Visvesvaraya Technological University, Belagavi

# Scheme and Syllabus

for

M. Tech

(Defence Technology)

Specialization: Communication Systems and Sensors

(2021-22)

Department of Electronics and Communication Engineering
Basaveshwar Engineering College (Autonomous)
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# Contents

# M. Tech. (Defence Technology)

## 1. Introduction

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

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

DRDO has established very good connect with faculties and researchers of academia through research projects. So far the engineering education in the country does not have M. Tech courses, adapted to impart knowledge related to defence and security applications. Defence Institute of Advanced Technology (DIAT) Pune, CME Pune and select institutes and industries have been mainly providing required specialized knowledge related to defence and security to the students and armed forces personnel. The M. Tech. in defence technology courses has been designed to produce Post Graduates who will have the necessary theoretical & experimental knowledge, skill and aptitude in various defence technologies areas and pursue them to carry out R&D in defence. The students will be provided valuable exposure & knowledge for various state of the art defence systems and contemporary technologies through class lectures & main thesis work. During the program, the students would be given valuable exposure by carrying out their main thesis work in DRDO labs, Defence PSUs & Private Defence Industries. This collaborative effort of DRDO, AICTE and Industries will provide required knowledge to the students and create job opportunities for them. The academic-industry trained workforce will immensely contribute in realizing GOI vision of Atmanirbhar Bharat.

## 3. Objectives

i. 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.

ii. To contrive skilled manpower in the field of defence technologies.

iii. 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.

iv. To acquaint students for the needs of technologies related to defence & security of nation and to create zeal among students to pursue research and development for defence technologies.

## 4. 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 analyze 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 analyze complex problems, apply creativity, carry out research investigation and development work to solve practical problems related to defence technological issues. | Design, Development & Solutions |
| PO – 06 | Ability to communicate effectively in both oral and written contexts in the form of technical papers, project reports, design documents and seminar presentations. | Communication |
| PO – 07 | Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. | Individual &Team Work |

**5. Guidelines from AICTE**

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

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

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

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

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

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

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

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

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

## 6. Syllabus for M. Tech in Defence Technology

### a. Semester - I

| Sl. No. | Course Code | Course of Study and Scheme of examination | M. Tech | | | Defence Technology |
|---|---|---|---|---|---|---|
| | | **Compulsory Course** | **Periods/Week** | | | **Total Credits** |
| | | | L | T | P | |
| 1 | DT-01-01 | Systems and Warfare Platforms | 4 | - | - | 4 |
| 2 | DT-01-02 | Warfare Simulations & Strategies | 4 | - | - | 4 |
| 3 | DT-01-03 | Advanced Engineering Mathematics | 4 | - | - | 4 |
| 4 | DT-01-04 | Research Methodology & IP | 3 | - | - | 3 |
| 4 | DT-01-L01 | Systems and Platforms Lab | - | - | 2 | 2 |
| 5 | DT-01-L02 | Warfare Simulations & Strategies Lab | - | - | 2 | 2 |
| | **Elective Courses** | | | | | |
| 6 | | Elective I | 3 | - | - | 3 |
| 7 | | Elective II | 3 | - | - | 3 |
| 8 | | Seminar | - | - | 1 | 1 |
| | | **Total Credits** | | | | **26** |

### b. Elective Courses

**Elective - I**

| Sl. No. | Course Code | Course of Study and Scheme of Examination | M. Tech | | | Defence Technology |
|---|---|---|---|---|---|---|
| | | **Elective I** | **Periods/Week** | | | **Total Credits** |
| | | | L | T | P | |
| 1. | DT-EL1-03 | Numerical Methods for Science & Engineering | 3 | - | - | 3 |
| 2. | DT-EL1-04 | Communication Technology | 3 | - | - | 3 |
| 3. | DT-EL1-05 | Advanced Mechanical Engineering | 3 | - | - | 3 |

**Elective - II**

| Sl. No. | Course Code | Course of study and Scheme of examination | M. Tech | | | Defence Technology |
|---|---|---|---|---|---|---|
| | | **Elective II** | **Periods/Week** | | | **Total Credits** |
| | | | L | T | P | |
| 1 | DT-EL2-01 | Autonomy and Navigation Technology | 3 | - | - | 3 |
| 2 | DT-EL2-02 | Optimization Theory & Applications | 3 | - | - | 3 |

