UNIVERSITY INSTITUTE OF ENGINEERING AND TECHNOLOGY
(A constituent Autonomous Institute and Recognized by UGC under Section 12(B) and 2(f))
KURUKSHETRA UNIVERSITY, KURUKSHETRA
Established by the state Legislature Act XII of 1956

('A+' Grade, NAAC Accredited)

MASTER OF TECHNOLOGY
IN
DEFENCE TECHNOLOGY (w. e. f. 2021-22)

Scheme and Syllabai of Examination

Program Outcomes

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

Semester -I

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IN

DEFENCE TECHNOLOGY (w. e. f. 2021-22)

SEMESTER-1

Sr. No.	Course Code	SUBJECT	L	T	P	Total	Minor Test	Major Test	Cr.	Duration of Exam (Hrs.)
1	DT-01-01	Systems and warfare Platforms	4	-	-	4	40	60	4	3
2	DT-01-02	Warfare Simulations & Strategies	4	-	-	4	40	60	4	3
3	DT-01-03	Advanced Engineering Mathematics	4	-	-	4	40	60	4	3
4	DT-01-L01	Systems and Platforms Lab	-	-	4	4	40	60	2	3
5	DT-01-L02	Warfare Simulations & Strategies Lab	-	-	4	4	40	60	2	3
6	*	Elective-I	3	-	-	3	40	60	3	3
7	**	Elective-II	3	-	-	3	40	60	3	3
8		Seminar	-	-	2	2	100	-	1	3
		Total	**18**	**-**	**10**	**28**	**380**	**420**	**23**	
							800			

*LIST OF ELECTIVES - I for 1st Semester		
Sr. No.	Course Code	Course of Study
1.	DT-EL1-01	Rockets & Missiles Fundamentals
2.	DT-EL1-02	Advanced Thermal Engineering
3.	DT-EL1-03	Numerical methods for science & engineering
4.	DT-EL1-04	Communication Technology
5.	DT-EL1-05	Advanced Mechanical Engineering

**LIST OF ELECTIVES - II for 1st Semester		
Sr. No.	Course Code	Course of Study
1.	DT-EL2-01	Autonomy and Navigation Technology
2.	DT-EL2-02	Optimization theory & applications
3.	DT-EL2-03	Military Electronics System Engineering
4.	DT-EL2-04	System Engineering & Analysis

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

Semester -II

SEMESTER-II
MASTER OF TECHNOLOGY
IN
DEFENCE TECHNOLOGY (w. e. f. 2021-22)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

Sr. No.	Course Code	Subject	L	T	P	Total	Minor Test	Major Test	Cr.	Duration of Exam (Hrs.)
1	DT-CSS-01	Radar Technologies	4	-	-	4	40	60	4	3
2	DT-CSS-02	Digital & satellite Communication and Navigation from Space	4	-	-	4	40	60	4	3
3	DT-CSS-03	Tactical battlefield Communication & Electronic Warfare	4	-	-	4	40	60	4	3
4	DT-CSS-L01	Radar Technologies Lab	-	-	4	4	40	60	2	3
5	DT-CSS-L02	Digital & satellite Communication and Navigation from Space Lab	-	-	4	4	40	60	2	3
6	*	Elective-III	3	-	-	3	40	60	3	3
7	**	Elective-IV	3	-	-	3	40	60	3	3
8		Seminar	-	-	2	2	100	-	1	3
		Total	**18**		**10**	**28**	**380**	**420**	**23**	
							800			

SEMESTER-II
MASTER OF TECHNOLOGY
IN

Sr. No.	Course Code	Subject	L	T	P	Total	Minor Test	Major Test	Cr.	Duration of Exam (Hrs.)
1	DT-DET-01	Directed Energy Sources (Lasers, Microwave)	4	-	-	4	40	60	4	3
2	DT-DET-02	Beam Control Technology, Target acquisition, Beam Pointing & Tracking	4	-	-	4	40	60	4	3
3	DT-DET-03	Directed Energy Weapons (DEW) System Engineering	4	-	-	4	40	60	4	3
4	DT-DET-L01	Directed Energy Sources (Lasers, Microwave) Lab	-	-	4	4	40	60	2	3
5	DT-DET-L02	Beam Control Technology, Target acquisition, Beam Pointing & Tracking Lab	-	-	4	4	40	60	2	3
6	*	Elective-III	3	-	-	3	40	60	3	3
7	**	Elective-IV	3	-	-	3	40	60	3	3
8		Seminar	-	-	2	2	100	-	1	3
		Total	**18**	**-**	**10**	**28**	**380**	**420**	**23**	
							800			

DEFENCE TECHNOLOGY (w. e. f. 2021-22)
SPECIALIZATION: DIRECTED ENERGY TECHNOLOGY

*LIST OF ELECTIVES - III (for all Specializations) for 2nd Semester		
Sr. No.	Course Code	Course of Study
1.	DT-EL3-01	Robotics (MSS, MCC)
2.	DT-EL3-02	EMI/EMC in Military Systems
3.	DT-EL3-03	Defence Electro-Optics and Imaging Systems
4.	DT-EL3-04	Structural Dynamics and Aero-elasticity
5.	DT-EL3-05	Safety, Health & Hazard Management
6.	DT-EL3-06	Fundamental of telemetry, telecomm and transponder
7.	DT-EL3-07	Jamming and ECM/ECCM technologies
8.	DT-EL3-08	Software defined Radios
9.	DT-EL3-09	Advanced Lightweight and Composite Structures
10.	DT-EL3-10	Test methodologies for DEW systems (Lasers & Microwave)
11.	DT-EL3-11	Advanced Analytical Techniques / Lab testing
12.	DT-EL3-12	Sonar System Engineering

** LIST OF ELECTIVES - IV (for all Specializations) for 2nd Semester		
Sr. No.	Course Code	Course of Study
1.	DT-EL4-01	Unmanned Aerial Vehicle Design
2.	DT-EL4-02	Naval Ocean Analysis and Prediction
3.	DT-EL4-03	Modeling & simulation of Laser Matter Interaction
4.	DT-EL4-04	Computational Aerodynamics
5.	DT-EL4-05	Launch Vehicle Design & Analysis
6.	DT-EL4-06	Acquisition, Tracking & Pointing Technology
7.	DT-EL4-07	Data acquisition, tracking & post flight analysis
8.	DT-EL4-08	Air independent propulsion & batteries
9.	DT-EL4-09	Advanced digital modulation technologies & standards
10.	DT-EL4-10	Trajectories modeling & simulation
11.	DT-EL4-11	Sensor Technology

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

Semester -III

SEMESTER-III

Sr. No.	Course Code	Subject	L	T	P	Total	Minor* Test	Major Test	Cr.	Duration of Exam (Hrs.)
1	DT-PDP-01	Project Dissertation- Phase 1	-	-	20	20	100	00	10	3
2		Seminar/Industrial Training	-	-	8	8	100	00	4	3
Total			**-**	**-**	**28**	**28**	**200**	**-**	**14**	
							200			

Semester -IV

SEMESTER-IV

Sr. No.	Course Code		L	T	P	Total	Minor Test	Major Test	Cr.	Duration of Exam (Hrs.)
1	DT-PDP-02	Project Dissertation-Phase- 2	-	-	40	40	100	200	20	3
						Total	**100**	**200**	**20**	
							300			

