VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE

(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum

(Scheme of Instruction & Evaluation and Course contents)

For

Multi-Disciplinary Minor

in

Defense Technology

Implemented for the batch admitted in Academic Year 2023-24

V J T I Veermata Jijabai Technological Institute
(Central Technological Institute, Maharashtra State, INDIA)
H. R. Mahajani Marg, Matunga, Mumbai 400019
Tel.No. +91 22 24198101-02 Fax +91 22 24102874
www.vjti.ac.in

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Credit Framework for

Multi-Disciplinary Minor

in

Defense Technology

Sr.	Semester	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	III	R5ME2202T	Warfare Platforms and Systems	2	0	0	2	2	20	30	50
2	IV	R5ME2205T	Airforce Systems and Configurations	2	0	0	2	2	20	30	50
3	V	R5ME3202T	Navigation, Guidance, and Control	3	0	0	3	3	20	30	50
4	VI	R5ME3204T	Communication Systems and Sensors	3	0	0	3	3	20	30	50
5	VII	R5ME4202T	Unmanned Vehicle Technology	3	1	0	4	4	20	30	50
			Total					**14**			

Abbreviations: **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination,

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – III*
Course Code	**R5ME2202T**	
Course Title	**Warfare Platforms and Systems**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:

1. Understand the basics of defence technology and modern military operations.
2. Analyse the different combat systems in different warfare scenarios.
3. Evaluate the performance of various weapon systems used in military operations.
4. Understand various advancements in defence technologies and their impact on modern conflict.
5. Integrate knowledge from various branches of engineering for developing warfare systems.

Course Contents

Introduction to Defense Technology

Overview of defense technology, Importance, and impact, Historical evolution of defense systems Types of warfare platforms: land, sea, air; Significance of defense technology in modern military operations

Fundamentals of Warfare Systems

Fundamentals of Land, Naval and Air Warfare Systems, Basic principles of operation and design

Weapon Systems

Guided and precision munitions. Emerging technologies in weapon systems

Electronic Warfare

Concepts of electronic warfare: jamming, spoofing, and countermeasures. Technologies and techniques used in electronic warfare

Communication Systems, Cyber Defense and Security

Introduction to cyber warfare and its impact on defense. Basic principles of network security and cyber threat analysis. Military communication systems and protocols. Secure communication techniques and technologies

Text Books

1. Minah Sindane Bloem & Llewellyn Hartnick, Defence Technology Made easy, BK Publishing (Pty) Ltd. South Africa, 2015.
2. David Miller Modern Naval Combat, Crescent Publication.
3. S.A. Vakin, L.N. Shustov & R.H. Dunwell, Fundamentals of Electronic Warfare 2001
4. Neri Filippo, Introduction to Electronic Defense Systems, Artech House Publishers.
5. G. Maral, M. Bousquet, Z. Sun., Satellite Communications Systems: systems, techniques and technology, John Willy and Sons.
6. Yacov Bar-Shlomo, An Introduction to Weapons Systems, Create Space, Independent Publishing Platform.
7. M.I. Skolnik, Introduction to Radar Systems, Tata McGraw Hill edition, 2001.

Recommended Readings

1. Nunney, Light and Heavy Vehicle Technology, Elsevier.
2. Alastair D. McAulay, Military Laser Technology for Defense: Technology for Revolutionizing 21st Century Warfare, 1st edition Wiley-Interscience Publication.
3. Tupper, E. C Fourth, Introduction to Naval Architecture. Butterworth-Heinemann Publication.
4. Thor I. Fossen, Marine Control Systems Guidance, Navigation, and Control of Ships, Rigs, and Underwater Vehicles, Marine Cybernetics, Trondheim, Norway.
5. B.P. Lathi and Zhi Ding, Modern digital and analog communication systems, Oxford University Press.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – IV*
Course Code	**R5ME2205T**	
Course Title	**Airforce Systems and Configurations**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:

1. Evaluate the airforce systems for various mission profiles.
2. Apply basic principles of engineering and aeronautics for enhancing the performance of aircraft systems.
3. Analyze the design considerations and configurations of various airforce platforms.
4. Evaluate the aerodynamic principles, propulsion mechanisms, and flight performance of the missile.

