KUMARAGURU COLLEGE OF TECHNOLOGY,

An autonomous Institution affiliated to Anna University, Chennai

COIMBATORE – 641 049

M.Tech in Defence Technology

REGULATIONS 2018

CURRICULUM AND SYLLABI

Semesters I - IV

Department of Aeronautical Engineering

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1. **Program Objectives**

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

2. **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

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3. Program Structure

It is a 4 semester program with total 80 credits. It is having 6 specializations, as regard to the specializations, semester -1 will have common curriculum and semester 2 curriculum will be varied as per the specialization. Semester 3 & 4 includes dissertation and industrial training. The M.Tech. in Defence Technology will be having following specializations:

S. No.	Specialization
1.	Combat Vehicle Engineering
2.	Aerospace Technology
3.	Naval Technology
4.	Communication Systems & Sensors
5.	Directed Energy Technology
6.	High Energy Materials Technology

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

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Semester – 1

	Course Code	Course of study and scheme of examination	M.Tech Semester-1			Branch Defence Technology
S. No.		**Compulsory Courses**	**Periods/Week**			**Total Credits**
			L	**T**	**P**	
1.	P18DTT1001	Systems and warfare Platforms	4	-	-	4
2.	P18DTT1002	Warfare Simulations & Strategies	4	-	-	4
3.	P18DTT1003	Advanced Engineering Mathematics	4	-	-	4
4.	P18DTP1504	Systems and Platforms Lab	-	-	2	2
5.	P18DTP1505	Warfare Simulations & Strategies Lab	-	-	2	2
		Elective Courses				
6.	P18DTE----	Elective 1	3	-	-	3
7.	P18DTE----	Elective 2	3	-	-	3
8.	P18DTP1506	Seminar	-	-	1	1
		Total credits				23

Semester -1 Elective Courses

	Course Code	Course of study and scheme of examination	M.Tech Semester-1			
S. No.		**Elective 1**	**Periods/Week**			
			L	**T**	**P**	**Total Credits**
1.	P18DTE0001	Rockets & Missiles Fundamentals	3	-	-	3
2.	P18DTE0002	Advanced Thermal Engineering	3	-	-	3
3.	P18DTE0003	Numerical methods for science & engineering	3	-	-	3
4.	P18DTE0004	Communication Technology	3	-	-	3
5.	P18DTE0005	Advanced Mechanical Engineering	3	-	-	3

S. No.	Course Code	Course of study and scheme of examination	M.Tech Semester-1			
		Elective 2	**Periods/Week**			
			L	**T**	**P**	**Total Credits**

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1.	P18DTE0006	Autonomy and Navigation Technology	3	-	-	3
2.	P18DTE0007	Optimization theory & applications	3	-	-	3
3.	P18DTE0008	Military Electronics System Engineering	3	-	-	3
4.	P18DTE0009	System Engineering & Analysis	3	-	-	3

Semester - 2: **Main Stream Defence Technology with following six specialization**

S. No.	Main Stream Defence Technology
1.	Combat Vehicle Engineering
2.	Aerospace Technology
3.	Naval Technology
4.	Communication Systems & Sensors
5.	Directed Energy Technology
6.	High Energy Materials Technology

1. Combat Vehicle Engineering

	Course Code	Course of study and scheme of examination	M.Tech Semester-2			Branch Defence Technology
S. No.		Compulsory Courses	Periods/Week			Total Credits
		Combat Vehicle Engineering	L	T	P	
1.	P18DTT2001	Combat Vehicle Dynamics	4	-	-	4
2.	P18DTT2002	Combat System Engineering	4	-	-	4
3.	P18DTT2003	Test & Evaluation of Weapon System	4	-	-	4
4.	P18DTP2504	Combat Vehicle Dynamics Lab	-	-	2	2
5.	P18DTP2505	Combat System Engineering Lab	-	-	2	2
		Elective Courses				
6.	P18DTE----	Elective 1	3	-	-	3
7.	P18DTE----	Elective 2	3	-	-	3
8.	P18DTP2506	Seminar	-	-	1	1
		Total credits				23

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2. Aerospace Technology

	Course Code	Course of study and scheme of examination	M.Tech Semester-2			Branch Defence Technology
S. No.		**Compulsory Courses**	**Periods/Week**			**Total Credits**
		Aerospace Technology	**L**	**T**	**P**	
1.	P18DTT2007	Aerospace System Configuration, Design & Simulation	4	-	-	4
2.	P18DTT2008	Guidance & control	4	-	-	4
3.	P18DTT2009	Aerospace Propulsion	4	-	-	4
4.	P18DTP2510	Aerospace System Configuration, Design & Simulation Lab	-	-	2	2
5.	P18DTP2511	Guidance & control Lab	-	-	2	2
		Elective Courses				
6.	P18DTE----	Elective 1	3	-	-	3
7.	P18DTE----	Elective 2	3	-	-	3
8.	P18DTP2506	Seminar	-	-	1	1
		Total credits				23

3. Naval Technology

	Course Code	Course of study and scheme of examination	M.Tech Semester-2			Branch Defence Technology
S. No.		**Compulsory Courses**	**Periods/Week**			**Total Credits**
		Naval Technology	**L**	**T**	**P**	
1.	P18DTT2012	Naval combat system engineering	4	-	-	4
2.	P18DTT2013	Guidance, Navigation, and Control of Marine Systems	4	-	-	4
3.	P18DTT2014	Marine Propulsion	4	-	-	4
4.	P18DTP2515	Naval combat system engineering Lab	-	-	2	2
5.	P18DTP2516	Guidance, Navigation, and Control of Marine Systems Lab	-	-	2	2
		Elective Courses				
6.	P18DTE----	Elective 1	3	-	-	3
7.	P18DTE----	Elective 2	3	-	-	3

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8.	P18DTP2506	Seminar	-	-	1	1
		Total credits				23