Syllabus

2425

INSTRUCTIONS FOR PAPER SETTER

- The question paper is to be attempted in **THREE Hours**.
- Maximum Marks for the paper are **60.**
- The syllabus for the course is divided into **SIX units.**
- The paper will have a total of **THIRTEEN questions.**
- **Question No. 1,** which is compulsory, shall be OBJECTIVE Type **and have content from the entire syllabus (all SIX Units).**

Q. No. 2 & 3	**from**	**Unit I**
Q. No. 4 & 5	**from**	**Unit II**
Q. No. 6 & 7	**from**	**Unit III**
Q. No. 8 & 9	**from**	**Unit IV**
Q. No. 10 & 11	**from**	**Unit V**
Q. No. 12 & 13	**from**	**Unit VI**

- The candidate will attempt a total of **SEVEN questions. Q. No. 1** is **compulsor**y and carries **12 marks**. The candidate shall attempt remaining **SIX questions each of 8 marks** by selecting **only one question from each unit.**
- A question may have any number of sections labeled as 1(a), 1(b), 1(c), 1(d), ---- 2(a), 2(b), --.A section may further have any number of subsections labeled as (i), (ii), (iii),.
- **SPECIAL INSRUCTIONS FOR Q. No. 1 ONLY**

  Question No. 1, which is compulsory, shall be OBJECTIVE/ short answer type **and have content from the entire syllabus with equal weightage of all Six Units.**

  Emphasis is to be given on the basic concepts, analytical reasoning and understanding of the various topics in the subject. This question may have a number of parts and/or subparts. The short questions could be combination of following types:

  - Multiple Choice
  - Yes/ No choice
  - Fill in Blanks type
  - Short numerical computations
  - Short Definitions
  - Matching of Tables

  The above-mentioned question types is **only a Guideline**. Examiner could set the question as per the nature of the subject.

Semester -I

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

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DT-01-01	SYSTEMS AND WARFARE PLATFORMS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	**4**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand types of warfare platform used for Army, Air and Marine and their design fundamentals.						
CO 2	Students will be able to understand the weapon systems like guns, ordnance, missiles projectiles, mines/ countermines, lasers, undersea weapons, air-launched weapons, anti-aircraft, anti-ship and anti-submarine.						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

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

Suggested Books:

1. "Light And Heavy Vehicle Technology ", by Nunney. Publisher Elsevier.
2. "Practical approach to motor vehicle engineering and maintenance", by Bon-nick Allan et. Al. Publisher: Yesdee.
3. "Automotive Vibration Control Technology: Fundamentals, Materials, Construction, Simulation, and Applications", by Trelleborg.
4. "An Introduction to Weapons Systems", by Yacov Bar-Shlomo. Publisher: Create Space Independent Publishing Platform.
5. "Heavy Vehicle Mechanics", by Ian Nicholson. Publisher: McGraw-Hill Education – Europe.
6. "Military Laser Technology for Defense: Technology for Revolutionizing 21st Century Warfare", by Alastair D. McAulay. Publisher: Wiley-Interscience; 1st edition.
7. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-01-02	WARFARE SIMULATIONS & STRATEGIES						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	**4**	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students about warfare system and affluent them with combat modeling using mathematical modeling.						
Course Outcomes							
CO 1	Students will be able to understand the systems used in warfare scenario.						
CO 2	Students will be able to understand combat simulation & modelling.						
CO 3	Students will be able to understand the war gaming simulation & modelling and human factor representation.						

Unit l

Introduction to Warfare systems: air, surface, subsurface, littoral, electronic.

Unit ll

Military capabilities: air warfare, surface warfare, sub surface warfare, littoral warfare

Unit lll

Introduction to the methods used in modeling combat and their application in support of defence decision making and training, Combat simulation

Unit IV

War gaming/interactive simulation, Lanchester's equations, Mathematical models of combat

Unit V

War gaming and combat modeling in practice, manual war gaming

Unit VI

Human factors representation in war gaming and combat modeling

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-01-03	ADVANCED ENGINEERING MATHEMATICS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	**4**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to know the methods for solving differential equations, generating functions.						
CO 2	Students will be able to understand basic concepts of Fourier Transform, Laplace Transforms and solve problems with periodic functions, step functions, impulse functions and convolution.						
CO 3	Students will be able to demonstrate MATLAB programming for engineering problems.						
CO 4	Students will be able to understand the utilization of mathematical methods for solving problems having relevance to defence applications.						

Unit l

Elements of Probability and Statistics, components of operations research, Linear Algebra.

Unit ll

Ordinary Differential equations, Numerical methods for ODE and P.D.E. Generating functions, recurrence relations

Unit lll

Transform Techniques, Fourier series, Fourier Transform, Laplace Transform

Unit IV

Special functions: Power series method, Frobenious method, Legendre equation, Legendre polynomials, Bessel equation, Bessel functions of first kind, Orthogonal property

Unit V

Elements of Ramsey theory, theorems of Burnside and Polya, and balanced incomplete block designs

Unit VI

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

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-01-L01	SYSTEMS AND WARFARE PLATFORMS LAB						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**4**	**2**	**60**	**40**	**100**	**3**

List of Experiments

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

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-01-L02	SYSTEMS AND WARFARE PLATFORMS LAB						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**4**	**2**	**60**	**40**	**100**	**3**

List of Experiments

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

Semester 1, Elective-1 Courses

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL1-01	ROCKETS & MISSILES FUNDAMENTALS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students about missile system, classification of missiles, aerodynamics of missiles, subsystems and missile trajectory.						
Course Outcomes							
CO 1	Students will be able to understand basics of missile physics as well as the engineering aspects of missile integration.						
CO 2	Students will be able to understand physics behind guided missiles and aero dynamics of missiles.						
CO 3	Students will be able to understand concept of characterization of sub-systems used in missiles.						

Unit l

Basics of Missile Physics, Introduction to Guided Missiles, Classification of Missiles

Unit ll

Missile Aerodynamic Configurations, Introduction to Missile System, Interrelationship between various Missile Sub-Systems

Unit lll

Basic Characteristics of Guided Missile Systems, Missile System Reliability, Range dispersion and CEP Concept

Unit IV

Design, System Layout and integration of Sub-Systems

Unit V

Coordinate Transformation, Transformation Matrices. Two, Three and Six DOF Equations of Motion, Ballistic Missile Trajectory

Unit VI

Effect of Curvature of Earth, Rotation of Earth, Variation of Gravity on Missile Trajectory

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL1-02	ADVANCED THERMAL ENGINEERING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand thermal design and simulations for system design.						
CO 2	Students will be able to carry out CFD simulations, design of heat exchangers, refrigeration.						
CO 3	Students will be able to the concept of thermal management requirement & design for defence systems.						

Unit l

System thermal design & Analysis, Tools for thermal design and simulation, Heat transfer analysis (conduction, convection & radiation),

Unit ll

Computation fluid dynamics (CFD), Thermal Finite Element Analysis

Unit lll

Heat Exchangers for: Heat Exchanger Network Design

Unit IV

Refrigeration, Humidifiers, Air Washers and Cooling Towers

Unit V

Thermal management design of defence system (combat vehicles, missiles, aerial vehicles etc.)

