IMAGING SYSTEMS

Category	L	T	P	Credit
PE	3	0	0	3

Course Objectives

The aim of the course is to introduce 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

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

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

Syllabus

Principles of radiometry, The human eye, Visible band optical sighting systems.
Camera systems, Image intensifiers, Missile seekers.
Electro-optic countermeasures.
Thermal imagers, II cameras, Hyper-spectral imaging, Digital image processing.
EO sensors for Lasers and laser DEW
Electro-optic protection measures.

Learning Resources

- “Systems engineering analysis of electro-optical and Infrared system”, by William Wolfgang Arrasmith,1st edition,2015.
- “Introduction to Infrared and Electro-Optical Systems”, by Author Ronald G. Driggers Ronald G. Driggers, Unabridged edition,2012.
- “Handbook of Defence Electronics and Optronics: Fundamentals, Technologies and Systems”, by Author(s): Anil K. Maini,1st edition,2018.
- “Building Electro-Optical Systems: Making It all Work”, by Author Philip C. D. Hobbs,2nd edition,2009.
- “Electro-Optical Instrumentation: Sensing and Measuring with Lasers”, by Author Silvano Donati,2004.
- “Electro-optical systems design, Analysis and testing”, by Author Michael C. Dudzik.
- Literature / books suggested by respective course Lecturers,1993.

22DTRD0	STRUCTURAL DYNAMICS AND AERO-ELASTICITY

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

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

Learning Resources

- "Elements of vibration analysis", by Leonard Meirovitch. Publisher: McGraw-Hill Inc., US; 2nd edition (1 March 1986)
- "Finite Element Analysis Theory and Application With ANSYS", by Moaveni Publisher: Pearson Education; 3rd edition (1 January 2011)
- "Mechanical Vibrations | SI Edition | Sixth Edition", by Singiresu S. Rao. Publisher: Pearson,6th edition,2018.
- "Elements of Fracture Mechanics", by Prashant Kumar. Publisher: McGraw Hill Education,1st edition,2017.
- "Introduction to Structural Dynamics and Aeroelasticity", by Dewey H. Hodges and G. Alvin Pierce. Publisher: Cambridge University Press,2nd edition,2014.
- Literature / books suggested by respective course Lecturers.

22DTRE0	SAFETY, HEALTH & HAZARD MANAGEMENT

Category	L	T	P	Credit
PE	3	0	0	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 thetoxic chemicals, gases, explosives etc.

Course Outcomes

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

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

Syllabus

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

Fire triangle and Handling of Toxic, Industrial Gases

Hazard Management: HAZOP and HAZAN techniques, Hazard in manufacture, Hazard prevention measures, Disposal of hazardous materials;

Warfare: Classifications of explosives based on hazards, Nuclear, biological and chemical warfare safety;

Health: Assessment of human factors, Health & Environment safety

Nano materials safety (Toxicology study)

Learning Resources

- "Occupational Health and Safety Management A Practical Approach", by Charles D. Reese. Publisher: CRC Press,3rd edition,2015.
- "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
- "Handbook of Occupational Safety and Health", by S. Z. Mansdorf. Publisher: Wiley,3rd edition,2019.
- "Institution of Chemical Engineers", by Trevor Kletz"Hazop and Hazan,4th edition,2006.
- "Handbook Of Toxicology Of Chemical Warfare Agents", by Ramesh C. Gupta 2nd Edition Elsevier, 2015.
- "Nanomaterials Safety Toxicity And Health Hazards", by Shyamasree Ghosh De Gruyter,2018.
- "Hazardous Chemicals Handbook", by Phillip Carson, Clive Mumford Butterworth-Heinemann,2nd edition,2002.
- Literature / books suggested by respective course Lecturers.

22DTRF0	FUNDAMENTAL OF TELEMETRY, TELECOMMAND & TRANSPONDER

Category	L	T	P	Credit
PE	3	0	0	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

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

- 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.