4. Communication Systems & Sensors

	Course Code	Course of study and scheme of examination	M.Tech Semester-2			Branch Defence Technology
S. No.		**Compulsory Courses**	**Periods/Week**			**Total Credits**
		Communication Systems & Sensors	**L**	**T**	**P**	
1.	P18DTT2017	Radar Technologies	4	-	-	4
2.	P18DTT2018	Digital & satellite Communication and Navigation from Space	4	-	-	4
3.	P18DTT2019	Tactical battlefield Communication & Electronic Warfare	4	-	-	4
4.	P18DTP2520	Radar Technologies Lab	-	-	2	2
5.	P18DTP2521	Digital & satellite Communication and Navigation from Space Lab	-	-	2	2
		Elective Courses				
6.	P18DTE----	Elective 1	3	-	-	3
7.	P18DTE----	Elective 2	3	-	-	3
8.	P18DTP2506	Seminar	-	-	1	1
		Total credits				23

5. Directed Energy Technology

	Course Code	Course of study and scheme of examination	M.Tech Semester-2			Branch Defence Technology
S. No.		**Compulsory Courses**	**Periods/Week**			**Total Credits**
		Directed Energy Technology	**L**	**T**	**P**	
1.	P18DTT2022	Directed Energy Sources (Lasers, Microwave)	4	-	-	4

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2.	P18DTT2023	Beam Control Technology, Target acquisition, Beam Pointing & Tracking	4	-	-	4
3.	P18DTT2024	Directed Energy Weapons (DEW) System Engineering	4	-	-	4
4.	P18DTP2525	Directed Energy Sources (Lasers, Microwave) Lab	-	-	2	2
5.	P18DTP2526	Beam Control Technology, Target acquisition, Beam Pointing & Tracking Lab	-	-	2	2
		Elective Courses				
6.	P18DTE----	Elective 1	3	-	0	3
7.	P18DTE----	Elective 2	3	-	0	3
8.	P18DTP2506	Seminar	-	-	1	1
		Total credits				23

6. High Energy Materials Technology

	Course Code	**Course of study and scheme of examination**	**M.Tech Semester-2**			**Branch Defence Technology**
S. No.		**Compulsory Courses**	**Periods/Week**			**Total Credits**
		High Energy Materials Technology	**L**	**T**	**P**	
1.	P18DTT2027	High Energy Materials Modeling & Simulation	4	-	-	4
2.	P18DTT2028	Munitions and Target Response	4	-	-	4
3.	P18DTT2029	Manufacturing and Materials Properties of Explosives	4	-	-	4
4.	P18DTP2530	High Energy Materials Modeling & Simulation Lab	-	-	2	2
5.	P18DTP2531	Munitions and Target Response Lab	-	-	2	2
		Elective Courses		-		
6.	P18DTE----	Elective 1	3	-	-	3
7.	P18DTE----	Elective 2	3	-	-	3
8.	P18DTP2506	Seminar	-	-	1	1
		Total credits				23

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Elective Courses offered for Semester 2

	Course Code	Course of study and scheme of examination	M.Tech Semester-2			
S. No.		**Elective 1 (for all Specializations)**	**Periods/Week**			
			L	**T**	**P**	**Credits**
1.	P18DTE0010	Robotics (MSS, MCC)	3	-	-	3
2.	P18DTE0011	EMI/EMC in Military Systems	3	-	-	3
3.	P18DTE0012	Defence Electro-Optics and Imaging Systems	3	-	-	3
4.	P18DTE0013	Structural Dynamics and Aero-elasticity	3	-	-	3
5.	P18DTE0014	Safety, Health & Hazard Management	3	-	-	3
6.	P18DTE0015	Fundamental of telemetry, telecommand& transponder	3	-	-	3
7.	P18DTE0016	Jamming and ECM/ECCM technologies	3	-	-	3
8.	P18DTE0017	Software defined Radios	3	-	-	3
9.	P18DTE0018	Advanced Lightweight and Composite Structures	3	-	-	3
10.	P18DTE0019	Test methodologies for DEW systems (Lasers & Microwave)	3	-	-	3
11.	P18DTE0020	Advanced Analytical Techniques / Lab testing	3	-	-	3
12.	P18DTE0021	Sonar System Engineering	3	-	-	3

	Course Code	Course of study and scheme of examination	M.Tech Semester-2			
S. No.		**Elective 2 (for all Specializations)**	**Periods/Week**			
			L	**T**	**P**	**Credits**
1.	P18DTE0022	Unmanned Aerial Vehicle Design	3	-	-	3
2.	P18DTE0023	Naval Ocean Analysis and Prediction	3	-	-	3
3.	P18DTE0024	Modeling & simulation of Laser Matter Interaction	3	-	-	3
4.	P18DTE0025	Computational Aerodynamics	3	-	-	3
5.	P18DTE0026	Launch Vehicle Design & Analysis	3	-	-	3
6.	P18DTE0027	Acquisition, Tracking & Pointing Technology	3	-	-	3

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7.	P18DTE0028	Data acquisition, tracking & post flight analysis	3	-	-	3
8.	P18DTE0029	Air independent propulsion & batteries	3	-	-	3
9.	P18DTE0030	Advanced digital modulation technologies & standards	3	-	-	3
10.	P18DTE0031	Trajectories modelling& simulation	3	-	-	3
11.	P18DTE0032	Sensor Technology	3	-	-	3

Semester - 3

S. No.	Course Code	Course	Credit
1.	P18DTP3701	Project Dissertation- Phase 1	10
2.	P18DTP3502	Seminar/ Industrial training	4
		Total credits	**14**

Semester – 4

S. No.	Course Code	Course	Credit
1	P18DTP4701	Project Dissertation Phase-2	20
		Total credits	**20**

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Semester-1

Compulsory Courses

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Course Title : Systems and warfare Platforms

Course Code : P18DTT1001

Teaching Scheme: L: 4, T: 0, P:0 Credits: 4

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

1. "Light and Heavy Vehicle Technology ", by Nunney. Publisher Elsevier.
2. "Practical approach to motor vehicle engineering and maintenance", by Bonnick 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.