Unit VI

Thermal testing, thermal operation, and integration of thermal design into the defence systems

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL1-03	NUMERICAL METHODS FOR SCIENCE AND ENGINEERING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to Use the numerical techniques (algorithms) to find the solution (approximate) algebraic equations and system of equations.						
CO 2	Students will be able to fit the data using interpolation technique and spline methods.						
CO 3	Students will be able to use finite element analysis, interpretation of analysis results. They will be able to understand computational engineering process						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

Fluid Simulation for Computer Graphics, Modelling techniques

Suggested Books:

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

7. "Finite Elements in Engineering", by Chandrupatla and Belegundu.
8. "Finite element Method", by J.N.Reddy.
9. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL1-04	COMMUNICATION TECHNOLOGY						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand communication system design methodologies, communication system architecture, analogue & digital modulation techniques.						
CO 2	Students will be able to do computation of data rates, bandwidth, BER.						
CO 3	Students will be able to carry out the link budget analysis						

Unit l

Introduction on Communication Systems, Basics of wireless channel behaviour

Unit ll

Digital data communication systems, digital signalling techniques

Unit lll

Data rates and bandwidth calculation in digital data communication systems

Unit IV

Probability of error and BER calculation, Modulation technologies (analogue & digital), Voice source coding, transmitter and receiver systems

Unit V

Communication system architectures, terminal design and performance, associated information systems

Unit VI

Link budget calculations, telemetry and control and IO/IW implications. Antenna types and their impact on the communication systems

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL1-05	ADVANCED MECHANICAL ENGINEERING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students about different methods of mechanical system analysis, mechanical simulation soft-ware and use of computational techniques for structural and fluid dynamics.						
Course Outcomes							
CO 1	Students will be able to understand mechanical analysis software and carry out mathematical modeling for simulation of phenomena behind the structural and fluid dynamics.						
CO 2	Students will be able to carry out design & finite element analysis of components of systems and sub-systems.						
CO 3	Students will be able to carry out the CFD analysis						

Unit l

Introduction to tools for mechanical design & analysis

Unit ll

Stress engineering – theory & simulation, mechanics of solids

Unit lll

Finite element methods in structural dynamics, Structural integrity

Unit IV

Fluid mechanics

Unit V

Computational fluid dynamics

Unit VI

Component design, Applied materials and corrosion

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks***.

Semester 1, Elective-2 Courses

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL2-01	AUTONOMY AND NAVIGATION TECHNOLOGY						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students about technology of modern navigation systems, particularly satellite-based systems, UAV guidance systems, GPS, SLAM.						
Course Outcomes							
CO 1	Students will be able to describe the basic principle of operation of a global navigation satellite system.						
CO 2	Students will be able to understand the navigation systems and derive the navigation equations.						
CO 3	Students will be able to carry out path planning the UGV / UAV						
CO 4	Students will be able to solve the equations for calculating a position estimate from a given satellite constellation.						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

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

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL2-02	OPTIMIZATION THEORY & APPLICATIONS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand mathematical modeling and the formulation of optimization problems.						
CO 2	Students will be able to create programs based on different optimization algorithms using IT tools, such as MATLAB etc.						
CO 3	Students will be able to understand theory about linear programming, integer programming, and stochastic programming						
CO 4	Students will be able to understand the process of finalizing design of engineering systems by applying the numerical optimization.						

Unit l

Introduction to optimization, classical optimization techniques

Unit ll

Linear programming & nonlinear programming and dimensional minimization methods

Unit lll

Non coordination optimization techniques, coordinated optimization techniques, coordinated programming

Unit IV

Dynamic programming, integer programming, stochastic programming

Unit V

Solution of a variety of design problems in mechanical engineering, using numerical optimization techniques

Unit VI

Additional Topics: multi-objective, optimization, game theory, optical control theory

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL2-03	MILITARY ELECTRONICS SYSTEM ENGINEERING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand the military electronics systems.						
CO 2	Students will be able to generate system design requirements as per mission needs & operational requirements.						
CO 3	Students will be able to create digital simulation models						
CO 4	Students will be able to understand the limitations of the COTS available electronics systems.						
CO 5	Students will be able to evaluate the radiation effects on the performance of electronics systems						

Unit l

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

Unit ll

Familiarity with the systems engineering process through case studies of representative defense systems

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

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

Suggested Books:

1. "Introduction to Electronic Defense Systems", by Neri Filippo. Publisher: Artech House Publishers.
2. "Military Handbook of Electronic Reliability design", by US Department of Defence.
3. "Defence Electronics Standards and Quality Assurance", by Ray Tricker. Pub-lisher : Elsevier
4. "Handbook of Defence Electronics and Optronics: Fundamentals, Technologies and Systems", by Anil K. Maini. Publisher: John Wiley & Sons Ltd

5. "Digital Simulation Methods", by M.G. Hartley. Publisher: P. Peregrinus Ltd
6. "Analysis and Simulation of Noise in Nonlinear Electronic Circuits and Systems", By Alper Demir. Publisher: Springer.
7. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (1ST Sem.)

DT-EL2-04	SYSTEM ENGINEERING AND ANALYSIS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand the system design requirements, architecture, functional requirements.						
CO 2	Students will be able to generate the system requirements documents as per the requirement analysis.						
CO 3	Students will be able to understand the system reliability, maintainability, usability issues						
CO 4	Students will be able to carry out the system reliability analysis.						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

Supportability, and producibility, System cost assessment and effectiveness estimation

Unit VI

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

Suggested Books:

1. "The Engineering Design of Systems: Models and Methods", by Buede D.M.2. Publisher: John Wiley & Sons Inc.
2. "Systems engineering fundamentals", by Defense Acquisition University Pressfort Belvoir, Virginia
3. "System Analysis Design and Development", by Charles S. Wasson. Publisher : Wiley Series in System Engineering and Management.
4. "Principles of Planned Maintenance", by Clifton R H. Publisher: McGraw Hill, New York.
5. "An introduction to Reliability and Maintainability Engineering", by Ebling CE. Tata Mc Graw Hill.

6. "Reliability Engineering", by Srinath L S. Publisher: Affiliated East-West Press Limited, New Delhi, 2002.
7. "Engineering Maintainability", by Dhillon B S. Publisher: Prentice Hall of India.
8. Literature / Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

Semester -II

MASTER OF TECHNOLOGY
IN
DEFENCE TECHNOLOGY (w. e. f. 2021-22)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

DT-CSS-01	RADAR TECHNOLOGIES						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	4	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students 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							
CO 1	Students will be able to understand the design of radar systems, solve range equations.						
CO 2	Students will be able to Apply appropriate mathematical and computer models relevant to radar systems to calculate system performance and assess the limitations of particular cases.						
CO 3	Students will be able to understand the major components of a modern radar system						
CO 4	Students will be able to learn basic radar signal processing techniques and understand advanced radar techniques.						
CO 5	Students will be able to know the major functions and applications of a modern radar systems.						

Unit l

Introduction to RADAR, Radar parameters/definitions, radar equations

Unit ll

Radar cross section (RCS) & Theory of detection, Clutter

Unit lll

Atmospheric propagation, Surveillance and Tracking Radar, Radar Designs

Unit IV

Radar elements Design, Radar Transmitter design, Radar antenna design, Duplexer/TR switch & Radar Receiver.