### c. Semester – II

**Specialization course offered during 2nd Semester: Communication Systems & Sensors (CSS)**

| Sl. No. | Course Code | Course of Study and Scheme of examination | M. Tech | | | Defence Technology |
|---|---|---|---|---|---|---|
| | | **Compulsory Courses** | **Periods/Week** | | | **Total Credits** |
| | | | L | T | P | |
| 1 | DT-CSS-01 | Radar Technologies | 4 | - | - | 4 |
| 2 | DT-CSS-02 | Digital and Satellite Communication and Navigation from space | 4 | - | - | 4 |
| 3 | DT-CSS-03 | Tactical Battlefield Communication and Electronic Warfare | 4 | - | - | 4 |
| 4 | DT-CSS-L01 | Radar Technologies Lab | - | - | 2 | 2 |
| 5 | DT-CSS-L02 | Digital and Satellite Communication and Navigation from space Lab | - | - | 2 | 2 |
| | **Elective Courses** | | | | | |
| 6 | | Elective I | 3 | - | - | 3 |
| 7 | | Elective II | 3 | - | - | 3 |
| 8 | | Seminar | - | - | 1 | 1 |
| **Total Credits** | | | | | | **23** |

### d. Elective Courses

**Elective - I**

| Sl. No. | Course Code | Course of Study and Scheme of examination | M. Tech | | | Defence Technology |
|---|---|---|---|---|---|---|
| | | **Elective I** | **Periods/Week** | | | **Total Credits** |
| | | | L | T | P | |
| 1. | DT-EL3-01 | Robotics | 3 | - | - | 3 |
| 2. | DT-EL3-05 | Safety, Health & Hazard Management | 3 | - | - | 3 |
| 3. | DT-EL3-06 | Fundamental of Telemetry, Telecom and Transponder | 3 | - | - | 3 |
| 4. | DT-EL3-08 | Software Defined Radios | 3 | - | - | 3 |
| 5. | DT-EL3-11 | Advanced Analytical Techniques / Lab Testing | 3 | - | - | 3 |

**Elective - II**

| Sl. No. | Course Code | Course of Study and Scheme of examination | M. Tech | | | Defence Technology |
|---|---|---|---|---|---|---|
| | | Elective II | Periods/Week | | | Total Credits |
| | | | L | T | P | |
| 1. | DT-EL4-05 | Launch Vehicle Design & Analysis | 3 | - | - | 3 |
| 2. | DT-EL4-09 | Advanced Digital Modulation Technologies & Standards | 3 | - | - | 3 |
| 3. | DT-EL4-11 | Sensor Technology | 3 | - | - | 3 |

**Semester – III**

| Sl. No. | Course | Credits |
|---|---|---|
| 1. | Project Dissertation-Phase I | 12 |
| 2. | Seminar/Industrial Training | 6 |
| | **Total credits** | **18** |

**Semester – IV**

| Sl. No. | Course | Credits |
|---|---|---|
| 1. | Project Dissertation-Phase II | 21 |
| | **Total credits** | **21** |

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**

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

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

**Course Objectives:**

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

**Course Outcomes:**

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

- Understand the systems used in warfare scenario.
- Understand combat simulation & modeling.
- 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.

4. Literature / books suggested by respective course Lecturers.

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**


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

| | | |
|---|---|---|
| **Course Title** | **Systems and Warfare Platforms Lab** | |
| **Course Code** | **DT-01-LO1** | |
| **Teaching Scheme** | **L: 0, T: 0, P: 2** | Credits: 2 |

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

| | | |
|---|---|---|
| **Course Title** | **Warfare simulations & Strategies Lab** | |
| **Course Code** | **DT-01-LO2** | |
| **Teaching Scheme** | **L: 0, T: 0, P: 2** | Credits: 2 |

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

## Semester I, Elective-I Courses

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

**Course Objectives:**

The main objective of the course is to provide knowledge to the students to develop numerical methods aided by technology to solve algebraic equations, calculate derivatives and integrals, curve 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, Modeling 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. Sastry. Publisher: PHI Pvt. Ltd., 5th Edition, New Delhi, 2009.
4. “Applied Numerical Methods Using MATLAB", by W.Y. Yang, W. Cao, T.S. Chung and J. Morris. Publisher: Wiley India Edn., 2007.
5. “Numerical Methods for Engineers with Programming and Software Applications”, by Steven C. Chapra and Ra P. Canale. Publisher: Tata McGraw Hill, 2014 7th Edition.
6. “Finite Element Procedures’, by K.J. Bathe, Prentice Hall of India.
7. “Finite Elements in Engineering’ by Chandrupatla and Belegundu.
8. “Finite element Method", by J. N. Reddy.

| 9. Literature / books suggested by respective course Lecturers. |
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| |

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**

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

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**

1.“An Introduction to Computational Fluid Dynamics: The Finite Volume Method” by H. Versteeg. Publisher: Pearson.

2.“Computational Fluid Dynamics the Basics with Applications’, by John D. An-der Jr. Publisher: McGraw Hill Education (1 July 2017)

3.“Fluid Mechanics: Volume 2: Foundations and Applications of Mechanics (Cambridge-iisc)” by C. S. Jog. Publisher: Cambridge University Press.