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Course Title : Warfare Simulations & Strategies
Course Code : P18DTT1002
Teaching Scheme : L: 4, T:0, P:0, Credits: 4

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

Course Outcomes:
At the end of the course the student should be able to.
- Understand the systems used in warfare scenario
- Understand combat simulation & modelling
- Understand the war gaming simulation & modelling and human factor representation.

Course Content

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

References / Suggested Books:

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


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Course Title : Advanced Engineering Mathematics
Course Code : P18DTT1003
Teaching Scheme : L: 4, T:0, P:0 Credits: 4

Course Objectives

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

Course Outcomes

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

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

Course Content:

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

References / Suggested Books:

1. "Advanced engineering mathematics", by Kreyszig. Publisher: Wiley.
2. "Advanced engineering mathematics",by Jain/Iyenger. Publisher: Narosa.
3. "Advanced engineering mathematics",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.

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Semester 1

Elective-1 Courses

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- **Course Title : Rockets & Missiles Fundamentals**

Course Code : P18DTE0001

Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

1. "Fundamentals of Guided Missiles",by S. R. Mohan. Publisher : Defence Research and Development Organisation.
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.

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Course Title : Advanced Thermal Engineering
Course Code : P18DTE0002
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives

The main objective of the course is to provide knowledge to the students for the thermal management requirements / problems of the defence systems and thermal system design & simulation for the various air, land & naval defence systems utilized under different environmental conditions.

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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Course Title : Numerical methods for science and engineering
Course Code : P18DTE0003
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives

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

Course Outcomes

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

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

Course Content:

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

References / Suggested Books:

1. "Numerical Methods for 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.

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Course Title : Communication Technology
Course Code : P18DTE0004
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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- **Course Title : Advanced Mechanical Engineering**
  Course Code : P18DTE0005
  Teaching Scheme : L: 3, T: 0, P:0 - Credits: 3

Course Objectives:

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

Course Outcomes

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

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

Course Content

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

References / Suggested Books:

1. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method " by H. Versteeg. Publisher : Pearson.
2. "Computational Fluid Dynamics the Basics with Applications", by John D. Ander 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

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Semester 1

Elective-2 Courses

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Course Title : Autonomy and Navigation Technology
Course Code : P18DTE0006
Teaching Scheme : L: 3, T: 0, P: 0 - Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

1. "Global Navigation Satellite Systems: Insights Into GPS", by Bhatta, B., Glonass, Galileo, Compass, and Others. Publisher **:** BS Publications, New Delhi 2010.
2. "Global Positioning Systems, Inertial Navigation, and Integration", by Grewal, M. S., Weill, L. R., Andrews, A. P., Publisher: John Wiley & Sons, New York, 2006.
3. "GNSS – Global Navigation Satellite Systems", by Verlag Wien. HofmannWellenhof, 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.

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Course Title : Optimization theory & applications
Course Code : P18DTE0007
Teaching Scheme : L: 3, T:0 , P: 0 - Credits: 3

Course Objectives

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

Course Outcomes

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

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

Course Content:

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

References / Suggested Books:

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

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Course Title : Military Electronics System Engineering
Course Code : P18DTE0008
Teaching Scheme : L: 3, T:0 , P: 0 - Credits: 3

Course Objectives

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

Course Outcome

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

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

Course Content:

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

References / Suggested Books:

1. "Introduction to Electronic Defense Systems", by Neri Filippo. Publisher: Artech House Publishers.
2. "Military Handbook of Electronic Reliability design", by US Department of Defence.
3. "Defence Electronics Standards and Quality Assurance", by Ray Tricker. Publisher : 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.


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Course Title : System engineering and analysis
Course Code : P18DTE0009
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcome

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

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

Course Content

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

References / Suggested Books:

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


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Semester – 2

(Compulsory Courses)

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1. Combat Vehicle Engineering

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Course Title : Combat Vehicle Dynamics Course Code : P18DTT2001
Teaching Scheme : L: 4, T: 0, P: 0 Credits: 4

Course Objectives:

The main objective of the course is to provide knowledge to the students about important concepts of combat vehicle dynamics, terrain modeling, vehicle suspension systems, wheeled & tracked vehicles.

Course Outcomes

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

- Carry out terrain modeling.
- Carry out simulation and testing of suspension system.
- Carry out design of military vehicles.
- Understand longitudinal dynamic response during acceleration and braking,
- Vertical dynamic response to analyze ride, pitch and roll.

Course Content:

Unit	Contents	Contact Hrs.
1.	Human response to vibration (HRV).	5
2.	Terrain modeling.	7
3.	Selection and design for military vehicles.	6
4.	Suspension types, modeling, simulation and testing of suspension systems and components, this includes transient, frequency random response.	8
5.	Spring and damper types, selection and characteristics, effects of noise Tires for military and civilian vehicles and their behavior.	7
6.	Wheeled and tracked vehicles at low and high speed including steady state and transient response.	7
	Total	40

References / Suggested Books:

1. "Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles", by Matthew Harrison. Publisher : Butterworth-Heinemann .
2. "Vehicle Noise and Vibration Refinement", by Xu Wang. Publisher : Woodhead Publishing.
3. "Noise and Torsional Vibration Analysis of Hybrid Vehicles (Synthesis Lectures on Advances in Automotive Technology)", by Xiaolin Tang, Yanjun Huang. Publisher : Morgan & Claypool Publishers.
4. "Principles of Vibration Analysis with Applications in Automotive", by C.Q. Liu. Publisher : SAE International.
5. Literature / books suggested by respective course Lecturers.