Unit V

Radar signals and networks, Radar signal processing chain, Pulse compression and micro-doppler processing, Tracking algorithms

Unit VI

Phased array radar, Data processing for phased array radar, Airborne radar, imaging radar, Synthetic aperture radar, inverse synthic aperture radar, adaptive array processing

Suggested Books:

1. "Introduction to Radar Systems" by M.I. Skolnik. Publisher: Tata McGraw hill edition, 2001.
2. "Radar Systems Analysis and Design using MATLAB", by B.R. Mahafza. Publisher CRC Press, 2013.
3. "Monopulse Principles and Techniques", by S.M. sherman and D.K. Barton. Publisher: Artech house, 2011
4. "Fundamentals of Radar Signal Processing", by M.A. Richards. Publisher Tata McGraw hill.
5. "Ground Penetrating Radar: Theory and Applications", by, Editor: H.M. Jolt. Publisher: Elsevier.

6. "Radar, Sonar And Navigation Engineering", by K. K Sharma. Publisher: S K Kataria & Sons.
7. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

DT-CSS-02	DIGITAL & SATELLITE COMMUNICATION AND NAVIGATION FROM SPACE						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	4	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students learning on the analogue and digital communication systems, optical communication, satellite communications systems, modulations techniques, signal propagation effects, navigation techniques.						
Course Outcomes							
CO 1	Students will be able to understand the communication techniques.						
CO 2	Students will be able to evaluate the performance of communication systems.						
CO 3	Students will be able to design the analogue and digital communication systems						
CO 4	Students will be able to understand and analyse the signal transmission effects.						
CO 5	Students will be able understand the different types of navigation techniques.						

Unit l

Elements of a communications system and their relationship to system performance

Unit ll

Free space optical communication, Fiber optics communication, Wireless/cellular communications

Unit lll

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

Unit IV

Modulation transmission and reception; baseband and passband digital modulation; system, noise, transmission lines, waveguides and antennas, FEC techniques for mitigating channel errors.

Unit V

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

Unit VI

Navigation techniques from space regarding functioning of GPS, GLONASS, IRNSS & Galileo

Suggested Books:

1. "Satellite communication", by T. Pratt, C. W. Bostian, J. E. Allnut. Publisher: John Willey and sons
2. "Satellite Communications Systems: systems, techniques and technology", by G. Maral, M. Bousquet, Z. Sun. Publisher: John Willy and sons
3. "Digital Communications: Fundamentals and Applications", B. Sklar . Prentice-Hall, Inc.

4. "Understanding of GPS/GNSS: Principles and Applications", by E. Kaplan and C. Hegarty. Publisher: Artech House Publishers.
5. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

DT-CSS-03	TACTICAL BATTLEFIELD COMMUNICATION & ELECTRONIC WARFARE						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	4	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students learning 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							
CO 1	Students will be able to understand the nature of tactical battlefield communication.						
CO 2	Students will be able to calculate communication link performance.						
CO 3	Students will be able to calculate the requirements for interception of tactical communication						
CO 4	Students will be able to Calculate the requirements for emitter location, intercept and jamming of tactical comm, signals including weapon control link, UAV links, Cell phone links.						
CO 5	Students will be able to use various tools to perform electronic warfare calculations.						

Unit l

Radiometry and power calculation, signature generation, atmospheric effects

Unit ll

Radar ES operational use, radar/ES detection battle, quiet radar, jamming techniques & strategies, jamming of SAR systems

Unit lll

Introduction to radar waveform interception, Technology and operational characteristics of electronic warfare, Signal processing statics & analysis, statistics & noise, analogue & digital signal processing

Unit IV

Decision theory- hypothesis testing, probabilities of false alarm and detection, Bayesian systems, error probability and bit error rate, receiver operating.

Unit V

UAV Payload/link Issues, cell phone issues, Intercept links, Frequency hopping and other LPI threats; Special techniques for jamming LPI signals

Unit VI

Introduction to electronic counter measures and counter-counter measures

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

DT-CSS-L01	RADAR TECHNOLOGIES LAB						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**4**	**2**	**60**	**40**	**100**	**3**

List of Experiments

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

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

DT-CSS-L02	DIGITAL & SATELLITE COMMUNICATION AND NAVIGATION FROM SPACE LAB						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**4**	**2**	**60**	**40**	**100**	**3**

List of Experiments

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

Semester -II

MASTER OF TECHNOLOGY
IN
DEFENCE TECHNOLOGY (w. e. f. 2021-22)
SPECIALIZATION: DIRECTED ENERGY TECHNOLOGY

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: DIRECTED ENERGY TECHNOLOGY

DT-DET-01	DIRECTED ENERGY SOURCES (LASERS, MICROWAVE)						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	4	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students on the high-power laser sources, laser power scaling methodologies, laser beam characterization, optics requirements for high power lasers and generation of high power microwave sources.						
Course Outcomes							
CO 1	Students will be able to understand high power lasers sources, power scaling methodologies of lasers.						
CO 2	Students will be able to carry out the atmospheric effects on high power laser beam propagation.						
CO 3	Students will be able to estimate optics requirement for handling high power laser beams						
CO 4	Students will be able understand generation and testing of high-power microwave sources.						

Unit l

Introduction of directed energy weapons, Potential weapon applications, how they work, application scenarios

Unit ll

High power laser sources (solid state, fiber, free election, liquid etc.), Laser power scaling

Unit lll

Atmospheric Laser Beam propagation

Unit IV

Characterization of laser beam parameters

Unit V

Optical material & coating for high energy lasers

Unit VI

High power microwave sources, HPM effects, testing of HPM sources

Suggested Books:

1. "High Power Laser Handbook,by HagopInjeyan & Gregory D. Goodno
2. "High Power Microwaves James Benford", by John A. Swegle, EdlSchamiloglu.
3. "Coherent Laser Beam Combining", by Arnaud Brignon.
4. "High-Power Optics Lasers and Applications", by Apollonov, Victor V.
5. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: DIRECTED ENERGY TECHNOLOGY

DT-DET-02	BEAM CONTROL TECHNOLOGY, TARGET ACQUISITION, BEAM POINTING & TRACKING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	4	**60**	**40**	**100**	**3**
Objective	To provide knowledge to the students about high power laser & microwave beam control technologies, laser beam directors, their operational requirements, design procedure, design criticality, active target imaging & target tracking, recent developments in the target tracking, atmospheric effects on laser propagation, mitigation methodologies and adaptive optics.						
Course Outcomes							
CO 1	Students will be able to understand of high-power laser & microwave beam directors, design requirements & design methodologies.						
CO 2	Students will be able to gain knowledge of active target imaging, coarse & fine target tracking and contemporary target tracking technologies.						
CO 3	Students will be able to compute atmospheric effects on the laser beam performance and hence carry out conceptual design of adaptive optics						

Unit l

Introduction to beam control, Beam control hardware

Unit ll

Introduction to laser beam directors, Requirement for high power laser beam directors, Conceptual optical design & analysis of beam Directors

Unit lll

Laser beam tracking, pointing & control, Gimbals, Coarse & fine tracking

Unit IV

Active laser imaging & target tracking, Closed loop image tracking, Hardware requirement, Various tracking algorithms, multi-spectral target imaging, Multiple target engagements, rapid retargeting.