Course Contents

Basics of thermodynamics, fluid Dynamics & Solid Mechanics

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, and payload.

Classification & mode of operation of various propulsion systems

Introduction to Gas Turbine Jet Engine design & performance.

Introduction to Aircraft and Missile Structural Components

Spars; Ribs; Stringer; Longerons, Analysis of stress; Analysis of strain, Failure Theories; Fatigue theory

Rockets & Missiles Fundamentals

Basics of Missile Physics, Introduction to Guided Missiles, Classification of Missiles, Missile Aerodynamic Configurations, Two, Three and Six DOF Equations of Motion, Ballistic Missile Trajectory, Basic Characteristics of Guided Missile

Reference Books

1. John D. Anderson, Jr, Introduction to Flight, McGraw Hill Education, Eighth Edition,
2. John D. Anderson Jr., Computational Fluid Dynamics: Basics with Applications, McGraw Hill Education
3. James Njuguna, Lightweight Composite Structures in Transport: Design, Manufacturing, Analysis and Performance, Woodhead Publishing, 2016
4. Jack D. Mattingly, Keith Boyer, Elements of Propulsion: Gas Turbines and Rockets, American Institute of Aeronautics & Astronautics.
5. George Paul Sutton and Oscar Biblarz, Rocket Propulsion Elements, John Wiley & Sons
6. Jeffrey A. Isaac-son, David R. Vaughan, Estimation and Prediction of Ballistic Missile Trajectories, RAND (29 May 1996)

Recommended Readings

1. Chuan Tau Edward Lan, Airplane Aerodynamics and Performance,
2. Manoj Kumar Buragohain, Composite Structures: Design, Mechanics, Analysis, Manufacturing and Testing, CRC Press.
3. S. R. Mohan, Fundamentals of Guided Missiles, Defence Research and Development Organisation
4. H.I.H. Saravanamuttoo, Prof G.F.C. Rogers, H. Co-hen, Gas Turbine Theory, Prentice Hall.
5. D. Raymer, Aircraft design: a conceptual approach.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester* – V
Course Code	**R5ME3202T**	
Course Title	**Navigation, Guidance, and Control**	
Prerequisites	**Basic knowledge of control systems, dynamics, and differential equations**	

COURSE OUTCOMES

After completing this course, students will be able to:

1. Understand the principles of navigation and various navigation systems.
2. Analyze and apply different guidance laws for accurate missile and UAV trajectories.
3. Design control strategies for stabilizing and controlling dynamic systems.
4. Evaluate the performance of NGC systems through simulations and real-world applications.
5. Implement NGC algorithms using computational tools.

Course Contents

Introduction to Navigation, Guidance, and Control

Overview of NGC systems, Role of NGC in modern warfare, Applications in aerospace, robotics, and automotive systems, Historical advancements and modern developments.

Navigation Systems

Inertial Navigation Systems (INS), Global Navigation Satellite Systems (GNSS) (e.g., GPS, GLONASS, Galileo), Dead Reckoning and Terrain Referenced Navigation (TRN), Kalman Filtering for Sensor Fusion, Error sources and correction techniques.

Guidance Principles

Concept of guidance and types (e.g., Line-of-Sight, Proportional Navigation), Classical guidance laws: Pursuit, Proportional Navigation, and Waypoint Navigation, Terminal guidance and homing methods (Active, Passive, Semi-Active Homing), Optimal guidance strategies for missiles and UAVs, Swarm guidance and cooperative engagement of UAVs.

Control Mechanisms

Linear and Nonlinear Control Systems, PID Control for trajectory stabilization, State-space representation and feedback control, Adaptive and Robust Control Techniques, Application of AI/ML in control systems.