4. “Fundamentals of Machine Component Design’, by Robert C. Juvinall, Kurt M. Marshek. Publisher: John Wiley & Sons.

5.Literature / books suggested by respective course Lecturers.

## Semester I, Elective-II Courses

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**

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

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**


1. "Numerical Optimization', by Jorge Nocedal and Stephen J. Write. Publisher: Springer, 2006.
2."Practical methods of Optimization" by R. Fletcher. Publisher: Wiley, 1987.
3."Iterative method for optimization" by C. T. Kelley. Publisher: SIAM, 1999.
4."Introduction to Nonlinear Optimization: Theory, Algorithm, and Application with MATLAB. MOS-SIAM Series on Optimization", by Amir Becker.
5."Dynamic Programming and Optimal Control (Volumel)" by Dimitri P. Bertsekas. Publisher: Athena Scientic, 2005.
6."Optimization Theory and Applications', by S S Rao.
7.Literature / books suggested by respective course Lecturers.

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**


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

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

**Course Objectives:**

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

**Course Outcomes:**

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

- Understand the communication techniques
- Evaluate the performance of communication systems
- Design the analogue and digital communication systems
- Understand and analyze 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 pass band 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, concept of frequency hopping. | 7 |
| 6. | Navigation techniques from space regarding functioning of GPS, GLONASS, IRNSS & Galileo | 6 |
| | Total | 40 |

**References/Suggested Books:**


1. "Satellite communication', by T. Pratt, C. W. Bostian, J. E.Allnut. Publisher: John Willey and sons
2. "Satellite Communications Systems: systems, techniques and technology', by G. Maral, M. Bousquet, Z. Sun. Publisher:John Willy and sons
3. "Digital Communications: Fundamentals and Applications', B. Sklar. Prentice-Hall, Inc.
4. "Understanding of GPS/GNSS: Principles and Applications'/by E. Kaplan and C. Hegarty. Publisher:Artech House Publishers.
5. Literature / books suggested by respective course Lecturers.

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**


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

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

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

| | | |
|---|---|---|
| Course Title | **Digital and Satellite Communication and Navigation from space Lab** | |
| Course Code | **DT-CSS-L02** | |
| Teaching Scheme | **L: 0, T: 0, P: 2** | Credits: 2 |

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

## Semester II, Elective-I Courses

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

**Course Objectives:**

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

**Course Outcomes:**

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

- Use matrix algebra and Lie algebra for computing the kinematics of robots.
- Calculate the forward kinematics and inverse kinematics of serial and parallel robots.
- Calculate the Jacobean 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 teleportation. | 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, Jacobeans. | 4 |
| 4 | Modeling Control, Proportional (P), Proportional-Integral (Pl), 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 Al, Programming methods for robotics, Human-Robot interaction. | 6 |
| | Total | 36 |

**References/Suggested Books:**


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

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References / Suggested Books:**


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

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

**Course Objectives:**

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

**Course Outcomes:**

The students will have in depth knowledge on:

- Satellite communication and related technologies.
- Overall control of satellites through collection, processing, and transmission of data.
- Determination of the satellites 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.

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References / Suggested Books:**

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

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

**Course Objectives:**

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

**Course Outcomes:**

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

- Understand different characterization techniques.
- Apply appropriate analytical technique for a particular material organic/inorganic/nano material/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), lon 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.

**Semester-II, Elective-II Courses**

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

| **Unit** | **Contents** | **Contact Hrs.** |
|---|---|---|
| 1. | Introduction to propulsion for launch vehicles, beginning with mission energy requirements and an overview of current and proposed launch propulsion devices. | 6 |
| 2. | Performance analysis, operating characteristics and propellant selection criteria for air breathing and solid | 5 |
| 3. | Liquid and nuclear rocket motor propulsion systems. | 7 |
| 4. | Advanced cycles and concepts are presented. Design of components and subsystems | 7 |
| 5. | FE modeling: 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 Aeronautics & 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: ALAA (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. Pub-lisher: Lap Lambert Academic Publishing.
5. "Space Vehicle Design, Second Edition', by Michael D. Griffin and James R. French. Publisher The American Institute of Aeronautics and Astronautics, Inc.
6. Literature / books suggested by respective course Lecturers.

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**


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.
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, PB. and Rutledge, J.C Publisher: McGraw-Hill.
6. “Detection, Estimation and Modulation Theory Part |’, by Van Trees, H.L. Pub-lisher : 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.

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

**Course Objectives:**

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

**Course Outcomes:**

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

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

**Course Content:**

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

**References/Suggested Books:**

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