Syllabus

Fundamental of satellite communication, different modulation and multiplexing schemes.
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.
Satellite Packet Communications, Tracking and Telemetry.
Doppler and Electro-Optical methods of tracking, Airborne Missile.
Signal Processing: Processing of Signal, Data Acquisition and Reduction.
Introduction to satellite communication, transponders..

Learning Resources

- "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,2nd edition, 2002.
- "Satellite Communications Systems: Systems, Techniques and Technology", by Gerard Maral, Michel Bousquet, Zhili Sun. Publisher: Wiley, 6th edition, 2020,
- "Satellite Communications", by Timothy Pratt, Jeremy E. Allnutt, 3rd Edition Publisher: Wiley,3rd edition, 2019.
- "Principles of Modern Communication Systems", by Samuel O. Agbo, Matthew N. O. Sadiku 2017.
- Literature / books suggested by respective course Lecturers.

22DTRG0	JAMMING AND ECM/ECCM TECHNOLOGIES

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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 electronic counter measures and counter – counter measures.

Syllabus

Principals of Electronic Attack (EA), Jamming-to-Signal Ratio, Jamming Types Burn-Through, Cover Jamming, Range Deceptive Jamming, Inverse Gain Jamming.

Repeater Jamming Equations, Noise Jamming vs. Deception, Repeater vs. Transponder, Side lobe Jamming vs. Main lobe Jamming.

Stand-Off Jamming, Escort Jamming, Self-Protection Jamming, ECM techniques, On- Board ECM Systems, Off-Board ECM Systems.

Infrared Countermeasures (IRCM), Off-Board ECM Systems, Communications Countermeasures (COM-ECM), Electro-Optic Counter Measure (EOCM) Systems.

Airborne Tactical Jamming System, Shipboard Self Defence System, EA/Susceptibility against Weapon Systems. Search Radar Counter-Countermeasures, Tracking Radar.

Counter-Countermeasures, Infrared Counter-Countermeasures, Communications Counter-Countermeasures.

Learning Resources

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

22DTRH0	SOFTWARE DEFINED RADIOS

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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

Syllabus

SDR introduction, major standards, SDR architecture, SDR enablers, advantage / disadvantages, Applications.

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.

SDR Hardware, super-heterodyne architecture, homodyne architecture, advantages & disadvantages, Software for SDR, Processing architecture for SDR.

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.

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).

Case studies in software radio design, Introduction and a Historical perspective.

Learning Resources

- "Software Radio, (A modern approach to radio engineering)", by Jeffery H.Reed Publisher : PHIPTR,2002.
- "RF and Digital Signal Processing for Software Defined Radio", by John J. Rouphael. Publisher :Elesiver,1st edition,2009.
- "Digital Techniques in Frequency Synthesis", by B.G.Golderg. Publisher: McGraw-Hill.
- "Multirate Signal Processing", by N.J.Fliege. Publisher: John Wiley and sons,1st edition,1999.
- Literature / books suggested by respective course Lecturers.

22DTRJ0	ADVANCED LIGHTWEIGHT AND COMPOSITE STRUCTURES

Category	L	T	P	Credit
PE	3	0	0	3

Course Objectives

The main objective 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

On the successful completion of the course students will 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.

Syllabus

Review of Strength of Materials, Introduction to Aerospace Materials – Metal Alloys and Fiber Reinforced Composite

Introduction to different types of constructions: Monocoque, Semi-Monocoque, Truss, and Corrugated shell

Introduction to Aircraft and Missile Structural Components: Spars; Ribs; Stringer; Longerons

Analysis of stress; Analysis of strain

Material Constitutive Relations

Failure Theories; Fatigue theory.

