Semester - II

Systems and Warfare Platforms			
Course Code	MMDT201	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 10-12 Lab slots	Total Marks	100
Credits	04	Exam Hours	

Course objectives:

- Understand different defence platforms, including land, sea, and air, along with their lifecycle stages such as design, production, operation, and support.
- Learn the fundamentals of ship, submarine, and military vehicle design, focusing on buoyancy, stability, survivability, power requirements, and structural considerations.
- Explore the principles of flight for fixed-wing and rotary-wing aircraft, covering aerodynamics, control mechanisms, power needs, speed, range, and operational capabilities.
- Examine various weapon systems and self-defence technologies, including armour, decoys, countermeasures, and emerging protection concepts in modern warfare.

MODULE-1

Types of platforms: land, sea and air; Lifecycle: concept, design, pre-production, production, operations, support, major aspects of different platforms, qualitative and quantitative treatment of major aspects

MODULE-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

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

MODULE-4

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

MODULE 5

Self defence and Protection systems: Armour, smoke, chaff, decoys; Introduction to instrumentation, lab tests and flight trials, Other protection systems, unconventional and innovative concepts.

PRACTICAL COMPONENT OF IPCC*(May cover all / major modules)*

Sl.NO	Experiments
1	Simulate projectile trajectories under varying conditions
2	Simulate countermeasures to missile and ordnance threats
3	Simulate a bomb drop from an aircraft on a moving tank for pure-pursuit motion
4	Simulate the take off Trajectory
5	Simulate the Landing trajectory
6	Understanding the principle of Doppler RADAR of Time and Frequency measurement with the help of moving pendulum
7	Simulate combat scenarios using Lanchester's equations to understand how force strength impacts outcomes

8	Study different guidance systems (e.g., proportional navigation, pursuit guidance).
9	Model the thrust and trajectory of a rocket under variable fuel burns.
10	Simulate the TR and PR Curve for various velocities

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIE for the theory component of IPCC

1. Two Tests each of **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIE for the practical component of IPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day. The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for **10 marks**. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test at the end /after completion of all the experiments shall be conducted for **50 marks** and scaled down to **05 marks.**

Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **20 marks**.

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SEE for IPCC

Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper shall include questions from the practical component).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratory component shall be included**.** The maximum of 04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course (CIE+SEE)

Suggested Learning Resources:

Books

1. Nunney, Light And Heavy Vehicle Technology, Publisher Elsevier, Fourth Edition,2006.
2. Bonnick Allan et. Al, Practical approach to motor vehicle engineering and maintenance, Publisher: Yesdee.
3. Trelleborg, Automotive Vibration Control Technology, Fundamentals, Materials, Construction, Simulation, and Applications, Publisher:, Vogel Business Media GmbH & Co. KG, 1st edition, 2015.
4. Yacov Bar-Shlomo, An Introduction to Weapons Systems, Create Space Independent Publishing Platform

Web links and Video Lectures (e-Resources):

1. **https://www.udemy.com/course/flight-mechanics-from-theory-to-certification-of-aircraft**
2. **https://www.youtube.com/watch?v=fBLHZwEXKeA**
3. **https://www.youtube.com/watch?v=sRp1_ndpsI4**

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

Case Study can be given

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply knowledge of warfare platforms to analyze the design fundamentals and operational requirements of Army, Air, and Marine systems.	3
CO2	Demonstrate the functioning and application of weapon systems, including guns, ordnance, missiles, projectiles, mines, countermines, lasers, and undersea weapons.	3
CO3	Utilize principles of flight mechanics to assess aircraft performance, control mechanisms, aerodynamics, and operational capabilities.	3
CO4	Analyze different weapon systems to evaluate their effectiveness in various combat scenarios and strategic defense operations.	3
CO5	Implement self-defence and protection strategies by applying knowledge of armour, decoys, countermeasures, and emerging protection technologies in modern warfare.	3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2							2	2		1
CO2	3	2							2	2		1
CO3	3	2							2	2		1
CO4	3	2							2	2		1
CO5	3	2							2	2		1

