| AVIATION MANAGEMENT | | Semester | 5 |
|---|---|---|---|
| Course Code | **BAE501/BAS501** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Acquire the leadership and perception of design feedback system.
- Realize the customer needs & Quality
- Understand the airline and airport operation, scheduling and management
- Acquire the general aviation management practices
- Grasp the broad disciplines of management at different levels of aviation industry

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Leadership:** Definition, characteristics of quality leaders, leadership concept, characteristics of effective people, ethics, the Deming philosophy, role of TQM leaders, implementation, core values, concepts and framework, strategic planning communication, decision making,

**Module-2**

**Continuous Process Improvement:**

Process, the Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies. Tools and Techniques: Benching marking, information technology, quality management systems, environmental management system, quality function deployment, quality by design, failure mode and effect analysis, product liability, total productive maintenance.

**Module-3**

**Customer Satisfaction and Employee Involvement:**

Customer Satisfaction : customer and customer perception of quality, feedback, using customer complaints, service quality, translating needs into requirements, customer retention, Case studies. Employee Involvement – Motivation, employee surveys, empowerment, teams, suggestion system, recognition and reward, gain sharing, performance appraisal, unions and employee involvement, case studies.

**Module-4**

Airline and Airport Management, Airline Operation and Scheduling, Data Analysis for Business Decisions, Economic Analysis for Business Decisions, Aircraft Rules and Regulation, Airline Business in the 21st Century. Human Resources Management, Organizational Behaviour, Accounting for Management, Airline Economics,

**Module-5**

Business Application Software, Communication Skills and Business Correspondence, Research Methods in Business, International Business Management, Aviation Systems: Management of the Integrated Aviation Value Chain Aviation Law , Aviation Safety Management and Accident Investigations, Emerging Trends in Management - Case Study Analysis, Entrepreneurship Development, Airline Advertising and Sales Promotion

**Course outcome (Course Skill Set)**

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

1. Analyse customer need and perceptions of design feedback systems
2. Infer the customer perception of quality
3. Apply the foundational knowledge of airline and airport operation, scheduling and management
4. Implement the general aviation management practices
5. Prepare for the management at different levels of aviation industry

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**

1. Introduction to Aviation Management, Andreas Wald, Christoph Fay, Ronald Gleich, LIT Verlag Münster,
2. Aviation Management (Ground Service & In-flight Service) Paperback – 1 January 2021 by Arijit Das (Author)
3. Total Quality Management: Dale H. Bester field, Publisher Pearson Education India, ISBN: 8129702606, Edition 03/e Paperback (Special Indian Edition)

**Reference Books**

1. Aviation Management : Global And National Perspectives Hardcover – 1 January 2008 by Ratandeep Singh (Author)

2. Aviation Leadership: The Accountable Manager by Mark J. Pierotti Airline Management Finance -The Essentials By Victor Hughes

3. A New American TQM, four revolutions in management, Shoji Shiba, Alan Graham, David Walden, Productivity press, Oregon, 1990

**Web links and Video Lectures (e-Resources):**

- https://www.youtube.com/watch?v=6Uk8F3_9ywY

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

1. Experimentation – gathering knowledge through experience through lab.
2. Exploration – gathering knowledge and attaining skills through active investigation.
3. Expression – encouraging students to express their views through visual presentations.

| Aircraft Structures | | Semester | 5 |
|---|---|---|---|
| Course Code | **BAE502** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:2:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 hours Theory + 8-10 Lab slots | Total Marks | 100 |
| Credits | 04 | Exam Hours | 03 |
| Examination nature (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Comprehend the basic concepts of stress and strain.
- Acquire the knowledge of types of loads on aerospace vehicles.
- Realise the bending stresses in unsymmetrical sections using different methods.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT.
2. Assignment of Home/field work on real-life problem.
3. Adoption of Project-based/Activity Based learning.
4. Practising the foundational knowledge.

**MODULE-1**

**Design for Static Strength:**

Introduction: Normal, shear, biaxial and tri-axial stresses, Stress tensor, Principal Stresses, Stress Analysis, Design considerations, Codes and Standards. Static Strength: Static loads and factor of safety, Theories of failure: Maximum normal stress theory, Maximum shear stress theory, Maximum strain theory, Strain energy theory, and Distortion energy theory, failure of brittle and ductile materials.

**MODULE-2**

**Design for Impact and Fatigue Strength**

Impact Strength: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia. Fatigue Strength: Endurance limit, modifying factors: size effect, surface effect, Stress concentration effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage. Stress concentration, and Determination of Stress concentration factor.

**MODULE-3**

**Columns:** Columns with various end conditions, Euler's Column curve, Rankine's formula, Column with initial curvature, Eccentric loading, south-well plot.

**Loads on Aircraft:** Structural nomenclature, Types of loads, load factor, Aerodynamics loads, Symmetric manoeuvre loads, Velocity diagram, Function of structural components.

**MODULE-4**

**Structures**

Statically Determinate and Indeterminate structures, Analysis of plane truss, Method of joints, 3D Truss, Plane frames, Composite beam, Clapeyron's Three Moment Equation. Moment Distribution Methods. Unit Load Methods-Application to beams, trusses, frames, etc.

**MODULE-5**

**Unsymmetrical Bending:** Bending Stresses in beams of unsymmetrical sections-bending of symmetric sections with skew loads.