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Course Title : Combat System Engineering Course Code : P18DTT2002
Teaching Scheme : L: 4, T: 0, P: 0 Credits: 4

Course Objectives:

The main objective of the course is to provide knowledge to the students about the basic principles, processes and products of combat systems engineering, sensor technologies. They will also be introduced to weapons of mass destruction.

Course Outcome:

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

- Understand principles of design of combat systems.
- Learn how to design, build, and maintain systems that control different kinds of weapons, including nuclear, chemical, and biological weapons.
- Understand sensor systems, such as radar and sonar.
- Understand risks and threats to combat systems.

Course Content:

Unit	Contents	Contact Hrs.
1.	Engineering principles to the design of combat systems with emphasis on detection, tracking, and identification systems	6
2.	Threat Spectrum, Battle Field Environment.	6
3.	Vehicle Configuration, Man Machine Interface.	6
4.	Sensor technologies (radars, ESM, active and passive sonar, infrared, electro-optical, and magnetic/electric/gravity field sensors).	8
5.	Introduction to information warfare and weapons (including electronic warfare).	7
6.	Directed energy weapons, weapons of mass destruction (nuclear, chemical, biological, and radiological), and nonlethal weapons.	7
Total		40

References / Suggested Books:

1. "Warship Combat System Engineering Management Software" by Zhao Xiao Zhe**.**
2. "Measurement, Instrumentation and sensor Handbook", by John G Webster. Publisher: CRC Press, Florida 2nd edition.
3. "Engineering Principles of Combat Modeling and Distributed Simulation", by Andreas Tolk. Publisher: Wiley Publication.
4. "Sensors and Transducers", by Patranabis D. Publisher: Prentice Hall India Limited.
5. "Magnetic Sensors Principles and Applications" by Author Kuang.
6. Literature / books suggested by respective course Lecturers.

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Course Title : Test and Evaluation of weapon system
Course Code : P18DTT2003
Teaching Scheme : L: 4, T: 0, P: 0 Credit: 4

Course Objectives:

The main objective of the course is to provide knowledge to the students about weapon system, the factors that affect their performance and test methodologies.

Course Outcome:

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

- Understand the weapon system requirements and weapon performance characterization under operating and ambient conditions.
- Understand the system reliability, maintenance, life cycle cost, and test procedures that govern the acceptance and induction of system.

Course Content

Unit	Contents	Contact Hrs.
1.	Weapon system requirements (land, air, naval).	6
2.	Weapon performance characterization, Operating environment and ambient conditions.	6
3.	Factors affecting system performance, System Acceptance testing.	6
4.	System reliability, system maintenance concept, functional analysis, life cycle costs, logistics support analysis, systems design, production, spare/repair parts management	8
5.	Static test procedures, Shock and vibration tests, Accelerated environmental tests. Closed vessel test. Conditioning chambers.	7
6.	Test methods for evaluation of safety. Dynamic trials. Range requirement analysis, range instrumentation. Post trial Analysis.	7
Total		40

References / Suggested Books:

1. "Reliability Evaluation of Engineering Systems Concepts and Techniques", by Billinton, Roy, Allan, Ronald N. Publisher: Springer
2. "Man-Machine-Environment System Engineering", by Editors: Long, Shengzhao, Dhillon, Balbir S. Publisher: Springer.
3. "Vibration Testing: Theory and Practice", by Kenneth G. Mcconnell. Publisher : John Wiley & Sons.
4. "Vibration Monitoring, Testing, and Instrumentation", by Clarence W. de Silva. Publisher : CRC Press.
5. Literature / books suggested by respective course Lecturers.

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- **Course title : Combat Vehicle Dynamics Lab**
  Course Code : P18DTP2504
  Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

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

- **Course title :Combat system engineering lab**
  Course Code : P18DTP2505
  Teaching Scheme : L: 0, T:, P: 2 Credits: 2

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

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2. Aerospace Technology

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Course Title : Aerospace System Configuration, Design and Simulation
Course Code : **P18DTT2007**
Teaching Scheme : L: 4, T:0, P:0 Credits: 4

Course Objectives

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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Course Title : Guidance & control
Course Code : P18DTT2008
Teaching Scheme : L: 4, T:0, P:0 Credits: 4

Course Objectives

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

Course Outcome:

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

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

Course Content:

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

References / Suggested Books:

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

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Course Title : Aerospace Propulsion **Course Code : P18DTT2009**
Teaching Scheme : L: 4, T: 0, P: 0 **Credits: 4**

Course Objectives

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

Course Outcomes

At the end of the course the student will have:

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

Course Content

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

References / Suggested Books:

1. "Rocket Propulsion Elements", by George Paul Sutton and Oscar Biblarz. Publisher: John Wiley & Sons
2. "Modern Engineering for Design of Liquid-Propellant Rocket Engines: Progress in Astronautics and Aeronautics Series" by Dieter K. Huzel, David H. Huang.
3. "An Introduction to Computational Fluid Dynamics: The Finite Volume Method" by H. Versteeg. Publisher : Pearson; 2nd edition.
4. "Computational Fluid Dynamics the Basics with Applications" by John D. Anderson, Jr. Publisher : McGraw Hill Education (1 July 2017)
5. " Fluid Mechanics: Volume 2: Foundations and Applications of Mechanics", by C. S. Jog. Publisher : Cambridge University Press; 3rd edition.

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6. "Parallel Processing for Jet Engine Control"" by Thompson, Haydn A, Publisher: Springer- Verlag London
7. "Fundamentals of Machine Component Design", by Robert C. Juvinall, Kurt M. Marshek. Publisher : John Wiley & Sons.
8. "Gas Turbines for Electric Power Generation",by S. Can Gülen.
9. "Gas Turbine Theory ",by H.I.H. Saravanamuttoo , Prof G.F.C. Rogers , H. Cohen. Publisher : Prentice Hall.
10. "Elements of Propulsion: Gas Turbines and Rockets" by Jack D. Mattingly, Keith Boyer. Publisher : American Institute of Aeronautics & Astronautics.
11. Literature / books suggested by respective course Lecturers.