Semester-

Warfare and Simulation Strategies			
Course Code	MMDT202	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	39	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Explore tactical mission support systems, command and control mechanisms, and mission planning for air, surface, naval, and electronic warfare.
- Examine different types of warfare, including surveillance, reconnaissance, communications, weapons, sensors, and combat simulation techniques.
- Utilize mathematical models such as Lanchester's equations and Lotka-Volterra equations to analyze war strategies, combat effectiveness, and decision-making.
- Apply interactive and manual wargaming techniques, combat modeling, and human factors representation to enhance military training and strategic planning.

Module-1

Introduction to Warfare systems: Tactical mission support system, mission planning: air, surface, naval vessels, subsurface, littoral, electronic, command and control, aviation support systems.

Module-2

Military capabilities: air warfare, surface warfare, subsurface warfare, littoral warfare, surveillance and reconnaissance, interior and exterior communications, top side design, weapons, sensors, navigation.

Module-3

Combat strategies: Introduction to the methods used in modeling combat and their application in support of defence decision making and training, Combat simulation: dog fighting, interception.

Module-4

War simulation: Wargaming/interactive simulation, war strategies, Lanchester's equations, Mathematical models of combat, Relation to the salvo combat model, Lotka -Volterra equations, scoring systems.

Module-5

Applications to real world: War gaming and combat modeling in practice, manual wargaming, Human factors representation in war gaming and combat modeling, Network and Non-network.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

1. Two Unit Tests each of **25 Marks**
2. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

1. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
2. The question paper will have ten full questions carrying equal marks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
4. Each full question will have a sub-question covering all the topics under a module.
5. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. DefenseModeling, Simulation, and Analysis: Meeting the Challenge", Publisher: National Academies Press, October 22, 2006

2. David L, Adamy: Introduction to Electronic Warfare Modeling and Simulation, Publisher : Artech Print on Demand, October 31, 2002

3. An-dreas Tolk (Editor), Old Dominion University, Engineering Principles of Combat Modeling and Distributed Simulation, John Wiley & Sons.

Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

Simulation of Warfare Systems using MATLAB

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply knowledge of warfare systems to analyze their roles and functions in different combat scenarios.	3
CO2	Demonstrate an understanding of military capabilities by evaluating their effectiveness in various warfare environments.	3
CO3	Utilize combat simulation and modeling techniques to assess strategic and tactical decision-making in military operations.	3
CO4	Implement mathematical models such as Lanchester's equations to design and evaluate combat simulations.	3
CO5	Apply war gaming simulation and human factor representation to enhance training, strategic planning, and operational effectiveness.	3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	**3**	**3**	**2**						**2**	**2**
CO2	**3**	**3**	**2**						**2**	**2**
CO3	**3**	**3**	**2**						**2**	**2**
CO4	**3**	**3**							**2**	**2**
CO5	**3**	**3**							**2**	**2**

Semester-

Aerospace Propulsion			
Course Code	MMDT203	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	39	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand the fundamentals of thermodynamics and propulsion systems by analyzing energy interactions, gas dynamics, and performance parameters of air-breathing engines.
- Apply principles of air-breathing propulsion to evaluate thrust generation, engine components, cycle efficiencies, and nozzle flow characteristics in various flight conditions.
- Analyze the performance and efficiency of air-breathing and rocket propulsion systems through ideal and non-ideal cycle analysis, thrust equations, and specific impulse calculations.
- Explore advanced propulsion technologies including scramjets, pulse jets, electric propulsion, and nuclear propulsion systems, along with their applications in modern aerospace engineering.