Learning Resources

- "Composite Structures Safety Management", by Dr. Bjorn Backman. Publisher: Elsevier Science, 1st edition,2010.
- "Composite Structures: Design, Mechanics, Analysis, Manufacturing and Testing", by Manoj Kumar Buragohain. Publisher: CRC Press, 1st edition, 2017.
- "Lightweight Composite Structures in Transport: Design, Manufacturing, Analy-sis and Performance", by James Njuguna Woodhead Publishing, 2016
- "Structural and Stress Analysis", by T.H.G. Megson. Publisher: Butterworth-Heinemann, 3rd edition, 2014.
- Literature / books suggested by respective course Lecturers

22DTRK0	TEST METHODOLOGIES FOR DEW SYSTEMS (LASERS & MICROWAVE)

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

Testing requirements of DEW system, types of testing, laser effect testing on target, system output testing.

System performance testing, System outdoor test & measurement instruments.

Laser testing issues, Laser safety, Laser safety standards, laser safety tools.

Microwave system testing Impedance measurement, S-Parameters and the Smith Chart.

Power Measurement, Noise Figure and Phase Noise measurement, Frequency measurements (Spectrum Analysis), Gain Compression and Intermodulation, Network Analysis,

Microwave subsystem / system characterization techniques. HPM safety tools, safety standards.

Learning Resources

- "An Introduction to Microwave Measurements" by Ananjan Basu, 1st edition, 2017.
- Literature / books suggested by respective course Lecturers.

22DTRL0	ADVANCED ANALYTICAL TECHNIQUES/LAB TESTING

Category	L	T	P	Credit
PE	3	0	0	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

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

- Understand different characterization techniques.
- Apply appropriate analytical technique for a particular material - organic/ inorganic/ nanomaterial/polymer etc.

Syllabus

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

Learning Resources

- "Fundamentals of molecular spectroscopy" by C. N. Banwell. Publisher: McGraw Hills, 4th edition, 2017.
- "Introduction to Spectroscopy" by Donald L. Pavia, Gary M. Lampman, and George S. Kriz. Publisher: Cengage Learning, 5th edition, 2014.
- "Chromatography: Concepts and Contrasts" by James M. Miller. Publisher: Wiley, 2nd edition, 2009.
- "Chromatography: Principles and Instrumentation", by Mark F. Vitha. Publisher: Wiley, 1st edition, 2016.
- "Elements of X-Ray Diffraction" by B.D. Cullity Deceased, S.R. Stock. Publisher: Pearson, 3rd edition, 2001.
- "Electron Microscopy: Principles and Fundamentals" by S. Amelinckx, Dirk van Dyck, J. van Landuyt, Gustaaf van Tendeloo. Publisher: Wiley1997.
- "Polymer Characterization: Physical Techniques", by Dan Campbell, Richard A. Pethrick, Jim R.White 2nd Edition. Publisher CRC Press, 2nd edition, 2017.
- Literature / books suggested by respective course Lecturers.

22DTRM0	SONAR SYSTEM ENGINEERING

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

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

Learning Resources

- “Fundamentals of Radar, Sonar and Navigation Engineering”, by K. K. Sharma, 2013.
- “Principles of Modern Radar: Advanced techniques”, by Editor William L. Mel-vin, 2012.
- “An Introduction to Sonar Systems Engineering”, by Lawrence J. Ziomek, 1st edition, 2019.
- “Sonar for practicing engineers”, by A. D. Waite, 3rd edition, 2002.
- “Underwater Acoustics: Analysis, Design and Performance of Sonar”, by Rich-ard P. Hodges, 1st edition, 2011.
- Literature / books suggested by respective course Lecturers.

Semester 2, Elective – 2 Courses

22DTRP0	UNMANNED AERIAL VEHICLE DESIGN

Category	L	T	P	Credit
PE	3	0	0	3

Course Objectives

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

Course Outcomes

On the successful completion of the course students will 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.

Syllabus

UAV design Requirements, design parameters, design algorithms, Certification approaches: aircrafts and UAVs. Airworthiness of aircrafts and UAVs.