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

| Sl.NO | Experiments |
|---|---|
| 1 | Deflection of a Simply Supported Beam |
| 2 | Verification of Maxwell's Reciprocal Theorem. |
| 3 | Determination of Young's Modulus using strain gages |
| 4 | Poisson Ratio Determination |
| 5 | Buckling load of slender Eccentric Columns and Construction of Southwell Plot |
| 6 | Shear Failure of Bolted and Riveted Joints |
| 7 | Bending Modulus of sandwich Beam |
| 8 | Verification of Superposition Theorem |
| 9 | Determination of fundamental frequency of a cantilever beam and harmonics. |
| 10 | Frequency spectrum analysis for a cantilever beam |
| 11 | Vibration induced structural damage studies. |
| 12 | Fault detection and de-lamination studies in composite plate. |

**Course outcomes (Course Skill Set):**

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

- Apply the basic concepts of stress and strain analysis.
- Understand different of types of loads on aerospace vehicles
- Analysis the bending stresses in unsymmetrical sections using different methods.

**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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 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 the IPCC (maximum marks 50)**

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.

- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

**CIE for the practical component of the IPCC**

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- 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 **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

**SEE for IPCC**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scoredby the student shall be proportionally scaled down to 50 Marks

**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 may include questions from the practical component**.

**Suggested Learning Resources:**

**Books**


1. V.B. Bhandari, 'Design of Machine Elements', Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.
2. Megson, T.M.G 'Aircraft Structures for Engineering Students', Edward Arnold, 1995.

Reference Books:

1. Robert L. Norton, Machine Design, Pearson Education Asia, 2001.
2. Donaldson, B.K., "Analysis of Aircraft Structures – An Introduction", McGraw-Hill, 1993.
3. Timoshenko, S., "Strength of Materials", Vol. I and II, Princeton D Von Nostrand Co, 1990.


**Web links and Video Lectures (e-Resources):**

- https://nptel.ac.in/courses/101105084

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| Unmanned Aerial Vehicles - Basics and Applications | | Semester | 5 |
|---|---|---|---|
| Course Code | **BAE503** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:2:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 04 | Exam Hours | 03 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Comprehend the basic aviation history and UAV systems.
- Acquire the knowledge of basic aerodynamics, performance, stability and control.
- Understand the propulsion, loads and structures.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Introduction**

Aviation History and Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology, UAV fundamentals , Examples of UAV systems-very small , small, Medium and Large UAV.

**Module-2**

**The Air Vehicle**

**Basic Aerodynamics:**

Basic Aerodynamics equations, Aircraft polar, the real wing and Airplane, Induced drag, the boundary layer, Flapping wings, Total Air-Vehicle Drag

**Performance:**

Overview, Climbing flight, Range and Endurance – for propeller driven aircraft, range- a jet-driven aircraft, Guiding Flight

**Module-3**

**Stability and Control**

Overview, Stability, longitudinal, lateral, dynamic stability, Aerodynamics control, pitch control, lateral control, Autopilots, sensor, controller, actuator, airframe control, inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.

**Module-4**

**Propulsion**

Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, Sources of Electrical Power

**Loads and Structures**

Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques

**Module-5**

**Mission Planning and Control:** Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch and Recovery Tradeoffs

**Course outcome (Course Skill Set)**

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

1. Apply the basic concepts of UAV systems.
2. Explain the basic aerodynamics, performance, stability and control required for UAV.
3. Select the propulsion system and materials for structures.

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Text Books**


1. Paul Gerin Fahlstrom , Thomas James Gleason, Introduction To UAV Systems, 4th Edition, Wiley Publication, 2012 John Wiley & Sons, Ltd
2. Landen Rosen, Unmanned Aerial Vehicle, Publisher: Alpha Editions, ISBN13: 9789385505034.


**Reference Books**


1. Unmanned Aerial Vehicles: DOD's Acquisition Efforts, Publisher: Alpha Editions, ISBN13: 9781297017544.
2. Valavanis, Kimon P., Unmanned Aerial Vehicles, Springer, 2011.
3. Valavanis, K., Vachtsevanos, George J., Handbook of Unmanned Aerial Vehicles, Springer, 2015.


**Web links and Video Lectures (e-Resources):**

- https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| Energy Conversion Lab | | Semester | 5 |
|---|---|---|---|
| Course Code | **BAEL504** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 0:0:2 | SEE Marks | 50 |
| Credits | 01 | Exam Hours | 100 |
| Examination type (SEE) | Practical | | |

**Course objectives:**

- Familiarize with the flash point, fire point and viscosity of lubricating oils.
- Energy conversion principles, analysis and understanding of I C Engines will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristic curves
- Understand the concept of design & process optimization of Engines.

| Sl.NO | Experiments |
|---|---|
| 1 | Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Pensky Martins Apparatus |
| 2 | Determination of Calorific value of solid, liquid and gaseous fuels |
| 3 | Determination of Viscosity of lubricating oil using Torsion viscometers |
| 4 | Valve Timing diagram of 4-stroke IC Engine |
| 5 | Calculation of work done and heat transfer from PV and TS diagram using Planimeter |
| 6 | Performance Test on Four stroke Petrol Engine and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet. |
| 7 | Performance Test on Multi-cylinder Engine (Morse test) and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet. |
| 8 | Performance Test on Four stroke Diesel Engine and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet. |
| | **Demonstration Experiments ( For CIE )** |
| 9 | Performance Test on variable compression ratio I C Engine |
| 10 | Performance Test on two stroke petrol Engine |
| 11 | Analysis of design & Development in Engines |
| 12 | Study of Process Optimization in Engines |

**Course outcomes (Course Skill Set):**

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

- Understand the flash point, fire point viscosity of lubricating oils
- Operate the instrument and measure the BP, FP, IP and AF ratio.
- Find the efficiency of the engine and Estimate the calorific value of the given fuel.
- Concept of design & optimization in Engines

**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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

**Continuous Internal Evaluation (CIE):**

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

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

- Each experiment is 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 are designed by the faculty who is handling the laboratory session and are 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 a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a 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 marks scored shall be 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 a test is the total CIE marks scored by the student.