❖ **Course title : Aerospace system configuration, Design & simulation Lab**
Course Code : P18DTP2510
Teaching Scheme : L: 0, T: 0, P: 2 Credits: 2

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

❖ **Course title : Guidance & Control lab**
Course Code : P18DTP2511
Teaching Scheme : L: 0, T:0 , P: 2 Credits: 2

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

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3. Naval Technology

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Course Title : Naval combat system engineering
Course Code : P18DTT2012
Teaching Scheme : L: 4, T:0, P:0 Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to the students about the basic principles, processes and products of combat systems engineering. They will learn about systematic approach for the development and management of complete naval combat systems and functional analysis, design synthesis and system analysis, ship integration and test, management and planning.

Course Outcomes

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

- Understand the theory of Naval Combat System Engineering.
- Understand the integration of components to develop survivable combat system
- Apply the knowledge to integrate the principles of Naval Architecture and Marine Engineering in the design of ship subsystems.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction of naval combat systems	6
2.	Integration of naval combat systems, Detection, engagement, and control elements interact with each other and on how to combine them into an efficient and survivable combat system	7
3.	Signature reduction	7
4.	Readiness assessment, embedded training, and support system interfaces	6
5.	System-oriented approach to integrating the principles of Naval Architecture and Marine Engineering in the design of ship subsystems	8
6.	Engineering design tools and analysis methods to meet specified systems requirements.	6
	Total	40

References / Suggested Books:

1. "Introduction to Naval Architecture", by Tupper, E. C Fourth. Publisher Butterworth-Heinemann. Formerly Muckle's Naval Architecture for Marine Engineers.
2. "Introduction to Naval architecture", by Gillmer, Thomas C. Naval Institute Press.
3. "The Maritime Engineering Reference Book: A Guide to Ship Design, Construction and Operation". Publisher : Butterworth-Heinemann.
4. "Naval Architecture for Marine Engineers: Vol 4", by Richard Pemberton, E A Stokoe. Publisher : Thomas Reed .
5. "Principles of Naval Architecture, Volumes 1 & 2", by Henry E. Rossel, Lawrence B. Chapman. Publisher : Society of Naval Architects and Marine Engineers.
6. "Modern Naval Combat", by David Miller. Publisher : Crescent
7. Literature / books suggested by respective course Lecturers.

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Course Title : Guidance, Navigation, and Control of Marine Systems
Course Code : P18DTT2013
Teaching Scheme : L: 4, T:0, P:0 - Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to the students about the fundamentals of inertial navigation, principles of inertial accelerometers, and gyroscopes. They will learn the classical approach to the robust design of nonlinear GNC system. They will learn the mathematical tools for generating theoretical building blocks for solutions to current and future naval challenges.

Course Outcomes:

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

- Understand the principles of inertial navigation.
- Understand various aspects of designing a navigation system
- Apply Mathematical modeling for design & analysis of navigation systems.
- Apply MATLAB and Simulink tool for simulation of navigation systems.

Course Content:

Unit	Contents	Contact Hrs.
1.	Fundamentals of inertial navigation, principles of inertial accelerometers, and gyroscopes.	5
2.	Derivation of gimbaled and strapdown navigation equations and corresponding error analysis.	7
3.	Classical approach to the robust design of nonlinear GNC systems that accounts for both the stability and performance specifications, robust autopilot design.	6
4.	Mathematical modeling.	8
5.	Advanced capabilities of MATLAB & Simulink.	8
6.	Multi-robot control techniques, theoretical building blocks for solutions to current and future naval challenges.	6
	Total	40

References / Suggested Books:

1. Modern Inertial Technology Navigation, Guidance, and Control" by Anthony Lawrence, Publisher: Springer New York, 2012
2. "Marine Control Systems Guidance, Navigation, and Control of Ships, Rigs and Underwater Vehicles" by Thor I. Fossen, Publisher: Marine Cybernetics, Trondheim, Norway (January 1, 2002)
3. "MATLAB for Engineering Applications" by William Palm Publisher : McGraw-Hill Education; 4th edition (February 6, 2018)
4. "Modeling and Simulation of Systems Using MATLAB and Simulink" by Devendra K. Chaturvedi, Publisher: CRC Press, 2010
5. "Autonomous Mobile Robots and Multi-Robot Systems: Motion-Planning, Communication, and Swarming" by Eugene Kagan, Nir Shvalb, Irad Ben-Gal, Wiley 2019.
6. Literature / books suggested by respective course Lecturers.


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Course Title : Marine Propulsion
Course Code : P18DTT2014
Teaching Scheme : L: 4, T:0, P:0 Credits: 4

Course Objectives:

The main objective of the course is to provide knowledge to the students about basic principles of power and propulsion of marine system. They will understand fluid mechanics, dynamic propulsion system modeling and aerothermodynamics of various subsystems of marine systems. They will be introduced to modern control design theory.

Course Outcome:

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

- Understand the propulsion of marine system
- Understand the aerothermodynamics of compressors, combustors, turbines, heat exchangers etc.
- Model the Dynamic propulsion systems
- Apply the analysis methods and design strategies for control system and marine propulsion.