Unit V

Atmospheric propagation of Laser beams, atmospheric propagation of laser beams, Correction of atmospheric effects, Adaptive optics, Atmospheric modeling of laser propagation

Unit VI

Introduction to HPM beam control technology, major sub-assemblies

Suggested Books:

1. "Beam Control for Laser Systems", by Paul Merritt.
2. "Principles of Adaptive Optics", by Robert Tyson.
3. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: DIRECTED ENERGY TECHNOLOGY

DT-DET-03	DIRECTED ENERGY WEAPON (DEW) SYSTEM ENGINEERING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
4	**0**	**0**	4	**60**	**40**	**100**	**3**
Objective	To provide knowledge to students about Directed Energy Weapon subsystems, systems. They will also gain knowledge about system design & analysis, thermal management & power management of DEW and the operational requirements. The course will also provide an insight about the DEW systems developed internationally.						
Course Outcomes							
CO 1	Students will be able to understand of DEW systems, design requirements.						
CO 2	Students will be able to evaluate the thermal and power requirements.						
CO 3	Students will be able to Evaluate the system performance.						

Unit l

Attributes of DEW, System requirements, DEW system design, system analysis

Unit ll

DEW subsystems, System modeling & simulation

Unit lll

Thermal management of DEW, Power management of DEW

Unit IV

Operational requirements of directed energy systems, platform integration.

Unit V

Weapon effectiveness under different operating conditions

Unit VI

Overview of internationally developed systems (Airborne Laser Laboratory, Airborne Laser, Tactical High Energy Laser, Advanced Tactical Laser, and Space-Based Laser programs

Suggested Books:

1. "Directed-Energy Beam Weapons Hardcover", by Bahman Zohuri.
2. "Directed Energy Weapons: Physics of High Energy Lasers (HEL)", by Bahman Zohuri.
3. "An Introduction to Laser Weapon Systems", by Glen P. Perram.
4. "Effects of Directed Energy Weapons", by Philip Nielsen.
5. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

DT-DET-L01	DIRECTED ENERGY LASER SOURCES LAB						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**4**	**2**	**60**	**40**	**100**	**3**

List of Experiments

1. Optical resonator design and experimental evaluation
2. Optics Alignment using He-Ne laser
3. Measurement of Laser Power, Beam Width, Spatial Profile, Wavelength
4. Measurement of Laser Beam Parameter (M2)
5. Optics Surface Quality test using Interferometer
6. Optical Coating Reflectivity, Transmission Test
7. Characterization of Microwave sources

More experiments may be planned in discussion with the concern DRDO Lab.

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2ND Sem.)
SPECIALIZATION: COMMUNICATION SYSTEMS & SENSORS

DT-DET-L02	BEAM CONTROL TECHNOLOGY, TARGET ACQUISITION, BEAM POINTING AND TRACKING LAB						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**4**	**2**	**60**	**40**	**100**	**3**

List of Experiments

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

Semester 2, Elective-III Courses
(For All Specializations)

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-01	ROBOTICS (MSS, MCC)						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide learning on the basic concepts of robotics by exposing students to a broad range of topics with emphasis on basics of manipulators, coordinate transformation and kinematics, trajectory planning, control techniques, sensors and devices, robot applications and economics analysis.						
Course Outcomes							
CO 1	Students will be able to use matrix algebra and Lie algebra for computing the kinematics of robots.						
CO 2	Students will be able to calculate the forward kinematics and inverse kinematics of serial and parallel robots.						
CO 3	Students will be able to calculate the Jacobian for serial and parallel robot.						
CO 4	Students will be able to do the path planning for a robotic system.						
CO 5	Students will be able to use software tools for analysis and design of robotic systems.						

Unit l

Fundamentals of land-based robotic systems covering the areas of locomotion, manipulation, grasping, sensory perception, and teleoperation

Unit ll

Kinematics, dynamics, manipulability, motion/force control, real-time programming, controller architecture, motion planning, navigation, and sensor integration, Control system design

Unit lll

Transformation of coordinates, Kinematics and inverse kinematics, Jacobians

Unit IV

Modelling Control, Proportional (P), Proportional-Integral (PI), Proportional-Integral-Derivative (PID) and Model Based Predictive Controller (MPC)

Unit V

Feedback Control System, Motion and path planning, Collision avoidance and navigation

Unit VI

Fundamental of AI, Programming methods for robotics, Human-Robot interaction

Suggested Books:

1. Textbook: Introduction to Robotics by S.K. Saha (Tata McGraw-Hill, New Delhi, India 2008, 1st Reprint 2009)
2. "Introduction to Robitcs: Mechanics and Control", by Craig, J.J. Publisher: Pear-son, Delhi.
3. "Fundamentals of Robotics: Analysis and Control", by Schilling Robert J. Pub-lisher : Prentice-Hall, 1990.

4. "An Introduction to Robotics Analysis, Systems, Applications", by Niku Saeed B. Publisher: Prentice-Hall, 2001.
5. Stuart Russell and Peter Norvig, Publisher: Prentice Hall
6. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-02	EMI/EMC IN MILITARY SYSTEMS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide learning on the basic concepts of EMI/EMC design, techniques for prevention of electronic equipment through good EMI/EMC design techniques – grounding, shielding, cable management, and power interface design, troubleshooting techniques, EMI/EMC standards.						
Course Outcomes							
CO 1	Students will be able to understand the concept of EMI / EMC protection of equipment.						
CO 2	Students will be able to Identify and prevent the common EMI/EMC problems in military systems.						
CO 3	Students will be able to understand the Design impact (by requirement) of military EMC specifications.						
CO 4	Students will be able to understand EMI/EMC troubleshooting tips and techniques.						
CO 5	Students will be able to learn generate EMI/EMC requirements document.						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

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

Suggested Books:

1. "EMI/EMC Computational Modeling Handbook", by brucearchambeault, Omar M. Ramahi, et al.

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-03	DEFENCE ELECTRO-OPTICS AND IMAGING SYSTEMS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To introduce the principles of wide range of current and future electro-optic and imaging devices. Course will also enable students to light on application of electro optics and imaging system in defence application.						
Course Outcomes							
CO 1	Students will be able to understand the technology and principles underpinning electro-optic devices and systems.						
CO 2	Students will be able to apply their knowledge to practical electro-optic design and acquisition problems.						
CO 3	Students will be able to understand the trade-offs in electro-optic systems design.						

Unit l

Principles of radiometry, The human eye, Visible band optical sighting systems

Unit ll

Camera systems, Image intensifiers, Missile seekers

Unit lll

Electro-optic countermeasures

Unit IV

Thermal imagers, II cameras, Hyper-spectral imaging, Digital image processing

Unit V

EO sensors for Lasers and laser DEW

Unit VI

Electro-optic protection measures

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-04	STRUCTURAL DYNAMICS AND AERO-ELASTICITY						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand vibrations and fluid dynamics behind the aerospace system.						
CO 2	Students will be able to understand of different design aspects related to loading in aerospace system.						
CO 3	Students will be able to do the system dynamic analysis using finite element methods.						