Air safety issues. Handling qualities. Maneuverability requirements. Aircraft design; UAV system design. UAV system identification

UAV aerodynamics, structures and propulsion, performance and stability analysis.

UAV project life cycles. Stages of Aircraft design. Initial sizing: aircrafts and of UAVs.

Ground control systems. Ground and flight testing of UAVs. UAV guidance and Navigation. Design for reliability.

Wind Tunnel Testing, Aerodynamic Characterization through Wind Tunnel Testing.

Learning Resources

- “Introduction to Flight”, by John D. Anderson, 6th edition, 2008.
- “Performance, Stability, Dynamics, and Control of Airplanes”, by Bandu N. Pamadi, 2nd edition, 2003.
- “Aircraft performance and design”, by John D. Anderson, 2017.
- “Unmanned Aircraft Design A review of fundamentals”, by Mohammad H. Sadraey, 2017.
- “Aircraft Design: A Conceptual Approach”, by Daniel P. Raymer, 5th revised edition, 2012.
- “Unmanned Aircraft Systems: UAVs Design Development and Deployment”, by Reg Austin, 1st edition, 2011.
- “Small Unmanned Fixed-wing Aircraft Design: A Practical Approach”, by Andrew J. Keane and James P. Scanlan, 1st edition, 2017.
- Literature / books suggested by respective course Lecturers.

22DTRQ0	NAVAL OCEAN ANALYSIS AND PREDICTION

Category	L	T	P	Credit
PE	3	0	0	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

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

- Understand and develop the Navy Ocean modelling 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.

Syllabus

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

Learning Resources

- Indian Navy: Ocean of opportunities (Defence Series Books) Author: by PRANAV ZOPE
- Elements of Ocean Engineering. Author Robert E. Randall, 2nd edition, 2010.
- Ocean Modelling for Beginners - Using Open-Source Software. Author Jochen Kaempf, 1st edition,2009.
- Literature / books suggested by respective course Lecturers.

22DTRR0	MODELING &SIMULATION OF LASER MATTER INTERACTION

Category	L	T	P	Credit
PE	3	0	0	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 modelling, damage mechanism & damage threshold measurement techniques and performance evaluation of high power laser systems.

Course Outcomes

On the successful completion of the course students will 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.

Syllabus

Laser beam characteristics, Laser lethality modeling & simulation with metal targets & composite materials.

Physics based models for vulnerability assessment, Effect of laser on metals & composite materials.

Measurement and Characterization of Damage Thresholds, Mechanisms of Damage, Exposure Limits and Their Interpretation.

Analysis Tools for the Estimation of Hazards, Laser parameters measurement techniques.

Tools to analyze and predict Laser System performance under different conditions like land, sea air, etc.

Introduction of full scale end to end modeling of laser system performance.

Learning Resources

- “High Power Laser-Matter Interaction”, by Mulser, Peter, Bauer, Dieter. Publisher: Springer, 2010th edition.
- Literature / books suggested by respective course Lecturers.

22DTRS0	COMPUTATIONAL AERODYNAMICS

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

Introduction to fluid mechanics & heat transfer,
Introduction to numerical analysis, Discretisation approaches: finite difference, finite volume, finite element and spectral methods,
Numerical methods for algebraic equations/systems of equations, Numerical schemes for hyperbolic, parabolic and elliptic systems and for fluid dynamics,
CFD analysis
Numerical modeling of compressible & in-compressible flow, turbulence modeling,
Grid generation/CAD, data analysis and uncertainties.

Learning Resources

- “A Textbook of Heat Transfer Paperback”, by S.P. Sukhatme. Publisher: Universities Press, 4th edition,2005.
- “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, by H. Versteeg. Publisher: Pearson, 2nd edition, 2007.
- “Computational Fluid Dynamics the Basics with Applications”, by John D. Anderson, Jr. Publisher: McGraw Hill Education, 2017.
- “Fluid Mechanics: Volume 2: Foundations and Applications of Mechanics (Cambridge-IIsc)”, by C.S. Jog. Publisher: Cambridge University Press; 3rd edition, 2015.
- “Numerical Modeling and Computer Simulation”, Edited by Dragan Cvetković, publisher intechopen, 2020.
- Literature / books suggested by respective course Lecturers.