Module-1

Review of thermodynamics: Work and energy interactions, Representation of isothermal, isentropic, isobaric and isochoric processes on P-V and T-S diagrams, Classical thermodynamics, conservation equations for systems and control volumes, one dimensional flow of a compressible perfect gas – isentropic and non-isentropic flows. Propulsion system performance, the gas generator Brayton cycle, zero dimensional analysis of ideal ramjet, turbojet and turbofan cycles, non-ideality and isentropic efficiencies. Performance analysis of inlets and nozzles, gas turbine combustors, compressors and turbines and discussion of factors limiting performance

Module-2

Basics of Air breathing Propulsion: Introduction to various air breathing and non-air breathing engines. Principle of thrust generation, Brayton cycle, types of air-breathing propulsion systems, components of jet engine and their functions, diffuser design for subsonic and supersonic flights, preliminary aspects of axial flow compressor and turbines, types of combustors, convergent nozzle, CD Nozzle, flow through nozzles – optimal, under and over expanded nozzles

Module-3

Performance of Air breathing engines: Ideal cycle analysis, efficiencies of components and non-ideal cycle analysis, engine performance analysis – specific thrust, specific fuel consumption, propulsive, thermal and overall efficiencies. Efficiencies of air breathing and non-air breathing engines.

Module-4

Rocket Propulsion: Classification based on energy system, nozzle and Thrust Equation; Specific Impulse, Thrust Coefficient, Characteristic Velocity and other Performance Parameters; liquid rocket engine, components and propellants, solid rocket propellants, performance parameters and motor design, hybrid rocket propulsion systems, selection of rocket propulsion systems, thrust vector control methods, rocket exhaust plumes, rocket testing.

Module-5

Advanced Propulsion: Scramjet and pulse jet engines - principle of operation. Electric propulsion thrusters: classification, principle and application. nuclear propulsion system, concepts, design and application, Recent Micro Spacecraft Developments; Micro-propulsion Options; Primary Set of Micro-propulsion Requirements

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

3. Two Unit Tests each of **25 Marks**
4. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

6. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
7. The question paper will have ten full questions carrying equal marks.
8. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
9. Each full question will have a sub-question covering all the topics under a module.
10. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1Cohen, H, Saravanamuttoo, HIH., Rogers, GFC, Paul Straznicky and Andrew Nix, "Gas Turbine Theory", Pearson Education Canada; 7th edition, 2017.
2. Gill,WP, Smith,HJ&Ziurys,JE, "Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980.
3. Hill, PG. & Peterson, CR. "Mechanics & Thermodynamics of Propulsion" Pearson education, 2 nd edition, 2014.
4. Oates, GC,"Aerothermodynamics of Aircraft Engine Components", AIAA Education Series, 2007.
5. Sutton,GP, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2017.
6. J Seddon & E L Goldsmith. "Intake Aerodynamics", AIAA education series. 1999.

Web links and Video Lectures (e-Resources):

- .https://www.youtube.com/watch?v=edLnZgF9mUg
- https://www.youtube.com/watch?v=cZCSyEIgA3U

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Apply the fundamentals of thermodynamics to compressible flows	3
CO2	Understand the working principle of air breathing propulsion systems	2
CO3	Use cycle analysis and assess performance of air breathing engines	3
CO4	Analyze the performance parameters of various rocket propulsion systems	3
CO5	Understand the concepts of advanced propulsion systems	2

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12
CO1	3	1							2	2		1
CO2	2	2							2	2		1
CO3	1			1	1				2	2		1
CO4	2								2	2		1
CO5	1	2		1					2	2		1

Semester-

Aerodynamics			
Course Code	MMDT204	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	39	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand the fundamental principles of fluid flow in aerodynamics by exploring governing equations, flow characteristics, and airfoil properties.
- Apply inviscid flow theories to analyze two-dimensional and three-dimensional aerodynamic flows, including flow over airfoils, wings, and circular cylinders.
- Examine the effects of compressibility and shock waves on aerodynamic performance, including transonic, supersonic, and high-speed flow phenomena.
- Develop practical knowledge of aerodynamic testing techniques through wind tunnel experiments, flow visualization methods, and measurement of aerodynamic forces and pressures.