Unit l

Principles and methods of computational structural dynamics and vibration analysis

Unit ll

Introduction to dynamic analysis using the finite element method, Calculation of modal parameters

Unit lll

System dynamic response via mode superposition, frequency response, model reduction, and structural synthesis techniques, Fatigue analysis

Unit IV

Introduction to aero-elasticity, Aerodynamic Loading, Bending Moment, Sectional properties of Aerofoil, V-n Diagram

Unit V

Basic theory of linear elastic fracture mechanics; strain energy release rate

Unit VI

Applications to delamination crack growth in polymer composite laminates, Damage tolerance issues in composites

Suggested Books:

1. "Elements of vibration analysis", by Leonard Meirovitch. Publisher : McGraw-Hill Inc.,US; 2nd edition (1 March 1986)
2. "Finite Element Analysis Theory And Application With ANSYS", by Moaveni Publisher : Pearson Education; 3rd edition (1 January 2011)
3. "Mechanical Vibrations | SI Edition | Sixth Edition", by Singiresu S. Rao. Publisher: Pearson

4. "Elements of Fracture Mechanics", by Prashant Kumar. Publisher : McGraw Hill Education.
5. "Introduction to Structural Dynamics and Aeroelasticity", by Dewey H. Hodges and G. Alvin Pierce. Publisher: Cambridge University Press.
6. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-05	SAFETY, HEALTH & HAZARD MANAGEMENT						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To inculcate a holistic approach towards safety health and hazard management. The course will provide understanding on the safety & hazard management of the toxic chemicals, gases, explosives etc.						
Course Outcomes							
CO 1	Students will be able to understand chemical safety standards, fire safety, hazard management.						
CO 2	Students will be able to handle toxic liquids & gases, explosives.						
CO 3	Students will be able to understand the NBC warfare safety, health & environment safety.						

Unit l

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

Unit ll

Fire triangle and Handling of Toxic, Industrial Gases

Unit lll

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

Unit IV

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

Unit V

Health: Assessment of human factors, Health & Environment safety

Unit VI

Nano materials safety (Toxicology study)

Suggested Books:

1. "Occupational Health and Safety Management A Practical Approach", by Charles D. Reese. Publisher: CRC Press.
2. "Occupational and Environmental Safety and Health", Arezes, P.M., Baptista, J.S., Barroso, M.P., Carneiro, P., Cordeiro, P., Costa, N., Melo, R.B., Abreu dos Santos Baptista, J.M., Perestrelo, G. (Eds.). Publisher: Springers, 2019
3. "Handbook of Occupational Safety and Health", by S. Z. Mansdorf. Publisher: Wiley.
4. "Institution of Chemical Engineers", by Trevor Kletz Hazop and Hazan

5. "Handbook Of Toxicology Of Chemical Warfare Agents", by Ramesh C. Gupta 2nd Edition Elsevier, 2015
6. "Nanomaterials Safety Toxicity And Health Hazards", by Shyamasree Ghosh De Gruyter.
7. "Hazardous Chemicals Handbook", by Phillip Carson, Clive Mumford Butterworth-Heinemann.
8. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-06	FUNDAMENTAL OF TELEMETRY, TELECOMMAND& TRANSPONDER						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide knowledge of the students about the satellite communication, telemetry, modulation techniques, target tracking, signal processing of communication systems						
Course Outcomes							
CO 1	Students will be able to understand Satellite communication and related technologies.						
CO 2	Students will be able to under concept of overall control of satellites through collection, processing, and transmission of data.						
CO 3	Students will be able to understand the concept of determination of the satellite's exact location through the reception, processing, and transmitting of ranging signals.						
CO 3	Students will be able to understand the concept of proper control of satellite through the reception, processing, and implementation of commands transmitted from the ground						

Unit l

Fundamental of satellite communication, different modulation and multiplexing Schemes

Unit ll

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

Unit lll

Satellite Packet Communications, Tracking and Telemetry

Unit IV

Doppler and Electro-Optical methods of tracking, Airborne Missile

Unit V

Signal Processing: Processing of Signal, Data Acquisition and Reduction

Unit VI

Introduction to satellite communication, transponders

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-07	JAMMING AND ECM/ECCM TECHNOLOGIES						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand the concept of electronic attacks						
CO 2	Students will be able to understand the principles and the practical applications of current and evolving electronic jamming technology.						
CO 3	Students will be able to understand the concept of determination of the satellite's exact location through the reception, processing, and transmitting of ranging signals.						
CO 4	Students will be able to understand the different types of electronic counter measures and counter – counter measures						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

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

Suggested Books:

1. "Electronic Countermeasure and Electronic Counter-Countermeasure", by Bahman Zohuri.
2. "Fundamentals of Electronic Warfare 2001", by S.A. Vakin , L.N. Shustov, R.H. Dunwell.
3. "Communications, Radar and Electronic Warfare by Adrian Graham 2010
4. "Electronic Warfare & Radar Systems Engineering Handbook" 2013, Naval Air Warfare Center Weapons Division.

5. "EW 101: A First Course in Electronic Warfare (Artech House Radar Library)", 1st Edition
6. Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-08	SOFTWARE DEFINED RADIOS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand the concept, application of SDRs						
CO 2	Students will be able to understand of analog RF components as front end block in implementation of SDR.						
CO 3	Students will be able to gain knowledge of digital hardware architectures and its development techniques.						
CO 4	Students will be able to gain knowledge of software development for embedded wireless systems						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

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).

Unit VI

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

Suggested Books:

1. "Software Radio, (A modern approach to radio engineering)", by Jeffery H.Reed Publisher : PHI PTR.
2. "RF and Digital Signal Processing for Software Defined Radio", by John J. Rouphael. Publisher: Elsevier.

3. "Digital Techniques in Frequency Synthesis", by B.G. Golderg. Publisher: McGraw-Hill.
4. "Multirate Signal Processing", by N.J. Fliege. Publisher: John Wiley and sons.
5. Literature / books suggested by respective course Lecturers Literature / books suggested by respective course Lecturers.

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-09	ADVANCED LIGHTWEIGHT AND COMPOSITE STRUCTURES						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand the design of advanced structures and lightweight materials for aerospace materials						
CO 2	Students will be able to understand the numerical and analytical skills in structural mechanics for both composite and metallic components.						
CO 3	Students will be able to gain knowledge of digital hardware architectures and its development techniques.						
CO 4	Students will be able to apply knowledge to solve real engineering problems						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

Analysis of stress; Analysis of strain

Unit V

Material Constitutive Relations.

Unit VI

Failure Theories; Fatigue theory

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-10	TEST METHODOLOGIES FOR DEW SYSTEMS (LASERS & MICROWAVE)						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand the characterization and testing requirements of DEW systems						
CO 2	Students will be able to carry out the indoors & outdoors system performance testing.						
CO 3	Students will be able to understand the safety issues, safety standards, handling high power sources.						

Unit l

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

Unit ll

System performance testing, System outdoor test & measurement instruments

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

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

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-11	ADVANCED ANALYTICAL TECHNIQUES/LAB TESTING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand different characterization techniques						
CO 2	Students will be able to apply appropriate analytical technique for a particular material organic/ inorganic/ nanomaterial/polymer etc.						

Unit l

Instrumental Analysis: Qualitative analysis

Unit ll

Genesis of instrumental analysis, hyphenated techniques

Unit lll

Polymeric Techniques: Rheology Techniques, Molecular weight determination; Thermal Techniques: Thermo Gravimetry (TG), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC)

Unit IV

Chromatographic Techniques: Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Thin Layer Chromatography (TLC), Ion chromatography

Unit V

Spectroscopy: Ultraviolet-Visible Spectroscopy UV-VIS, Infra-Red spectroscopy (IR), Nuclear Magnetic Resonance (NMR), Mass spectroscopy, Atomic Absorption Spectroscopy (AAS)

Unit VI

XRD and SEM techniques, Sensitivity studies

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL3-12	SONAR SYSTEM ENGINEERING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to know the basic building blocks of a radar system						
CO 2	Students will be able to have an in-depth knowledge on different types of signals that are used.						
CO 3	Students will be able to know about the ambiguity function and its significance in radar signal processing						
CO 4	Students will be able to know the physics behind sound propagation in water and principle of operation of sonar						
CO 5	Students will be able to apply the knowledge acquired in this course in real time applications						

Unit l

Mathematical development and discussion of fundamental principles that pertain to the design and operation of passive and active sonar systems critical to naval operation.