**Semester End Evaluation (SEE):**

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of 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 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 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

**Suggested Learning Resources:**

- https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1208&context=mesp

| FINITE ELEMENT METHOD | | Semester | 5 |
|---|---|---|---|
| Course Code | **BAE515A/BAS515A** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Understand the importance of discretisation of domain using different finite elements
- Acquire the knowledge of different loading and boundary conditions
- Understand the governing methods of finite element analysis

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Introduction: Basic Concepts, Background Review:** Stresses and Equilibrium, Plane stress, Plane strain, Potential energy and Equilibrium. Rayleigh - Ritz Method, Galerkin's Method, Simple applications in structural Analysis. Construction or discrete models - sub domains and nodes - simple elements for the FEM - Simplex, complex and multiples elements Polynomial selection -illustrative examples Elements and shape functions and natural coordinates, Use of local and natural coordinates, compatibility and convergence requirements of shape functions.

**Module-2**

**Fundamentals of Finite Element Method**: Construction of shape functions for bar element and beam element, Bar elements, uniform bar elements, uniform section, mechanical and thermal loading, varying section, truss analysis, Frame element, Beam element, problems for various loadings and boundary conditions.

**Module-3**

**Analysis of Two and Three dimensional Elements:** Shape functions of Triangular, Rectangular and Quadrilateral elements, different types of higher order elements, constant and linear strain triangular elements, stiffness matrix Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family.

**Module-4**

**Theory of Isoparametric Elements and Axisymmetric:** Isoparametric, sub parametric and super-parametric elements, characteristics of Isoparametric quadrilateral elements, structure of computer program for FEM analysis, description of different modules, pre and post processing, Axisymmetric formulation finite element modeling of triangular and quadrilateral element.

**Module-5**

**Field Problems:** Heat transfer problems, Steady state fin problems, 1D heat conduction governing equation, Derivation of element matrices for two dimensional problems, Dynamic consideration- Formulation- Hamilton's principle, Element mass matrices.

**Course outcome (Course Skill Set)**

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

1. Apply discretisation technique for domain decomposition.
2. Evaluate the effects of different loading and boundary conditions
3. Analyze the governing equations of finite element analysis

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**

1. Chandrupatla T. R., "Finite Elements in engineering", PHI, 3rd edition, 2002, ISBN-13: 978-8120321069.
2. Bhavikatti, Finite element Analysis, New Age International,3rd edition,2015, ISBN-13: 978-8122436716

**Reference Books:**

1. 1.Rajasekharan. S - "Finite element analysis in engineering design", Wheeler Publishers
2. 2.Bathe. KJ, "Finite Element Procedures", PHI Pvt. Ltd., New Delhi,1996, ISBN-13: 978-8126529988
3. 3.Zienkiewicz. O.C. - "The Finite Element Method", Elsevier,7th edition,2013, ISBN-13: 978-9351071587
4. 4.Rao S. S., "Finite Elements Method in Engineering", Elsevier,5th edition, 2008, ISBN-13: 978-9380931555
5. 5.C.S. Krishnamurthy - "Finite Element analysis - Theory and Programming", Tata McGraw Hill Co. Ltd, New Delhi,2nd edition,2011,ISBN-13: 978-0074622100.

**Web links and Video Lectures (e-Resources):**

- https://archive.nptel.ac.in/content/syllabus_pdf/105105041.pdf

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| ROCKETS & MISSILES | | Semester | 5 |
|---|---|---|---|
| Course Code | **BAE515B** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Understand the types of space launch vehicles and missiles.
- Study the solid and liquid rocket motors.
- Acquire the knowledge on launch vehicle dynamics, attitude control, rocket testing and materials.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT.
2. Assignment of Home/field work on real-life problem.
3. Adoption of Project-based/Activity Based learning.
4. Practising the foundational knowledge.

**Module-1**

**Introduction**: Space launch Vehicles and military missiles, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation, similarities and differences. Some famous space launch vehicles and strategic missiles.

**Module-2**

**Solid Propellant Rocket Motor Systems:** Solid Propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, preparation, loading, structural design of grain. Liners, insulators and inhibitors, function, requirements, materials. Rocket motor casing – materials. Nozzles, types, design, construction, thermal protection. Igniters, types, construction. Description of modern solid boosters I) Space Shuttle SRB, II)the Arienne SRB

**Liquid Propellant Rocket Motor Systems:** Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build up, system calibration, integration and optimisation – safety and environmental concerns. Description of the space shuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines.

**Module-3**

**Aerodynamics of Rockets and Missiles:** Classification of missiles. Airframe components of rockets and missiles, Forces acting on a missile while passing through atmosphere, method of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion, re-entry body design considerations.

**Module-4**

**Launch Vehicle Dynamics:** Tsiolskovsky's rocket equation, range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging. Earth launch trajectories – vertical segment, the gravity turn, constant pitch trajectory, orbital injection. Actual launch vehicle trajectories, types. Examples, the Mu 3-S-II, Ariane, Pegasus launchers. Reusable launch vehicles, future launchers, launch assist technologies.

**Attitude Control of Rockets and Missiles:** Rocket Thrust Vector Control – Methods of Thrusts Vector Control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; stage separation dynamics, separation techniques.