Module-1

Governing equations: Euler and Lagrangian descriptions, Control volume approach to continuity and momentum equations, Path lines, Streamlines and Streak lines, Stream function, Velocity potential. Types of flow.

Airfoil Characteristics: Airfoil section geometry and wing plan form geometry, aerodynamic forces and moment and pressure coefficient. Centre of pressure, calculation of airfoil lift and drag from measured surface pressure distributions, typical airfoil aerodynamic characteristics at low speeds. High lift Devices.

Module-2

Two-Dimensional Inviscid Incompressible Flows: Bernoulli's equation and applications. Condition on velocity for incompressible flow. Laplace equation and boundary conditions. Two-dimensional source, sink and doublet flows and vortex flow and combinations of elementary flows.

Flow over Circular Cylinders: Non-lifting flow over a two-dimensional circular cylinder, Lifting flow over a two-dimensional circular cylinder, Kutta-Joukowski theorem and generation of lift, D'Alembert's paradox.

Module-3

Incompressible Flow over Airfoils: Kelvin's circulation theorem and the starting vortex, Kutta condition, Classical thin airfoil theory for symmetric and cambered airfoils.

Incompressible Flows over Finite Wings: Downwash, Induced drag, vortex filament, the Biot-Savart Law, Prandtl's lifting line theory and its limitations, Elliptic lift distribution. Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane, ground effects.

Module-4

Subsonic linearized flow over airfoils: Full velocity potential equation, linearized velocity potential equation and boundary condition, Prandtl-Glauert compressibility correction.

Effects of Compressibility: Basics of speed of sound, Mach waves, Normal shock waves, Oblique shock waves, Expansion fan, Prandtl – Meyer expansion, Critical Mach number; Drag- divergence Mach number, Sound Barrier, Transonic area rule. Swept wing.

Module-5

Viscous Flows: Derivation of Navier-Stokes equation for two-dimensional flows, boundary approximations, laminar boundary equations and boundary conditions, Blasius solution, qualitative features of boundary layer flow under pressure gradients, aspects of transition to turbulence, turbulent boundary layer properties over a flat plate at low speeds.

Introduction to Aerodynamic Testing: Principles of wind tunnel flow simulation, Classification and Major features of subsonic, supersonic and hypersonic wind tunnels. Flow visualization techniques. Measurement of pressure, velocity and Aerodynamic load measurements on a model.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

5. Two Unit Tests each of **25 Marks**
6. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

11. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
12. The question paper will have ten full questions carrying equal marks.
13. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
14. Each full question will have a sub-question covering all the topics under a module.
15. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. J.D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill Education, 6th edition, 2017.
2. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 7th edition, 2020.
3. Shapiro, AH, "Dynamics & Thermodynamics of Compressible Fluid Flow", Ronald Press, 1982.
4. Houghton, EL and Caruthers, NB,"Aerodynamics for Engineering Students", Butterworth- Heinemann series, 7th edition 2017.
5. Zucrow, M.J, and Anderson, J.D, "Elements of gas dynamics" McGraw-Hill Book Co., New York, 1989.
6. Rae, WH and Pope, A, "Low speed Wind Tunnel Testing", John Wiley Publications, 3rd edition, 1999.