Implementation and Case Studies

Hardware and software tools for defence NGC systems. Case studies on autonomous vehicles, drones, missile guidance, and UAV swarm intelligence. Hands-on projects and simulations

Reference Books

1. Hofmann-Wellenhof, B., Lichtenegger, H., Verlag Wien, Collins, J. Global Positioning System Theory and Practice, Publisher: Springer 2001.
2. Grewal, M. S., Weill, L. R., A. P., Global Positioning Systems, Inertial Navigation, and Integration, Publisher: John Wiley & Sons, New York, 2006.
3. Verlag Wien. Hofmann-Wellenhof, B., Lichtenegger, H., Wasle, E., GNSS – Global Navigation Satellite Systems, Publisher: Springer 2008.
4. Anthony Lawrence, Modern Inertial Technology Navigation, Guidance, and Control, Publisher: Springer New York.2012.
5. Eugene Kagan, Nir Shvalb, Irad Ben-Gal, Autonomous Mobile Robots and Multi-Robot Systems: Motion-Planning, Communication, and Swarming Publisher: Wiley, 2019.

Recommended Readings

1. Jay Farrell, The Global Positioning System & Inertial Navigation, Publisher: McGraw-Hill Education, 1998.
2. Groves, P. D., Principles of GNSS, inertial and multi-sensor integrated navigation systems, Publisher: Artech House.
3. Thor I. Fossen, Marine Control Systems Guidance, Navigation, and Control of Ships, Rigs, and Underwater Vehicles, Marine Cybernetics, Trondheim, Norway.
4. Devendra K. Chaturvedi, Modeling and Simulation of Systems Using MATLAB and Simulink, Publisher: CRC Press, 2010.
5. E. Kaplan and C. Hegarty, Understanding of GPS/GNSS: Principles and Applications, Artech House Publishers.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester* – **VI**
Course Code	**R5ME3204T**	
Course Title	**Communication Systems and Sensors**	
Prerequisites	**Basic knowledge of electronic circuits, signal processing, and electromagnetics**	

COURSE OUTCOMES

After completing this course, students will be able to -

1. Understand the fundamentals of military communication systems and their applications.
2. Analyze different sensor technologies used for surveillance, targeting, and reconnaissance.
3. Evaluate the effectiveness of secure communication protocols in defense technology.
4. Design and simulate radar and sonar systems for battlefield applications.
5. Implement signal processing techniques for sensor fusion and data analysis.

Course Contents

Introduction to Defense Communication Systems

Overview of military communication networks, Secure and encrypted communication, Tactical data links and protocols, electronic warfare, and countermeasures.

Radio and Satellite Communications

Principles of RF and microwave communication, Satellite-based communication for defense applications, Software-defined radios (SDR), cognitive radio systems, Anti-jamming and frequency-hopping techniques.

Radar and Sonar Systems

Fundamentals of radar technology, Types of radars: Pulse-Doppler, Synthetic Aperture Radar (SAR), Phased Array Radar, Sonar principles and underwater detection systems, Applications in missile defense and naval warfare.

Infrared and Optical Sensor Systems

Infrared (IR) and thermal imaging, Laser-based communication and LiDAR, Night vision technologies, Optical sensors for missile guidance and surveillance.

Sensor Fusion and Signal Processing

Introduction to multisensor data fusion, Kalman Filtering and tracking algorithms, Image and signal processing techniques, AI, and machine learning applications in defense sensing.

Reference Books

1. Proakis and Salehi, Fundamentals of communication systems, Pearson.
2. B.P. Lathi and Zhi Ding, Modern digital and analog communication systems, Oxford University Press.
3. G. Maral, M. Bousquet, Z. Sun., Satellite Communications Systems: systems, techniques and technology, John Willy and Sons.
4. M.I. Skolnik, Introduction to Radar Systems, Tata Mcgraw Hill edition, 2001.
5. K. K Sharma, Radar, Sonar and Navigation Engineering, S K Kataria& Sons.