22DTRT0	LAUNCH VEHICLE DESIGN & ANALYSIS

Category	L	T	P	Credit
PE	3	0	0	3

Course Objectives

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

Course Outcomes

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

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

Syllabus

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

Learning Resources

- "Design of Rockets and Space Launch Vehicles", by Don Edberg, Willie Costa. Publisher: American Institute of Aeronautics & Ast. (August 21, 2020).
- "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, Subsequent edition, 1992.
- "Fundamentals of Astrodynamics 1st Edition", by Roger R. Bate, Donald D. Mueller. Publisher: The American Design Ethic, MIT, USA, 1st edition, 1971.
- "Commercial Launch Vehicle Design", by Nickolay Mykola Zosimovych. Publisher: Lap Lambert Academic Publishing.
- "Space Vehicle Design, Second Edition", by Michael D. Griffin and James R. French. Publisher The American Institute of Aeronautics and Astronautics, Inc, 2nd edition, 2004.
- Literature / books suggested by respective course Lecturers.

22DTRU0	ACQUISITION, TRACKING & POINTING TECHNOLOGY

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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 commonly utilized in the design of tracking systems.

Syllabus

Acquisition, tracking, and pointing (ATP) design for military systems
Target tracking and related mathematics, SNR requirement, the Johnson criteria, probability of estimation, detection criteria
Tracking algorithms, track filters, multi target tracking,
Electronic countermeasures against modern target tracking radars
multiplatform-multi-sensor-multi target tracking
Doppler and Electro-Optical methods of tracking

Learning Resources

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

22DTRV0	DATA ACQUISITION, TRACKING & POST FLIGHT ANALYSIS

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

Importance of Flight Trials in Missile Development, Facilities, Safety Requirements
Methods of Measurement, Introduction to Measuring Instruments: Functional elements of an instrument
Static and Dynamic Characteristics, Zero, First and Second order of Instruments and their response
Calibration of Instruments
Sensors and Transducers: Passive and Active types, their uses in measurement of acceleration, angle, vibration, pressure, flow and temperature, strain etc.,
Methods for post flight data analysis.

Learning Resources

- “Advances in Missile Guidance, Control, and Estimation: 47 (Automation and Control Engineering)”, by Editors S.N. Balakrishnan, A. Tsourdos, B.A. White, 1st edition, 2016.
- “Calibration Handbook of Measuring Instruments 1st Edition”, by Alessandro Brunelli. Publisher: International Society of Automation,Pap/Cdr edition, 2017.
- “Calibration Book”, by Janne Kivilaakso, Antero Pitkäkoski Jori Valli, Mike Johnson, Nobuo Inamoto Arja Aukia Masaki Saito. Publisher: VaisalaOyj, 2006.
- “Sensors and Transducers”, by Patranabis D. Publisher: Prentice Hall India Learning Private Limited, 2nd edition, 2003.
- “Sensors and Transducers Paperback”, by Ian Sinclair. Publisher: Elsevier, 2011.
- Literature / books suggested by respective course Lecturers.

22DTRW0	AIR INDEPENDENT PROPULSION AND BATTERIES

Category	L	T	P	Credit
PE	3	0	0	3

Course Objectives

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

Course Outcomes

On the successful completion of the course students will 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.

Syllabus

Introduction to Hybrid Electric Vehicles: Impact of modern drive-trains on energy supplies;
Hybrid Electric Drive-trains: hybrid traction, various hybrid drive-train topologies, power flow control, fuel efficiency analysis;
Electric Drive-trains: electric traction, electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis;
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;
Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles,
Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Learning Resources

- "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", by Chris Mi, M. Abul Masrur. Publisher: Wiley, 2nd edition, 2017.
- "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, 2009.
- Literature / books suggested by respective course Lecturers.