Web links and Video Lectures (e-Resources):

- .https://www.youtube.com/watch?v=edLnZgF9mUg
- https://www.youtube.com/watch?v=cZCSyEIgA3U

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Analyze the airfoil characteristics	3
CO2	Analyze the incompressible inviscid flows and their combinations.	3
CO3	Analyze the incompressible inviscid flow over airfoil and finite wing.	3
CO4	Analyze the subsonic linearized flow over airfoil and effect of compressibility	3
CO5	Analyze the features of viscous flow and discuss the aerodynamic testing.	3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12
CO1	**3**								**2**	**2**		**1**
CO2	**3**	**3**	**3**						**2**	**2**		**1**
CO3	**3**	**2**	**3**						**2**	**2**		**1**
CO4	**3**	**3**	**3**						**2**	**2**		**1**
CO5	**3**	**3**	**3**						**2**	**2**		**1**

Semester- II

Guidance & Control			
Course Code	MMDT205	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	39	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand the fundamental principles of navigation systems by exploring conventional navigation methods, geometric concepts, sensors, and mathematical foundations.
- Apply satellite navigation principles to analyze the functioning of Global Navigation Satellite Systems (GNSS), inertial navigation, and terrestrial radio positioning techniques.
- Examine instrumentation and integration techniques for navigation systems, including error analysis, dead reckoning, attitude measurement, and INS/GNSS integration.
- Analyze missile control and guidance systems by modeling missile dynamics, designing autopilots, and simulating six-degree-of-freedom trajectories using computational tools like MATLAB.

Module-1

Introduction: Introduction to Navigation, General principles of early conventional navigation systems. Geometric concepts of navigation. sensors used in navigation systems, Navigation Mathematics.

Module-2

Global Navigation Satellite System: Fundamentals, Signals, and Satellites: Fundamentals of Satellite Navigation, Inertial Navigation, Advanced satellite Navigation, Principles of radio Positioning, Terrestrial radio Navigation, Short-Range Positioning, Satellite Navigation Processing

Module-3

Instrumentation : Errors and Geometry, Dead Reckoning, Attitude, and Height Measurement, Feature matching, Integration of Inertial Navigation System / Global Navigation Satellite System.

Module-4

Missile Control Methods: Elements of flight control system, Aerodynamic and Thrust Vector Control, Engine gimbal control and Secondary injection thrust vector control, Polar and Cartesian Control

Module-5

Modeling, Design and Analysis: Mathematical Modeling of Missile Dynamics; Missile Actuators and Sensors. Roll and Roll Rate Stabilization. Design and Analysis of Lateral Autopilots, 6 degree of freedom trajectory simulation for aircraft / missile using MATLAB

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

7. Two Unit Tests each of **25 Marks**
8. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

16. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
17. The question paper will have ten full questions carrying equal marks.
18. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
19. Each full question will have a sub-question covering all the topics under a module.
20. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. Anthony Lawrence, Modern Inertial Technology Navigation, Guidance, and Control, Springer New York, 2012.
2. William Palm, MATLAB for Engineering Applications, McGraw-Hill Education, 4th edition (February 6, 2018).
3. Jay Farrell, The Global Positioning System & Inertial Navigation, McGraw-Hill Education, 16 December 1998
4. Grewal, M. S., Andrews, A. P., Bartone, C. G, Global Navigation Satellite Systems, Inertial Navigation, and Integration, John Wiley and Sons Inc, 2013.
5. Groves, P. D, Principles of GNSS, inertial and multisensor integrated navigation systems, Artech House.
6. Kalman, H Infinity, Optimal State Estimation.

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=wAtWb404x2I
- https://www.youtube.com/watch?v=0AJ6E48Aj9U

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the principles of satellite navigation, inertial navigation, radio positioning.	2
CO2	Understand various aspects of designing a navigation system	2
CO3	Develop mathematical model of missile dynamics	3
CO4	Understand methods of thrust vector control	2
CO5	Carry out simulation for aircraft/missile using mathematical tools like MATLAB	4

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12
CO1	3	3							2	2		1
CO2	3	2							2	2		1
CO3	3	2							2	2		1
CO4	3	2							2	2		1
CO5	3	2							2	2		1

Semester- II

Aerospace System Design and Configuration			
Course Code	MMDT206	CIE Marks	50
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	50
Total Hours of Pedagogy	39	Total Marks	100
Credits	03	Exam Hours	03