Recommended Readings

1. Simon Haykin and Michael Moher, Communication Systems, Wiley.
2. B.R.Mahafza, Radar Systems Analysis and Design Using MATLAB, CRC Press, 2013.
3. T. Pratt, C. W. Bostian, J. E.Allnut, Satellite communication, John Willey and Sons.
4. Anil K. Maini, Handbook of Defence Electronics and Optronics: Fundamentals, Technologies and Systems, John Wiley & Sons Ltd., 2018.
5. Samuel O. Agbo, Matthew N. O. Sadiku, Principles of Modern Communication Systems, Cambridge University Press, 2017.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – VII*
Course Code	**R5ME4202T**	
Course Title	**Unmanned Vehicle Technology**	
Prerequisites	Basics of Engineering Mechanics, Introduction to Aerodynamics and Control Systems, Fundamentals of Electronics and Communication	

COURSE OUTCOMES,

After completing this course, students will be able to -

1. Explain the fundamentals of unmanned vehicle systems used in defence applications.
2. Analyze the aerodynamic, propulsion, and control characteristics of unmanned aerial and ground vehicles.
3. Apply mission planning and autonomous operation concepts for defence applications.
4. Evaluate unmanned vehicle performance, endurance, and mission capability.
5. Design unmanned systems for Ground, Aerial and Naval platforms.

Course Contents

Fundamentals of Unmanned Vehicle Systems

Introduction to unmanned systems, Evolution and history of unmanned vehicles, Classification of unmanned systems, Architecture of unmanned Systems, Performance parameters, Mission profile and operations, Advantages and limitations of unmanned systems.

Unmanned Ground Vehicles (UGVs)

Classification of UGV Systems, Mobility and Terrain Adaptability, Stability and Operational Characteristics, Mobility versus stability trade-off, Autonomous Ground Operations. Future trends in robotic mobility systems.

Unmanned Surface Vehicles (USVs)

Introduction to marine unmanned systems, Classification of USV Systems, Floating body, Buoyancy and equilibrium, Static and dynamic stability, Hydrodynamic Resistance, Conceptual USV design.

Unmanned Underwater Vehicles (UUVs)

Deep-sea and shallow-water systems, Stability of underwater systems, Pressure-Resistant Structures, Battery systems and Energy management.

Unmanned Aerial Vehicles (UAVs)

Classification of UAV Systems, Airframe Configuration, Weight and Endurance Estimation, Launch and Recovery of UAVs, Stealth and Low-Observable UAV, Swarm Systems and Emerging Technologies.

Text Books:

1. Andall K. Nichols, Julie Ryan, Hans Mumm, Wayne Lonstein, Candice Carter, Jeremy Shay, Randall Mai, John P Hood, and Mark Jackson “Unmanned Vehicle Systems & Operations on Air, Sea, Land,” New Prairie Press.
2. Reg Austin, “Unmanned Aircraft Systems: UAVS Design, Development and Deployment”, Oxford University Press.
3. Mohammad Sadraey, “Unmanned Aircraft Design: A review of fundamentals”, Morgan & Claypool Publishers.
4. Sabiha Wadoo, Pushkin Kachro, “Autonomous Underwater Vehicles: Modeling, Control Design, and Simulation”, CRC Press.
5. K. K Sharma, “Radar, Sonar and Navigation Engineering”, S K Kataria & Sons.

Recommended Readings

1. Matthew Harrison, “Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles,” Wiley.
2. Narayan Panigrahi, Smita Tripath, “Design Principles of Autonomous Systems UAV, UGV, and AUV”, CRC Press.
3. Thor I. Fossen, Kristin Y. Pettersen, Henk Nijmeijer, “Sensing and Control for Autonomous Vehicles: Applications to Land, Water and Air Vehicles”, Springer Cham.
4. Roland Siegwart, Illah Nourbakhsh, and Davide Scaramuzza, “Introduction to Autonomous Mobile Robots”, MIT Press.
5. Steven W. Moore, Harry Bohm, and Vickie Jensen, “Underwater Robotics: Science, Design and Fabrication”, Marine Advanced Technology Education.
6. Huarong Zheng & Chen-Guang Liu, “Towards Unmanned Surface Vehicles: Methods and Practices”, CRC Press.