**Module-5**

**Rocket Testing**: Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground Testing, Flight Testing, Trajectory monitoring, post -accident procedures. Description of a typical space launch vehicle launch procedure.
**Materials:** Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for thermal protection and for pressure vessels.

**Course outcome (Course Skill Set)**

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

1. Identify the types of space launch vehicles and missiles.
2. Distinguish the solid and liquid propellant motors.
3. Classify different types of materials used for rockets and missies.

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**


1. George P Sutton and Oscar Biblarz, 'Rocket Propulsion Element', John Wiley and Sons Inc, 7th edition, 2010, ISBN-13: 978-8126525775.
2. Jack N Neilson,' Missile Aerodynamics' ,AIAA, 1st edition, 1988, ISBN-13: 978-0962062902.


Reference Books:


1. S S Chin, 'Missile Configuration Design'.

2. Cornelisse, J.W., Schoyer H.F.R. and Wakker,. K.F., Rocket Propulsion and Space-Flight Dynamics, Pitman, 1979,ISBN-13: 978-0273011415
3. Turner, M.J.L., Rocket and Spacecraft propulsion, Springer,3rd edition,2010,ISBN-13: 978-3642088698.
4. Ball, K.J., Osborne, G.F., Space Vehicle Dynamics, Oxford University Press, 1967,ISBN-13:978-0198561071
5. Parker, E.R., Materials for Missiles and Spacecraft, McGraw Hill, 1982.

**Web links and Video Lectures (e-Resources):**

- https://www.britannica.com/technology/rocket-and-missile-system
- https://aticourses.arlo.co/w/courses/101-rockets-missiles-fundamentals
- https://www.nasa.gov/pdf/635963main_RocketsPeopleVolume2-ebook.pdf
- http://nptel.ac.in/courses/112106073/

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| HELICOPTER DYNAMICS | | Semester | 5 |
|---|---|---|---|
| Course Code | **BAE515C** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Comprehend the basic concepts of helicopter dynamics.
- Acquire the knowledge of critical speed and rotor bearing system.
- Understand the turbo rotor system and blade vibration.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Introduction:** History of helicopter flight. Fundamentals of Rotor Aerodynamics; Momentum theory analysis in hovering flight. Disk loading, power loading, thrust and power coefficients. Figure of merit, rotor solidity and blade loading coefficient. Power required in flight. Axial climb, descent, and autorotation.

**Blade Element Analysis:** Blade element analysis in hovering and forward flight. Rotating blade motion. Types of rotors. Concept of blade flapping, lagging and coning angle. Equilibrium about the flapping hinge, lead/lag hinge, and drag hinge.

**Module-2**

**Basic Helicopter Performance:** Forces acting on helicopters in forward flight. Methods of achieving translatory flight. Controlling cyclic pitch: Swash-plate system. Lateral tilt with and without conning. Lateral and longitudinal asymmetry of lift in forward flight. Forward flight performance- total power required, effects of gross weight, effect of density altitude. Speed for minimum power, and speed for maximum range. Factors affecting forward speed, and ground effects.

**Module-3**

**Rotor Airfoil Aerodynamics:** Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics, high angle of attack range.

**Rotor Wakes and Blade Tip Vortices:** Flow visualization techniques, Characteristics of rotor wake in hover, and forward flight. Other characteristics of rotor wake.

**Module-4**

**Helicopter Stability and Control:** Introductory concepts of stability. Forward speed disturbance, vertical speed disturbance, pitching angular velocity disturbance, side-slip disturbance, yawing disturbance. Static stability of helicopters: longitudinal, lateral-directional and directional. Dynamic stability aspects. Main rotor and tail rotor control. Flight and Ground Handling Qualities-General requirements and definitions. Control characteristics, Levels of handling qualities.

**Flight Testing:** General handing flight test requirements and, basis of limitations.

**Module-5**

**Standards, and Specifications:** Scope of requirements. General and operational requirements. Military derivatives of civil rotorcraft. Structural strength and design for operation on specified surfaces. Rotorcraft vibration classification.

**Conceptual Design of Helicopters:** Overall design requirements. Design of main rotors-rotor diameter, tip speed, rotor solidity, blade twist and aerofoil selection, Fuselage design, Empennage design, Design of tail rotors, High speed rotorcraft.

**Course outcome (Course Skill Set)**

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

1. Apply the basic concepts of helicopter dynamics.
2. Compute the critical speed by using various methods.
3. Distinguish the turbo rotor system stability by using transfer matrix and finite element formulation.

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**


1. J. Gordon Leishman, Principles of Helicopter Aerodynamics, Cambridge University Press, 2002.
2. George H. Saunders, Dynamics of Helicopter Flight, John Wiley & Sons, Inc, NY,1975.


**Reference Books**


1. W Z Stepniewski and C N Keys, Rotary Wing Aerodynamics, Dover Publications, Inc, New York, 1984.
2. ARS Bramwell, George Done, and David Balmford, Helicopter Dynamics, 2nd Edition, Butterworth-Heinemann Publication, 2001.
3. John, M. Seddon and Simon Newman, Basic Helicopter Aerodynamics, Wiley, 2011.
4. Gareth D. Padfield, Helicopter Flight Dynamics, 2nd Edition, Wiley, 2011.


**Web links and Video Lectures (e-Resources):**

- https://nptel.ac.in/courses/101104017

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| INDUSTRIAL & EXPERIMENTAL AERODYNAMICS | | Semester | 5 |
|---|---|---|---|
| Course Code | **BAE515D** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 03 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Understand the basics of experimental aerodynamics.
- Understand the procedures for model measurements.
- Understand the aerodynamics of different shaped bodies & wind tunnel correction techniques

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Wind Energy Collectors:** Horizontal axis and vertical axis machines. Power coefficient. Betz coefficient by momentum theory.