Unit ll

Topics from complex aperture theory, array theory

Unit lll

Signal processing

Unit IV

Introduction to undersea warfare and engineering acoustics

Unit V

Principles of optimal signal processing techniques for detecting signals in noise, maximum likelihood, Bayes risk

Unit VI

Neyman-Pearson and min-max criteria and calculations of their associated error probabilities (ROC curves)

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

Semester 2, Elective-IV Courses
(For All Specializations)

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-01	UNMANNED AERIAL VEHICLE DESIGN						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide the understanding of the initial designing and sizing process for rapidly growing fixed – wing UAV technology, integrated with its performance and stability analysis, air safety issues, airworthiness and prototype testing.						
Course Outcomes							
CO 1	Students will be able to understand the design requirements, design parameters of UAV.						
CO 2	Students will be able to perform the aerodynamic analysis, performance and stability analysis.						
CO 3	Students will be able to understand the performance testing of the UAVs.						
CO 4	Students will be able to understand the airworthiness and safety requirements of UAV.						

Unit l

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

Unit ll

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

Unit lll

UAV aerodynamics, structures and propulsion, performance and stability analysis

Unit IV

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

Unit V

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

Unit VI

Wind Tunnel Testing, Aerodynamic Characterization through Wind Tunnel Testing

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-02	NAVAL OCEAN ANALYSIS AND PREDICTION						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand and develop the Navy Ocean modeling and prediction program						
CO 2	Students will be able to understand the need to evaluate ocean models and prediction systems for operational and tactical applications						
CO 3	Students will be able to understand and predict environmental conditions in the coastal ocean						

Unit l

Advanced knowledge of the Indian Navy Ocean analysis and prediction systems

Unit ll

Naval Ocean Modeling Program (NOMP), Naval Ocean data systems

Unit lll

Atmospheric forcing systems, data assimilation systems

Unit IV

Optimal Thermal Interpolation System (OTIS), Thermal Ocean Prediction Systems (TOPS)

Unit V

Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface layer, and bulk formula for estimating air-sea fluxes

Unit VI

The global ocean circulation prediction system, Shallow Water Analysis and Forecast System (SWAFS), Knowledge of ocean eddies

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-03	MODELING & SIMULATION OF LASER MATTER INTERACTION						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide understanding on the high-power laser beam interaction with metals and composite materials, physics-based models for the lethality modeling, damage mechanism & damage threshold measurement techniques and performance evaluation of high-power laser systems.						
Course Outcomes							
CO 1	Students will be able to understand of the laser matter interaction						
CO 2	Students will be able to develop physics-based model for evaluation of effect of laser on metals and composites						
CO 3	Students will be able to understand the laser parameter measurement techniques						
CO 4	Students will be able to analyse the performance of high-power laser systems						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

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

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-04	COMPUTATIONAL AERODYNAMICS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide learning on the computational aerodynamics, numerical methods for solving systems of equations, numerical modelling of fluids, CFD analysis, turbulence modelling.						
Course Outcomes							
CO 1	Students will be able to understand the CFD analysis, fluid mechanics, heat transfer analysis, numerical modelling of fluids						
CO 2	Students will be able to generate numerical model related to fluid dynamics						
CO 3	Students will be able to do the pre and post processing of CFD analysis						

Unit l

Introduction to fluid mechanics & heat transfer

Unit ll

Introduction to numerical analysis, Discretisation approaches: finite difference, finite volume, finite element and spectral methods

Unit lll

Numerical methods for algebraic equations/systems of equations, Numerical schemes for hyperbolic, parabolic and elliptic systems and for fluid dynamics

Unit IV

CFD analysis

Unit V

Numerical modeling of compressible & in-compressible flow, turbulence modeling

Unit VI

Grid generation/CAD, data analysis and uncertainties

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks***.

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-05	LAUNCH VEHICLE DESIGN & ANALYSIS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide learning on the launch vehicle design and analysis, components and subsystems of the launch vehicle, propulsion systems.						
Course Outcomes							
CO 1	Students will be able to understand the launch vehicle requirements, its functioning						
CO 2	Students will be able to design and analysis of launch vehicles						
CO 3	Students will be able to understand the propellant requirement for launch vehicles						

Unit l

Introduction to propulsion for launch vehicles, beginning with mission energy requirements and an overview of current and proposed launch propulsion devices

Unit ll

Performance analysis, operating characteristics and propellant selection criteria for air breathing and solid

Unit lll

Liquid and nuclear rocket motor propulsion systems

Unit IV

Advanced cycles and concepts are presented. Design of components and subsystems

Unit V

FE modelling: Idealization, Discretization, Meshing and Post Processing

Unit VI

Tracking and controlling errors, Nonlinear analysis in FEM, Launch dynamic analysis

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-06	ACQUISITION, TRACKING & POINTING TECHNOLOGY						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide learning on the acquisition, tracking & pointing technologies, development of tracking algorithms, design and analysis of tracking systems.						
Course Outcomes							
CO 1	Students will be able to understand the concepts and basic systems requirements tracking systems						
CO 2	Students will be able to 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						
CO 3	Students will be able to understand the control system and algorithm techniques and practices commonly utilized in the design of tracking systems						

Unit l

Acquisition, tracking, and pointing (ATP) design for military systems

Unit ll

Target tracking and related mathematics, SNR requirement, the Johnson criteria, probability of estimation, detection criteria

Unit lll

Tracking algorithms, track filters, multi target tracking

Unit IV

Electronic countermeasures against modern target tracking radars

Unit V

Multiplatform-multi-sensor-multi target tracking

Unit VI

Doppler and Electro-Optical methods of tracking

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-07	DATA ACQUISITION, TRACKING & POST FLIGHT ANALYSIS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide learning on the various aspects of flight trials, measurements & calibration, Generation & analysis of Data.						
Course Outcomes							
CO 1	Students will be able to understand the interfaces used in data acquisition and standalone instruments to real-world signals						
CO 2	Students will be able to understand the Sensors and transducers, Data acquisition hardware and data acquisition software						
CO 3	Students will be able to carry out post flight analysis						

Unit l

Importance of Flight Trials in Missile Development, Facilities, Safety Requirements

Unit ll

Methods of Measurement, Introduction to Measuring Instruments: Functional elements of an instrument

Unit lll

Static and Dynamic Characteristics, Zero, First and Second order of Instruments and their response

Unit IV

Calibration of Instruments

Unit V

Sensors and Transducers: Passive and Active types, their uses in measurement of acceleration, angle, vibration, pressure, flow and temperature, strain etc.

Unit VI

Methods for post flight data analysis

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-08	AIR INDEPENDENT PROPULSION AND BATTERIES						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide learning on the air independent propulsion systems, hybrid electric vehicles, power requirement of the vehicles, energy storage systems						
Course Outcomes							
CO 1	Students will be able to understand the requirements of air independent propulsion systems.						
CO 2	Students will be able to design and analysis of hybrid electric drive trains						
CO 3	Students will be able to design and analysis Energy storage systems for hybrid electric vehicles						

Unit l

Introduction to Hybrid Electric Vehicles: Impact of modern drive-trains on energy supplies

Unit ll

Hybrid Electric Drive-trains: hybrid traction, various hybrid drive-train topologies, power flow control, fuel efficiency analysis

Unit lll

Electric Drive-trains: electric traction, electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis

Unit IV

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

Unit V

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles

Unit VI

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

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks***.