Course Content:

Unit	Contents	Contact Hrs.
1.	Basic principles of power and propulsion of marine systems.	6
2.	Laws of thermodynamics and fluid mechanics to analyze and design of components and systems, Dynamic propulsion systems modeling and analysis methods.	7
3.	Aerothermodynamics of compressors, combustors, turbines, heat exchangers, inlets and nozzles.	7
4.	Mechanical and structural design aspects of engine development, Control design specifications and design strategies.	8
5.	Introduction to modern control design theory and multivariable methods. Theory and applications of optimal control and discrete-time control systems.	6
6.	Case studies of current naval propulsion control systems.	6
Total		40

References / Suggested Books:

1. "Marine Propellers and Propulsion", by John Carlton Publisher :ButterworthHeinemann.
2. "Advanced Thermodynamics for Engineers Book", by D. E. Winterbone. Publisher: Mercury Learning & Information
3. "Elements of classical thermodynamics: For advanced students of Physics", by A. B. Pippard. Publisher CAMBRIDGE UNIVERSITY PRESS
4. "Gas Turbines for Electric Power Generation", by S. Can Gülen.
5. Literature / books suggested by respective course Lecturers.

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- **Course title : Naval Combat system engineering lab**

Course Code : P18DTP2515

Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

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

- **Course title : Guidance, Navigation and control of Marine systems lab**

Course Code : P18DTP2516

Teaching Scheme: L: 0, T:0, P: 2 Credits: 2

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

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4. Communication Systems and sensors

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Course Title : Radar Technologies
Course Code : P18DTT2017
Teaching Scheme : L: 4, T: 0, P:0 Credits: 4

Course Objectives

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

Course Outcomes

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

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

Course Content:

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

References / Suggested Books:

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

Signature of BOS chairman, AE

Course Title : Digital & Satellite Communication and Navigation from Space

Course Code : P18DTT2018

Teaching Scheme : L: 4, T: 0, P:0 Credits: 4

Course Objectives

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

Course Outcomes:

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

Understand the communication techniques

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

Course Content

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

References / Suggested Books:

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

Signature of BOS chairman, AE

- **Course Title : Tactical Battlefield Communication & Electronic Warfare**
  Course Code : P18DTT2019
  Teaching Scheme : L: 4, T:0, P: 0 Credits: 4

Course Objectives

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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- **Course title : Radar Technologies Lab**
  Course Code : P18DTP2520
  Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

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

- **Course title : Digital & Satellite Communication and Navigation from Space**
  Course Code : P18DTP2521
  Teaching Scheme: L: 0, T:0, P: 2 Credits: 2

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

Signature of BOS chairman, AE

5. Directed Energy Technology

Signature of BOS chairman, AE

Course Title : Directed Energy Sources (Lasers, Microwave)
Course Code : P18DTT2022
Teaching Scheme : L: 4, T: 0, P:0 Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to the students on the 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 Outcome:

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

- Understand high power lasers sources, power scaling methodologies of lasers.
- Carry out the atmospheric effects on high power laser beam propagation.
- Estimate optics requirement for handling high power laser beams.
- Understand generation and testing of high power microwave sources.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction of directed energy weapons, Potential weapon applications, how they work, application scenarios	6
2.	High power laser sources (solid state, fiber, free election, liquid etc.), Laser power scaling	7
3.	Atmospheric Laser Beam propagation.	7
4.	Characterization of laser beam parameters	6
5.	Optical material & coating for high energy lasers.	7
6.	High power microwave sources, HPM effects, testing of HPM sources.	7
Total		40

References / 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.

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Course Title : Beam Control Technology, Target Acquisition, Beam Pointing & Tracking
Course Code : P18DTT2023
Teaching Scheme : L: 4, T: 0, P:0 Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to the students about 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 Outcome:

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

- Understand of high power laser & microwave beam directors, design requirements & design methodologies.
- Gain knowledge of active target imaging, coarse & fine target tracking and contemporary target tracking technologies
- Compute atmospheric effects on the laser beam performance and hence carry out conceptual design of adaptive optics.

Course Content:

Unit	Contents	Contact Hrs.
1.	Introduction to beam control, Beam control hardware	6
2.	Introduction to laser beam directors, Requirement for high power laser beam directors, Conceptual optical design & analysis of beam Dirtectors.	7
3.	Laser beam tracking, pointing & control, Gimbals, Coarse & fine tracking.	7
4.	Active laser imaging & target tracking, Closed loop image tracking, Hardware requirement, Various tracking algorithms, multi-spectral target imaging, Multiple target engagements, rapid retargeting.	6
5.	Atmospheric propagation of Laser beams, atmospheric propagation of laser beams, Correction of atmospheric effects, Adaptive optics, Atmospheric modeling of laser propagation.	6
6.	Introduction to HPM beam control technology, major sub-assemblies.	8
	Total	40

References / 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.

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Course Title : Directed Energy Weapon (DEW) System Engineering
Course Code : P18DTT2024
Teaching Scheme : L: 4, T: 0, P:0 Credits: 4

Course Objectives

The main objective of the course is to provide knowledge to students about Directed Energy Weapon sub-systems, 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 Outcome:

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

- Understand of DEW systems, design requirements
- Evaluate the thermal and power requirements
- Evaluate the system performance.

Course Content:

Unit	Contents	Contact Hrs.
1.	Attributes of DEW, System requirements, DEW system design, system analysis.	6
2.	DEW subsystems, System modeling & simulation.	6
3.	Thermal management of DEW, Power management of DEW.	7
4.	Operational requirements of directed energy systems, platform integration.	7
5.	Weapon effectiveness under different operating conditions.	7
6.	Overview of internationally developed systems (Airborne Laser	7
	Laboratory, Airborne Laser, Tactical High Energy Laser, Advanced Tactical Laser, and Space-Based Laser programs).	
Total		40

References / 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.

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- **Course title : Directed energy laser source Lab**
  Course Code : P18DTP2525
  Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

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 (M^2)
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.