**Vehicle Aerodynamics:** Power requirements and drag coefficients of automobiles. Effects of cut back angle. Aerodynamics of Trains and Hovercraft.

**Module-2**

**Building Aerodynamics:** Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city blocks, Special problems of tall buildings, building codes, building ventilation and architectural aerodynamics.

**Flow Induced Vibrations:** Effects of Reynolds number on wake formation of bluff shapes, Vortex induced vibrations, Galloping and stall

**Module-3**

**Model Measurements:** Balances: - design, installation and, calibration. Internal balances. Mounting of models, rigidity. Measurement of interference. Lift and drag measurements through various techniques. Testing procedures. Testing:- 3-D wings, controls, complete model, power effects, aero elasticity, dynamic stability. Testing with ground plane, testing wind mill generator. Testing for local loads. Testing of rotor. Testing engines, Jettison tests. Data reduction. Data correction.

**Module-4**

**Aerodynamics of Slender and Blunt Bodies:** Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles- determination of aero elastic effects.

**Module-5**

**Wind Tunnel Boundary Corrections and Scale Effects:** Effects of lateral boundaries. Method of images. Wall corrections. Effects of Buoyancy, Solid Blocking, Wake Blocking. General downwash correction. Lift interference correction. Corrections for reflection plane models. Scale effects on aerodynamic characteristics and stability derivatives

**Course outcome (Course Skill Set)**

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

1. Distinguish the building and vehicle aerodynamics.
2. Evaluate the boundary corrections and scale effects.
3. Evaluate the aerodynamics of different shaped bodies & wind tunnel correction techniques

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Text Books**


1. Jewel B. Barlow, William H RAE, Jr. and Alan Pope, ' Low speed Wind Tunnel Testing', John Wiley & Sons,3rd edition,2010,ISBN-13: 978-8126525683
2. M. Sovran (Ed), "Aerodynamics and drag mechanisms of bluff bodies and road Text Vehicles", Plenum press, New York, 1978.


**Reference Books:**


1. P. Sachs, "Winds forces in engineering", Pergamon Press, 2nd edition, 2013.
2. R.D. Blevins, "Flow induced vibrations", Van Nostrand, 1990.
3. N.G. Calvent, "Wind Power Principles", Calvert Technical Press, 2nd edition, 2004, ISBN-13: 978-0951362068.
4. Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., New York 1999


**Web links and Video Lectures (e-Resources):**

- https://archive.nptel.ac.in/courses/101/105/101105088/
- http://acl.digimat.in/nptel/courses/video/101105088/L01.html

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| Composite Materials & Structures | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE601** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:2:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40 hours Theory + 8-10 Lab slots | Total Marks | 100 |
| Credits | 04 | Exam Hours | 3 |
| Examination nature (SEE) | Theory | | |

**Course objectives:**

- Identify and differentiate amongst various types of composite materials and their constituents.
- Investigate the composite materials using micromechanics and macro mechanics approach.
- Analyse composite laminates using Classical Lamination theory.
- Understand the basic design concepts of sandwich construction and Materials used for sandwich construction, Failure modes of sandwich panels.
- Know various fabrication processes of composite materials. Manufacturing techniques of fibres - Types of resins and properties and applications

**Teaching-Learning Process (General Instructions)**

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**MODULE-1**

**Stress and Strain Relation:**

Introduction, Classification and Application to composite materials, Generalised Hooke's Law - Elastic constants for anisotropic, orthotropic and isotropic materials.

**MODULE-2**

**Method of Analysis:**

Micro mechanics - Mechanics of materials approach, elasticity approach to determine material properties - Macro Mechanics - Stress-strain relations with respect to natural axis, arbitrary axis.

**MODULE-3**

**Laminate Plates:**

Governing differential equation for a general laminate, Stacking sequences in laminate - Failure criteria for composites.

**MODULE-4**

**Sandwich Structures:**

Basic design concepts of sandwich construction - Failure modes of sandwich panels – Application and testing of sandwich structures.

**MODULE-5**

**Fabrication Process:**

Hand layup Process, Vacuum Bagging Process, Post Curing Process, Filament winding, Pultrusion, Pulforming, Autoclave Process Extrusion process, Injection Moulding Process, Thermo-forming process. Post Processing of Composites – Adhesive bonding, drilling, cutting processes. Netting analysis.

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

| Sl.NO | Experiments |
|---|---|
| 1 | Fabrication of Composite plate using Hand layup method. |
| 2 | Fabrication of Composite plate using Vacuum infusion method. |
| 3 | Fabrication of Composite plate using Compression Molding Technique. |
| 4 | Measurement of major constituent fraction by Burnout method using Muffle furnace. |
| 5 | Carry out the tensile test of the prepared composite specimen as per the ASTM procedure. |
| 6 | Carry out three point bending test of the composite specimen as per ASTM procedure. |
| 7 | Carry out shear test of the composite specimen as per ASTM procedure. |
| 8 | Perform single lap joint strength test as per the ASTM procedure. |
| 9 | Perform double lap joint strength test as per the ASTM procedure. |
| 10 | Perform double strap butt joint strength test as per the ASTM procedure. |
| 11 | Perform the low velocity projectile impact test. |
| 12 | Determine the critical buckling loads for given specimen using Buckling Test. |

**Course outcomes (Course Skill Set):**

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

- Differentiate amongst various types of composite materials and their constituents.
- Understand the composite materials using micro and macro mechanics approach.
- Examine composite laminates using Classical Lamination theory.
- Assess the basic design concepts of sandwich construction & Failure modes.
- Various fabrication processes of composite materials.