Course Learning objectives:

- Understand the fundamentals of missile systems and design processes by exploring missile classification, system components, and aero-elastic design requirements.
- Learn the principles of structural analysis and aero-elasticity by examining structural stiffness, coupling effects, vibration analysis, and torsional divergence in missile and aircraft structures.
- Explore advanced aerodynamics and aero-elastic analysis methods including flutter characteristics, computational fluid dynamics (CFD), and hypersonic flow effects.
- Analyze aircraft performance, stability, and control systems by studying flight dynamics, maneuverability, response characteristics, and modern weapon systems like UAV-mounted guided weapons (GW) and UCAVs.

Module-1

Missiles and Systems: Introduction (aero-elastic phenomena and design requirements), Introduction to missiles & systems, basic aspects of missiles and systems, classification, conceptual and detailed design process.

Module-2

Structural Analysis: A review of basic structures, Structural requirement, Structural and aerodynamic stiffness, Coupling between aerodynamics and structures, Static aero-elasticity: torsional divergence, Structural vibration and modal analysis.

Module-3

Aero-elasticity And Advanced Aerodynamics: Aerodynamic loads on an oscillating lifting surface, Characteristics of flutter and important design parameters, Methods for aero-elastic analysis, Computational fluid dynamics, advances in aerodynamics (Hypersonic Flows and Aerodynamic Heating).

Module-4

Aircraft Performance: Equations of motion, cruising, climb, descent, takeoff, landing, maneuver, flight path, expressions for range and endurance of propeller driven and jet driven aircrafts, v-n diagram and flight envelope

Module-5

Stability and Control System's stability & control, aerodynamics control, Introduction to dynamic stability, first and second order responses, Equations of motion and modal characteristics.
Introduction to air to air, ground to air, air to ground weapon systems, UAV mounted GW and UCAVs

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

9. Two Unit Tests each of **25 Marks**
10. Two assignments each of **25 Marks**or **oneSkill Development Activity of 50 marks** to attain the COs and POs

The sum of two tests, two assignments/skill Development Activities, will be **scaled down to 50 marks**

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

21. The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 50.
22. The question paper will have ten full questions carrying equal marks.
23. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions) from each module.
24. Each full question will have a sub-question covering all the topics under a module.
25. The students will have to answer five full questions, selecting one full question from each module

Suggested Learning Resources:

Books

1. D. Raymer, Aircraft design a conceptual approach, Sixth Edition, September 30th 2018.
2. Michael V. Cook, Flight Dynamics Principles, Elsevier Science & Technology, Third Edition ,2013
3. Dewey H. Hodges, G. Alvin Pierce, Introduction to Structural Dynamics and Aero-elasticity, Cambridge University Press, June 2012
4.Roskam Aviation and Engineering, Airplane Aerodynamics and Performance, Chuan Tau Edward Lan, 1981.
5. Roy R. Craig Jr., Andrew J. Kurdila , Fundamentals of Structural Dynamics, 2nd edition (1st September 2006)

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=8e91zTiztpw
- https://www.youtube.com/watch?v=3afHlAwBudM

Skill Development Activities Suggested

Course outcome (Course Skill Set)

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

Sl. No.	Description	Blooms Level
CO1	Understand the principles of missile system design and analyze its requirements, components, and development processes	2
CO2	Demonstrate structural analysis techniques to assess the strength, stability, and performance of aerospace structures.	3
CO3	Use aero-elastic analysis, computational fluid dynamics (CFD), and advanced aerodynamics to evaluate the aerodynamic behavior of missile and aircraft systems.	3
CO4	Analyze airplane performance parameters such as range, endurance, and maneuverability in different flight conditions.	3
CO5	Understand stability and control concepts for air-to-air, ground-to-air, air-to-ground weapon systems, UAV-mounted guided weapons (GW), and UCAV operations.	3

Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12
CO1	3	2							2	2		1
CO2	3	3							2	2		1
CO3	3	3							2	2		1
CO4	3	3							2	2		1
CO5	3	2							2	2		1

Aerospace Systems & Navigation Lab			
Course Code	MDTL207	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	30	SEE Marks	50
Credits	02	Exam Hours	03

Course objectives:

- **Understand the fundamentals of flight dynamics, control, and autopilot systems** for aerospace vehicles such as aircraft, missiles, and launch vehicles.
- **Explore various guidance algorithms and navigation techniques** used in aerospace applications, including trajectory planning and optimization.
- **Learn the principles of Kalman filtering and sensor fusion** for integrating navigation components like IMU, GPS, and other sensors.
- **Analyze the integration of guidance, navigation, and control (GNC) systems** to enhance the performance and stability of aerospace vehicles.

Sl.NO	Experiments
1	Study of Aircraft and Missile Autopilot Systems
2	Simulation of Equilibrium glide trajectories for atmospheric flight.
3	Simulation of Guidance Algorithms for Aerospace Vehicles
4	Design and Analysis of Proportional Navigation Guidance
5	Implementation of Kalman Filtering for State Estimation
6	Sensor Fusion Using IMU and GPS Data
7	Analysis of Stability and Control in Aerospace Vehicles
8	Integration of Guidance, Navigation, and Control (GNC) Systems in a Flight Simulator
	Demonstration Experiments (For CIE) if any
9	Performance Evaluation of Different Navigation Systems (IMU, GPS, and Other Sensors)
10	Trajectory Simulation and Optimization for Missiles and Launch Vehicles
11	Testing and Validation of Control Laws for Aerospace Vehicles
12	Flight Path Prediction and Correction Using Navigation Data

Course outcomes (Course Skill Set):

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

- Understand the fundamentals of flight dynamics and control for aerospace vehicles, including aircraft, missiles, and launch vehicles.
- Analyze various guidance algorithms used in aerospace applications and evaluate their effectiveness in different flight conditions.
- Apply Kalman filtering and sensor fusion techniques to improve navigation accuracy using IMU, GPS, and other sensors.
- Evaluate the integration of guidance, navigation, and control (GNC) systems in aerospace vehicles for optimal performance.
- Design and simulate aerospace trajectories by implementing control strategies and navigation techniques

for atmospheric and space flight.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

Continuous Internal Evaluation (CIE):

CIE marks for the practical course is**50 Marks**.

The split-up of CIE marks for record/ journal and test are in the ratio **60:40**.

- Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.
- **Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks).
- Weightage to be given for neatness and submission of record/write-up on time.
- Department shall conduct 01 tests for 100 marks, test shall be conducted after the 14th week of the semester.
- In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge will carry a weightage of 60% and the rest 40% for viva-voce.
- The suitable rubrics can be designed to evaluate each student's performance and learning ability.
- **The test marksis scaled down to 20 marks** (40% of the maximum marks).

The Sum of **scaled-down** marks scored in the report write-up/journal and marks of test is the total CIE marks scored by the student.

Semester End Evaluation (SEE):

SEE marks for the practical course is 50 Marks.

SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the University.

All laboratory experiments are to be included for practical examination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners. **OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

General rubrics suggested for SEE are mentioned here, writeup-20%, Conduction procedure and result in -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shall be scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Change of experiment is allowed only once and 10% Marks allotted to the procedure part to be made zero.

The duration of SEE is 03 hours

Suggested Learning Resources:

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Web links and Video Lectures (e-Resources):

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Skill Development Activities Suggested

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Program Outcome of this course

Sl. No.	Description	POs

Mapping of COS and POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	Po11	PO12
CO1	3	3	3		3				3	3		1
CO2	3	3	3		3				3	3		1
CO3	3	3	3		3				3	3		1
CO4	3	3	3		3				3	3		1
CO5	3	3	3		3				3	3		1