- **Course title :Beam Control technology, target acquisition, Beam pointing and tracking lab**
  Course Code : P18DTP2526
  Teaching Scheme : L: 0, T: 0, P: 2 Credits: 2

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

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6. High Energy Materials Technology

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Course Title : High Energy Materials Modeling & Simulation
Course Code : P18DTT2027
Teaching Scheme : L: 4, T:0, P:0 Credits: 4

Course Objectives

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

Course Outcome

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

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

Course Content:

Unit	Contents	Contact Hrs.
1	Understanding of high energy materials from theoretical and practical standpoints, to formulate the bases for evaluating competitive and alternative high energy material systems	8
2	High energy materials physics and chemistry	6
3	Molecular energetic of the high energy materials molecule including molecular orbital and valence bonding and resonance stabilization	7
4	Concepts and practical implications of sensitivity and energy potential, oxygen balance and thermodynamic, reaction rate theory, hot-spot theory, shock physics and detonation theory	7
5	Tools for high energy materials modeling & simulation	6
6	Overview high energy materials modeling using FEM technique	6
	Total	40

References / Suggested Books:

1. **"**Chemistry of High-Energy Materials", by Thomas M. Klapötke, De Gruyter, 2012
2. "Shock Waves Science and Technology Library, Detonation Dynamics- Vol. 6," by Zhang F. Publisher : Springer.
3. "Physics of Shock Waves" by Zel'dovich & Raizer.
4. "The Chemistry of Explosives", by Jacqueline Akhavan 2011
5. "High energy materials modeling & simulation", by Andreoni Wanda, Yip Sidney. Publisher: Springer, 2020.
6. Literature / books suggested by respective course Lecturers.

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Course Title : Munitions and Target Response
Course Code : P18DTT2028
Teaching Scheme : L: 4, T:0 , P: 0 Credits: 4

Course Objectives

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

Course Outcome

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

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

Course Content:

Unit	Contents	Contact Hrs.
1	Introduction to warheads and ammunition, Introduction to armour design	7
2	Wound ballistics and human vulnerability, Fragmentation theory and warheads, Small arms and cannon ammunition, Shell and projectile design	7
3	Target penetration and shock events covering subsonic to hydrodynamic regimes, Shaped charge and Explosively Formed Penetrator (EFP) warhead design, Kinetic Energy (KE) ammunition and penetrator design	7
4	Mine threat and damage mechanisms, Complex armour, spacing, obliquity, disposition and failure mechanisms	7
5	Characterization and testing of materials for high strain rate loading	6
6	Blast effects, blast-structure interactions including internal detonations, Terminal ballistics demonstration.	6
	Total	40

References / Suggested Books:

1. "A Comprehensive Guide to Munitions: Bullets, Bombs, Artillery, Mines, Missiles & Explosives" 2016", by Paul F. Kisak.
2. "Ammunition: Small Arms, Grenades and Projected Munitions",by Ian V. Hogg. Publisher: Greenhill Books.
3. "MILITARY SMALL ARMS: Design Principles and Operating", by Derek Allsop
4. "Armour: Materials, Theory, and Design", by Paul J. Hazell. Publisher: CRC Press, 2015.
5. Literature / books suggested by respective course Lecturers.


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Course Title : Manufacturing and Materials Properties of Explosives

Course Code : P18DTT2029

Teaching Scheme : L: 4, T:0, P: 0 Credits: 4

Course Objectives:

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

Course Outcome:

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

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

Course Content:

Unit	Contents	Contact Hrs.
1	Chemistry of the synthesis of high energy material molecules: Basic chemistry of nitration,	8
2	Synthesis examples of Lead Azide/Styphnate, TNT, RDX, NC, NG, Basic stability/compatibility	6
3	Material science of high energy materials: Basic hazard/performance properties, Crystal properties, Binder properties, Mechanical properties,	7
4	Environmental awareness, Engineering of the manufacturing of high energy materials	6
5	Filling processes of high energy materials, Plant design, safety, Quality control	6
6	Physics of high energy materials: Detonation theory, Shocks physics, Explosives train.	7
	Total	40

References / Suggested Books:

1. "Detonation: Theory and Experiment", by Wildon Fickett, Dover Publications Inc.
2. "Organic Chemistry of Explosives", Jai Prakash Agrawal, Robert Dale Hodgson, Publisher: Wiley and sons, 2006
3. "High explosives and propellants", by S. Fordham.
4. "Demystifying Explosives: Concepts in High Energy Materials", by Sethurama Sharma Venugopalan.
5. "Chemistry and Physics of Energetic Materials", by Bulusu, S.N. Publisher: Springer.
6. "High Energy Materials: Propellants, Explosives and Pyrotechnics", by Jai Prakash Agrawal. Publisher : Wiley.
7. Literature / books suggested by respective course Lecturers.

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- **Course title : High energy materials modeling & simulation lab**
  Course Code : P18DTP2530
  Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

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

- **Course title : Munitions and target response lab**
  Course Code : P18DTP2531
  Teaching Scheme : L: 0, T:0, P: 2 Credits: 2

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

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Semester 2

Elective-1 Courses

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❖ **Course Title : Robotics (MSS, MCC)**
Course Code : P18DTE0010
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

1. 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 : Pearson, Delhi.
3. "Fundamentals of Robotics: Analysis and Control", by Schilling Robert J. Publisher : 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.

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Course Title : EMI/EMC in Military Systems
Course Code : P18DTE0011
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content

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

References / Suggested Books:

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

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❖ **Course Title : Defence Electro-Optics and Imaging Systems**
Course Code : P18DTE0012
Teaching Scheme: L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content

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

References / Suggested Books:

1. "Systems engineering analysis of electro-optical and Infrared 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.

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❖ **Course Title : Structural Dynamics and Aero-elasticity**
Course Code : P18DTE0013
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

Signature of BOS chairman, AE

❖ **Course Title : Safety, Health & Hazard Management**
Course Code : P18DTE0014
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content

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

References / Suggested Books:

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

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Course Title : Fundamental of telemetry, telecommand& transponder
Course Code : P18DTE0015
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

The students will have in depth knowledge on:

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

Course Content:

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

References / Suggested Books:

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.