**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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 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 the IPCC (maximum marks 50)**

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the

theory component of IPCC (that is for **25 marks)**.

- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

**CIE for the practical component of the IPCC**

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- 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 **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

**SEE for IPCC**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scoredby the student shall be proportionally scaled down to 50 Marks

**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 may include questions from the practical component**.

**Suggested Learning Resources:**

**Text Books**

1. Calcote, L R. "The Analysis of laminated Composite Structures", Von - Nostrand Reinhold Company, New York 1991.
2. Jones, R.M., "Mechanics of Composite Materials", 2nd Edition McGraw-Hill, 1999.
3. Ronald F. Gibson., "Principles of composite material and mechanics" 2nd Edition Taylor and Francis group 2007.

**Reference Books:**

1. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons.Inc., New York, 1995.
2. Lubin, G., "Handbook on Advanced Plastics and Fibre Glass", Von Nostrand Reinhold Co., New York, 1991

**Web links and Video Lectures (e-Resources):**

- https://www.springer.com/in/book/9780387743646
- http://www.engbrasil.eng.br/artigos/art19.pdf
- https://www.mooc-list.com/tags/composite-structures

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| Aircraft Performance and Stability | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE602** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:2:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 50hrs | Total Marks | 100 |
| Credits | 04 | Exam Hours | 03 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Understand the aircraft performance in steady unaccelerated and accelerated flight.
- Understand the airplane performance parameters and Acquire the knowledge on aircraft maneuvers performance.
- Understand the basics of aircraft stability and control
- Understand the static longitudinal and static directional stability.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**The Equations of Motion Steady Unaccelerated Flight**

Introduction, four forces of flight, General equation of motion, Power available and power required curves. Thrust available and thrust required curves. Conditions for power required and thrust required minimum. Thrust available and maximum velocity, Power available and maximum velocity, Altitude effects on power available and power required; thrust available and thrust required.

**Steady Performance – Level Flight, Climb & Glide**

Performance: Equation of motion for Rate of climb- graphical and analytical approach -Absolute ceiling, Service ceiling, Time to climb – graphical and analytical approach, climb performance graph (hodograph diagram); maximum climb angle and rate of climb Gliding flight, Range during glide, minimum rate of sink and shallowest angle of glide.

**Module-2**

**Fundamental Airplane Performance Parameters**

The fundamental Parameters: Thrust – to – weight ratio, Wing loading, Drag polar, and lift-to – drag ratio. Minimum velocity. Aerodynamic relations associated with lift-to-drag ratio.

**Range and Endurance:**

**Propeller driven Airplane:** Physical consideration, Quantitative formulation, Breguet equation for Range and Endurance, Conditions for maximum range and endurance.

**Jet Airplane:** Physical consideration, Quantitative formulation, Equation for Range and Endurance, Conditions for maximum range and endurance, Effect of head wind tail wind.

**Module-3**

**Aircraft Performance in Accelerated Flight**

**Take-off Performance:** Calculation of Ground roll, Calculation of distance while airborne to clear obstacle, Balanced field length

**Landing Performance and Accelerated Climb:** Calculation of approach distance, Calculation of flare distance, Calculation of ground roll, ground effects. Acceleration in climb.

**Maneuvers Performance**

**Turning performance:** Level turn, load factor, Constraints on load factor, Minimum turn radius, Maximum turn rate. Pull-up and Pull-down maneuvers: (Turning rate, turn radius). Limiting case for large load factor. The V-n diagram. Limitations of pull up and push over.

**Module-4**

**Static Longitudinal Stability and Control-Stick Fixed**

Historical perspective, Aerodynamic Nomenclature, Equilibrium conditions, Definition of static stability, Definition of longitudinal static stability, stability criteria, Contribution of airframe components: Wing contribution, Tail contribution, Fuselage contribution, Power effects- Propeller airplane and Jet airplane Introduction, Trim condition. Static margin. Stick fixed neutral points. Longitudinal control, Elevator power, Elevator angle versus equilibrium lift coefficient, Elevator required for landing, Restriction on forward C.G. range.

**Module-5**

**Static Longitudinal Stability& Static Directional Stability and Control-Stick free**

Introduction, Hinge moment parameters, Control surface floating characteristics and aerodynamic balance, Estimation of hinge moment parameters, The trim tabs, Stick-free Neutral point, Stick force gradient in unaccelerated flight, Restriction on aft C.G. Introduction, Definition of directional stability, Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin. One engine inoperative condition. Weather cocking effect.

**Course outcome (Course Skill Set)**

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

1. Apply the basic airplane performance parameters.
2. Differentiate the aircraft performance in steady unaccelerated and accelerated flight.
3. Apply the basic concepts of aircraft stability and control.
4. Differentiate the static longitudinal and static directional stability.

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Text Books**


1. John D. Anderson, Jr. "Aircraft Performance and Design", McGraw-Hill International Editions, Aerospace Science/ Technology Editions, 1999.
2. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill International Editions, Aerospace Science/ Technology Editions, 2000.
3. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.
4. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2007.


**Reference Books**


1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.
2. Barnes W. McCormick, ` Aerodynamics, Aeronautics, and Flight Mechanics`, John Wiley& Sons, Inc. 1995.
3. Bandu N. Pamadi, `Performance, Stability, Dynamics and Control of Airplanes`, AIAA 2nd Edition Series, 2004.
4. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill, International Editions, Aerospace Science Technology Editions, 2000.
5. W.J. Duncan, The Principles of the Control and Stability of Aircraft, Cambridge University Press, 2016.