22DTRX0	ADVANCED DIGITAL MODULATION TECHNOLOGIES & STANDARDS

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

Design of digital communication system, transmitter and receiver communications system model

Voice source coding– pulse code modulation, delta modulation, vocoders

Digital modulation – Amplitude-shift, Frequency-shift, Phase-shift, differential phase- shift, Quadrature phase-shift, Quadrature phase-shift, and Minimum-shift keying, Quadrature amplitude modulation

Communications channel – Multipath effects, fading and diversity, models of Egli and Murphy

Receivers – super heterodyne systems, balanced and unbalanced mixers, frequency synthesizers, Link budget analysis

Introduction to cellular communication – CDMA, OFDM, MIMO, Introduction to digital modulation standards.

Learning Resources

- “Communication Systems”, by, Haykin, S. Publisher: John Wiley & Sons, 5th edition,2009.
- “Modern Digital and Analog Communication Systems”, by, Lathi, B.P. and Ding, Z. Publisher: Oxford University Press, 5th edition, 2018.
- “Signal Processing for Wireless Communication Systems”, by H. Vincent Poor, Lang Tong, Publisher: Springers, 2002.
- “Digital Communication: Fundamentals and Applications”, by Sklar, B., and Ray, P.K. Dorling Kindersley, 2nd edition, 2001.
- “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,
- 1st edition, 1985.
- “Detection, Estimation and Modulation Theory Part I”, by Van Trees, H.L. Publisher: Wiley Interscience, 2nd edition, 2013.
- “Information Theory, Coding and Cryptography”, by Bose, R. Tata McGraw-Hill, 2002.
- “Digital Communication”, by Barry, J.R., Lee, E.A. and Messerschmitt, D.G.Kluwer, 3rd edition, 2004..
- “Principles of Digital Transmission: Wireless Applications”, by Benedetto, S. and Biglieri, E. Publisher: Springer, 1999.
- Literature / books suggested by respective course Lecturers.

22DTRY0	TRAJECTORIES MODELLING & SIMULATION

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

Flight Dynamics, Flight envelope limitations. Aerodynamic sizing-equations of motion. Accuracy of simplified equations of motion, orbital mechanics.

Role of rocket propulsion in orbital trajectories and maneuvers, Maximizing missile flight performance. Benefits of flight trajectory shaping.

Flight performance prediction of boost, climb, cruise, coast, steady descent, ballistic, maneuvering, divert, and homing flight.

Practical implementation of integrated trajectory planning, Agility in maneuvering trajectories. 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.

Extensive MATLAB-based mini-projects.

Learning Resources

- “Flight Dynamics”, by Robert F. Stengel. Publisher: Princeton University Press, 2015.
- Literature / books suggested by respective course Lecturers.

22DTRZ0	SENSOR TECHNOLOGY

Category	L	T	P	Credit
PE	3	0	0	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

On the successful completion of the course students will 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.

Syllabus

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,

Phased array and pulsed compressed radars, imaging synthetic aperture and inverse synthetic aperture radars

Atmospheric propagation of signal. Noise resources and thermal radiation

Principles of semiconductor devices. Optical and infrared imaging detector systems.

Detector resolution limitations and bandwidth requirements, Relationship between signals and noise.

The characteristics of critical sensor functions (including detection, estimation, imaging, and tracking).

Learning Resources

- “Handbook of Modern Sensors”, by Jacob Fraden. Publisher: Springer, 5th edition, 2016.
- “Micro sensors, Principles and Applications”, by J. W. Gardner. Publisher: Wiley, 2nd rev edition, 2007.
- “Semiconductor Sensors”, by S. M. Sze. Publisher: Wiley, 1st edition, 1994.
- 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.**