Signature of BOS chairman, AE

❖ **Course Title : Jamming and ECM/ECCM technologies**
Course Code : P18DTE0016
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content

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

References / Suggested Books:

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

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Course Title : Software defined Radios
Course Code : P18DTE0017
Teaching Scheme : L: 3, T:0 , P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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❖ **Course Title : Advanced Lightweight and Composite Structures**
Course Code : P18DTE0018
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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❖ **Course Title : Test Methodologies for DEW Systems (Lasers & Microwave)**
Course Code : P18DTE0019
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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❖ **Course Title : Advanced Analytical techniques/Lab testing**
Course Code : P18DTE0020
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

1. "Fundamentals of molecular spectroscopy" by C. N. Banwell. Publisher : McGraw Hills.
2. "Introduction to Spectroscopy" by Donald L. Pavia, Gary M. Lampman, and George S. Kriz. Publisher: Cengage Learning, 2014.
3. "Chromatography: Concepts and Contrasts" by James M. Miller. Publisher : Wiley.
4. "Chromatography: Principles and Instrumentation", by Mark F. Vitha. Publisher: Wiley.
5. "Elements of X-Ray 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.

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❖ **Course Title : SONAR System Engineering**
Course Code : P18DTE0021
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content

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

References / Suggested Books:

1. "Fundamentals of Radar, Sonar and Navigation Engineering", by K. K. Sharma.
2. "Principles of Modern Radar: Advanced techniques", by editor William L. Melvin.
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 Richard P. Hodges.
6. Literature / books suggested by respective course Lecturers

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Semester 2

Elective – 2 Courses

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❖ **Course Title : Unmanned Aerial Vehicle Design**
Course Code : P18DTE0022
Teaching Scheme : L: 3, T: 0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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❖ **Course Title : Naval Ocean Analysis and Prediction**
Course Code : P18DTE0023
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

S. no.	Contents	Contact Hrs.
1.	Advanced knowledge of the Indian Navy ocean analysis and prediction systems.	6
2.	Naval Ocean Modeling Program (NOMP), Naval ocean data systems.	5
3.	Atmospheric forcing systems, data assimilation systems.	6
4.	Optimal Thermal Interpolation System (OTIS), Thermal Ocean Prediction Systems (TOPS).	6
5.	Fundamental concepts in turbulence. The atmospheric planetary boundary layer, including surface layer, and bulk formula for estimating air-sea fluxes.	7
6.	The global ocean circulation prediction system, Shallow Water Analysis and Forecast System (SWAFS), Knowledge of ocean eddies.	6
Total		36

References / Suggested Books:

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

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❖ **Course Title : Modeling &Simulation of Laser Matter Interaction**
Course Code : P18DTE0024
Teaching Scheme : L: 3, T: 0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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❖ **Course Title : Computational Aerodynamics**
Course Code : P18DTE0025
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

1. "A Textbook of Heat Transfer Paperback", by S.P. Sukhatme. Publisher: Universities 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. Anderson, 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 edition.
5. "Numerical Modeling and Computer Simulation", Edited by DraganCvetković, publisher intechopen.
6. Literature / books suggested by respective course Lecturers.

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❖ **Course Title : Launch Vehicle Design & Analysis**
Course Code : P18DTE0026
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

1. "Design of Rockets and Space Launch Vehicles", by Don Edberg, Willie Costa. Publisher : American Institute of Aeronauti cs &Ast. (August 21, 2020)
2. "Modern Engineering for Design of Liquid Propellant Rocket Engines (Progress in Astronautics and Aeronautics)", by Dieter K Huzel, David H Huang. Publisher : AIAA (American Institute of Aeronautics & Astronautics); Revised, Subsequent 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. Publisher: 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.

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Course Title : Acquisition, Tracking & Pointing Technology
Course Code : P18DTE0027
Teaching Scheme : L: 3, T: 0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

1. "Acquisition, Tracking, Pointing, and Laser Systems Technologies XXI (Proceedings 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.

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❖ **Course Title : Data acquisition, tracking & post flight analysis**
Course Code : P18DTE0028
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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❖ **Course Title : Air Independent Propulsion and Batteries**
Course Code : P18DTE0029
Teaching Scheme : L: 3, T:0, P: 0 Credits: 3

Course Objective

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

Course Outcome:

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

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

Course Content:

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

References / Suggested Books:

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

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❖ **Course Title : Advanced digital modulation technologies & standards**
Course Code : P18DTE0030
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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. "Signal Processing for Wireless Communication Systems", by H. Vincent Poor, Lang Tong, Publisher : Springers.

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4. “Digital Communication: Fundamentals and Applications”, by Sklar, B., and Ray, P.K. Dorling Kindersley.
5. “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.
6. “Detection, Estimation and Modulation Theory Part I”, by Van Trees, H.L. Publisher : Wiley Inter science.
7. “Information Theory, Coding and Cryptography”, by Bose, R. Tata McGraw-Hill.
8. “Digital Communication”, by Barry, J.R., Lee, E.A. and Messerschmitt, D.G.Kluwer.
9. “Principles of Digital Transmission: Wireless Applications”, by Benedetto, S. and Biglieri, E. Publisher : Springer.
10. Literature / books suggested by respective course Lecturers.

Signature of BOS chairman, AE

❖ **Course Title : Trajectories modelling& simulation**
Course Code : P18DTE0031
Teaching Scheme : L: 3, T:0, P:0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

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❖ **Course Title : Sensor Technology**
Course Code : P18DTE0032
Teaching Scheme : L: 3, T: 0, P: 0 Credits: 3

Course Objectives:

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

Course Outcomes:

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

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

Course Content:

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

References / Suggested Books:

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

Signature of BOS chairman, AE