**Web links and Video Lectures (e-Resources):**

https://nptel.ac.in/courses/101104062
https://nptel.ac.in/courses/101104007

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| Flight Vehicle Design | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE613A** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Comprehend the flight vehicle design process.
- Acquire the knowledge of vehicle configuration and structural components.
- Understand the stability & control and subsystems.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Overview of Design Process:** Introduction, Requirements, Phases of design, Conceptual Design Process, Initial Sizing, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take- off weight calculation. **Thrust to Weight Ratio & Wing Loading:** Thrust to Weight Definitions, Statistical Estimate of T/W. Thrust matching, Spread sheet in design, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult take-off, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance, Instantaneous Turn rate, Sustained Turn rate, Climb, & Glide, Maximum ceiling.

**Module-2**

**Configuration Layout & loft:** Conic Lofting, Conic Fuselage Development, Conic Shape Parameter, Wing-Tail Layout & Loft. Aerofoil Linear Interpolation. Aerofoil Flat-wrap Interpolation. Wing aerofoil layout-flap wrap. Wetted area determination. Special considerations in Configuration Layout: Aerodynamic, Structural, Detectability. Crew station, Passenger, and Payload arrangements.

**Design of Structural Components:** Fuselage, Wing, Horizontal & Vertical Tail. Spreadsheet for fuselage design. Tail arrangements, Horizontal & Vertical Tail Sizing. Tail Placement. Loads on Structure. V-n Diagram, Gust Envelope. Loads distribution, Shear and Bending Moment analysis.

**Module-3**

**Engine Selection & Flight Vehicle Performance**

Turbojet Engine Sizing, Installed Thrust Correction, Spread Sheet for Turbojet Engine Sizing. Propeller Propulsive System. Propeller design for cruise. Take-off, Landing & Enhanced Lift Devices: - Ground Roll, Rotation, Transition, Climb, Balanced Field Length, Landing Approach, Braking, Spread Sheet for Take-off and Landing. Enhanced lift design -Passive & Active. Spread Sheet.

**Module-4**

**Static Stability & Control**

Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe components on Static Stability. Lateral stability. Contribution of Airframe components. Directional Static stability. Contribution of Airframe components. Aileron Sizing, Rudder Sizing. Spread Sheets. Flying qualities. Cooper Harper Scale. Environmental constraints, Aerodynamic requirements.

**Module-5**

**Design Aspects of Subsystems**

Flight Control system, Landing Gear and subsystem, Propulsion and Fuel System Integration, Air Pressurization and Air Conditioning System, Electrical & Avionic Systems, Structural loads, Safety constraints, Material selection criteria.

**Course outcome (Course Skill Set)**

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

1. Calculate the thrust to weight ratio and wing loading.
2. Compute the flight vehicle performance.
3. Select the subsystems as per vehicle design.

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
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- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**

Text Books

1. Daniel P. Raymer, Aircraft Design - A Conceptual Approach- AIAA Education Series, IV Edition, 2006.
2. Thomas C Corke, Design of Aircraft- Pearson Edition. Inc. © 2003.

Reference Books

1. J Roskam, Aeroplane Design –Vol: 1 to 9.
2. John Fielding, Introduction to Aircraft Design - Cambridge University Press, 2009.
3. Standard Handbook for Aeronautical & Astronautical Engineers, Editor Mark Davies, Tata McGraw Hill, 2010.

**Web links and Video Lectures (e-Resources):**

- https://nptel.ac.in/courses/101104069

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| AIRFRAME STRUCTURAL DESIGN | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE613B** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Understand the concepts of open and closed thin walled beams.
- Acquire the knowledge of buckling of plates, joints and fittings.
- Comprehend the stress analysis on wings and fuselage.
- Able to understand the structural impact of rigid bodies

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Shear and Torsion of Open and Closed Thin Walled Beams-** General stress, strain, and displacement relationship for open and single-cell closed section thin-walled beams, shear of open section beams, shear centre, shear of closed section beams. Torsion of close section beam, and displacement associated with the Bredt-Batho shear flow. Torsion of open section beam. Combined bending, shear, torsion.

**Module-2**

**Buckling of Plates, Joints and Fittings**

Buckling of Isotropic flat plates in compression, ultimate compressive strength of Isotropic flat sheet, plastic buckling of flat sheet, columns subjected to local crippling failure, Needham & Gerard method for determining crippling stress, curved sheets in compression, elastic buckling of curved rectangular plates. Pure tension field beams, angle of diagonal tension in web.

**Joints and Fittings-** bolted or riveted joints, accuracy of fitting analysis, eccentrically loaded connections, welded joints, and concept of effective width.

**Module-3**

**Design Criteria and Structural Idealization**

Design Criteria, Safety Factor, Design life criteria, Analysis method, Life Assessment procedures, Design Principle, Two bay crack criteria, Widespread Fatigue damage.

**Structural Idealization**

Structural idealization Principle, Idealization of a panel, effect of idealization on the analysis of open and closed section beams. Bending of open and closed section idealized beams, shear of open section and closed section idealized beams. Deflection of open and closed section idealized beams.

**Module-4**

**Stress Analysis in Wing Spars and Box beams**

Tapered wing spar, open and closed section beams, beams having variable stringer areas, three- boom shell, torsion and shear, tapered wings, cut-outs in wings.