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-09	ADVANCED DIGITAL MODULATION TECHNOLOGIES & STANDARDS						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	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							
CO 1	Students will be able to understand the design digital communication systems						
CO 2	Students will be able to understand the transmitter, receiver communications system models, voice source coding– pulse code modulation, delta modulation and vocoders						
CO 3	Students will be able to understand the requirement of cellular communication						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

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

Unit V

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

Unit VI

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

Suggested Books:

1. "Communication Systems", by, Haykin, S. Publisher : John Wiley & Sons.
2. "Modern Digital and Analog Communication Systems", by, Lathi, B.P. and Ding, Z. Publisher: Oxford University Press.
3. Literature / books suggested by respective course Lecturers.
4. "Signal Processing for Wireless Communication Systems", by H. Vincent Poor, Lang Tong, Publisher: Springers.
5. "Digital Communication: Fundamentals and Applications", by Sklar, B., and Ray, P.K. Dorling Kindersley.
6. "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.

7. “Detection, Estimation and Modulation Theory Part I”, by Van Trees, H.L. Pub-lisher : Wiley Inter science.
8. “Information Theory, Coding and Cryptography”, by Bose, R. Tata McGraw-Hill.
9. “Digital Communication”, by Barry, J.R., Lee, E.A. and Messerschmitt, D.G.Kluwer.
10. “Principles of Digital Transmission: Wireless Applications”, by Benedetto, S. and Biglieri, E. Publisher: Springer.
11. Literature / books suggested by respective course Lecturers

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks****.*

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-10	TRAJECTORIES MODELLING & SIMULATION						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide the understanding of flight dynamics, trajectory design analysis, flight performance analysis and practical implications of trajectory planning						
Course Outcomes							
CO 1	Students will be able to understand the flight trajectories design requirements						
CO 2	Students will be able to evaluate and predict the flight performance for different trajectories						
CO 3	Students will be able to understand the practical implications while trajectory design						
CO 4	Students will be able to carry out MATLAB based simulation for trajectory modelling						

Unit l

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

Unit ll

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

Unit lll

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

Unit IV

Practical implementation of integrated trajectory planning, Agility in maneuvering trajectories

Unit V

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

Unit VI

Extensive MATLAB-based mini-projects

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks***.

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (2nd Sem.)

DT-EL4-11	**SENSOR TECHNOLOGY**						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
3	**0**	**0**	**3**	**60**	**40**	**100**	**3**
Objective	To provide learning on the basic physical principles and characteristic features in sensor technology, design, function and applications of different sensors						
Course Outcomes							
CO 1	Students will be able to understand the basic principles of sensor systems required for satellites and tactical aircraft						
CO 2	Students will be able to understand the atmospheric propagation and its impact on the performance of sensors						
CO 3	Students will be able to troubleshoot, repair/replace a faulty sensor in optimize process efficiency						

Unit l

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

Unit ll

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

Unit lll

Atmospheric propagation of signal. Noise resources and thermal radiation

Unit IV

Principles of semiconductor devices. Optical and infrared imaging detector systems

Unit V

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

Unit VI

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

Suggested Books:

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

Note: The paper will have a total of ***THIRTEEN*** *questions.* Question No. 1, which is compulsory, shall be OBJECTIVE Type and have contents from the entire syllabus (all SIX Units). **Q. No. 1 carries 12 Marks**.

The student will attempt a total of ***SEVEN*** *questions*, including compulsory Q. No. 1 and ***remaining SIX questions by selecting only one question from each unit and each question carries 8 Marks***.

Semester III

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (3rd Sem.)

DT-PDP-01	PROJECT DISSERTATION- PHASE 1						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**20**	**10**	**00**	**100**	**100**	
Objective	To identify the potential topics of research for dissertation phase II						
Course Outcomes							
CO 1	Students will be able to perform literature survey to identify the problem						
CO 2	Students will be able to identify the research gaps assisting them in problem formulation						
CO 3	Students will be able to formulate objectives, tools and methodology to pursue dissertation-II project						

The objective of First stage dissertation is to identify the topic and problem for the dissertation. An exhaustive review of literature is to be done and place the problem suitably in overall realm of research arena so that exact gap is identified. The student should have clear idea of objectives, tools, and methodology for the problem in hand. The student will present at least two seminars regarding the project.

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

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (3rd Sem.)

DT-PDP-01	SEMINAR/INDUSTRIAL TRAINING						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**8**	**4**	**00**	**100**	**100**	
Objective	To expose students to the 'real' working environment of defence sector and get them acquainted with the organization structure, industrial operations and administrative functions						
Course Outcomes							
CO 1	Students will be able to demonstrate the knowledge gain through cutting-edge technology related with defence sector						
CO 2	Students will be able to have hands-on-experience in defence industries and able to reinforce what has been taught at the university						

Industrial Training may be done in respective DRDO labs, DRDO established Centre of Excellence, DIAT Pune, PSUs and private defence industries.
The candidate has to submit a training report of his/her work/project/assignment completed in the industry during the training period. The evaluation will be made on the basis of submitted training report and viva-voce/presentation.

Semester IV

MASTER OF TECHNOLOGY IN DEFENCE TECHNOLOGY (3rd Sem.)

DT-PDP-02	PROJECT DISSERTATION- PHASE 2						
Lecture	**Tutorial**	**Practical**	**Credits**	**Major Test**	**Minor Test**	**Total**	**Time (Hrs.)**
0	**0**	**40**	**20**	**200**	**100**	**300**	
Objective	The main objective of the course is to make the students able to do some good research in the field of their interests related to defence sector or interrelated fields of applications						
Course Outcomes							
CO 1	Students will be able to conduct investigations of engineering problems using research-based knowledge and experimental/research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.						
CO 2	Students will be able to apply resources and modern engineering tools and techniques with an understanding of the limitations.						
CO 3	Students will be able to either work in a research environment or in an industrial environment.						
CO 4	Students will be conversant with technical report writing, professional ethics, responsibilities and norms of the engineering practice						
CO 5	Students will be able to present and convince their topic of study to the engineering community						

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

The students are required to continue Analytical/Experimental/Computational/Industrial Problems or Case studies investigations in the field of defence sector or other related fields which have been finalized in the third semester. They would be working under the supervision of a DRDO Scientist/faculty member. The students will be required to submit a progress report duly signed by their respective supervisors to the department, related to their dissertation work as per academic calendar. The progress report will cover the following:

- The goal set for the period.
- Research papers studied.
- Methodology used in achieving the goal.
- The extent of fulfillment of the goal.
- References

The progress report must be of at least of 3-4 pages and the cover page should include the tentative topic, name of the candidate, name of the supervisor, period of progress report, signature of candidate and supervisor. The candidate has to prepare a detailed dissertation report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up/numerical details/industrial case study etc. as the case may be) of solution and results and discussion. The report must bring out the conclusions of the work and future scope for the study. The final dissertation will be submitted in the end of semester as per academic calendar for the session, which will be evaluated by internal as well as external examiners based upon his/her research work. The

dissertation should be presented in standard format as provided by the department. The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a supervisor, co- supervisor etc. as decided by the Head and PG coordinator. The candidate has to be in regular contact with his supervisor