**Stress Analysis in Fuselage Frames**

Bending, shear, torsion, cut-outs in fuselages, principles of stiffeners construction, fuselage frames, shear flow distribution.

**Module-5**

**Introduction to Structural Impact**

Introduction to Structural Impact, Rigid Body Impact Mechanics, Coefficient of Restitution, Oblique Impact, One Dimensional Impact Mechanics of Deformable Bodies,1-D Wave Propagation in Solids Induced by Impact.

**Course outcome (Course Skill Set)**

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

1. Utilize the concepts of thin walled beams.
2. Calculate the buckling of plates.
3. Analysis the stress in wings and fuselage frames.
4. Comprehend the structural impact of rigid bodies

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**

1. Megson, T. H. G, Aircraft Structures for Engineering Students, Edward Arnold, 1995
2. Peery D J & Azar J J, Aircraft Structures, McGraw Hill N.Y, 2nd edition,1993
3. W.J.Stronge, Impact Mechanics, Cambridge University Press January 2010 doi.org/10.1017/CBO9780511626432

**Reference Books**

1. Bruhn E. F, Analysis & Design of Flight Vehicles Structures, Tri-State offset Co, USA, 1985
2. Megson, T. H. G, Introduction to Aircraft Structural Analysis, Elsevier, 2nd Edition, 2014

**Web links and Video Lectures (e-Resources):**

- https://www.mooc-list.com/course/engineering-mechanics-coursera

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| Guidance & Navigation | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE613C** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Comprehend the basic concepts of navigation, guidance and control.
- Acquire the knowledge of radar systems and other guidance systems.
- Understand the missile guidance and control system.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Introduction**

Concepts of navigation, guidance and control. Introduction to basic principles. Air data information.

**Radar Systems**

Principle of working of radar. MTI and Pulse Doppler radar. Moving target detector. Limitation of MTI performance. MTI from a moving platform (AMTI).

**Module-2**

**Tracking with Radar**

Mono pulse tracking. Conical scan and sequential lobbing. Automatic tracking with surveillance radar (ADT).

**Other Guidance Systems**

Gyros and stabilized platforms. Inertial guidance and Laser based guidance. Components of Inertial Navigation System. Imaging Infrared guidance. Satellite navigation. GPS.

**Module-3**

**Transfer Functions**

Input-output Transfer function. Basic altitude reference. Concepts of Open loop and Close Loop.

**Missile Control System**

Guided missile concept. Roll stabilization. Control of aerodynamic missile. Missile parameters for dynamic analysis. Missile autopilot schematics. Acceleration command and root locus.

**Module-4**

**Missile Guidance**

Proportional navigation guidance; command guidance. Comparison of guidance system performance. Bank to turn missile guidance

**Module-5**

**Integrated Flight/Fire Control System**

Director fire control system. Tracking control laws. Longitudinal flight control system. Lateral flight control system. Rate of change of Euler angle, Auto Pilot.

**Course outcome (Course Skill Set)**

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

1. Apply the basic concepts of navigation, guidance and control.
2. Compare the different types of missile guidance system performance.
3. Integrate the flight and fire control system.

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**

Text Books:


1. P.T. Kabamba and A.R. Girard, Fundamentals of Aerospace Navigation and Guidance, Cambridge Aerospace Series, 2014
2. Merrilh I. Skolnik,' Introduction to Radar Systems', 3rd edition, Tata Mc Graw Hill , 2001.
3. John H Blakelock,' Automatic control of Aircraft & Missiles', Wile – Inter Science Publication, 2nd edition, May 1990.
4. R.B. Underdown & Tony Palmer, 'Navigation', Black Well Publishing; 2001.


**Web links and Video Lectures (e-Resources):**

- https://archive.nptel.ac.in/courses/101/108/101108056/
- https://ocw.mit.edu/courses/16-885j-aircraft-systems-engineering-fall-2005/resources/lecture-16/

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| Vibration & Aeroelasticity | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE613D** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Understand the basics of vibrations and simple harmonic motion.
- Differentiate types of vibrations according to dampness and particle motion.
- Clearly understand the need of a multi degree of freedom particle and its characteristics.
- Solve various methods to find natural frequency of an object.
- Understand the formation of Aileron reversal, flutter and wing divergence.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Basic Notions:** Simple harmonic motion - Terminologies - Newton's Law - D' Alembert's principle - Energy Methods

**Module-2**

**Single Degree of Freedom Systems**

Free vibrations - Damped vibrations - Forced Vibrations, with and without damping - support excitation - Vibration measuring instruments.

**Module-3**

**Multi Degrees of Freedom Systems**

Two degrees of freedom systems - Static and Dynamic couplings vibration absorber- Principal coordinates, Principal modes and orthogonal condition - Eigen value problems.

Hamilton's principle- Lagrangean equation and application - Vibration of elastic bodies- Vibration of strings- Longitudinal, Lateral and Torsional vibrations.

**Module-4**

**Approximate Methods**

Method of matrix iteration-Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle. Holzer's method, Stodola method.

**Module-5**

**Elements of Aeroelasticity:**

Concepts - Coupling - Aero elastic instabilities and their prevention - Basic ideas on wing divergence, loss and reversal of aileron control - Flutter and its prevention.

**Course outcome (Course Skill Set)**

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

1. Apply the principle of super position to Simple Harmonic Motions.
2. Determine the types of vibrations according to dampness and particle motion.
3. Analyze the need of a multi degree of freedom particle and its characteristics.
4. Apply various methods to find natural frequency of an object.
5. Analyze the formation of Aileron reversal, flutter and wing divergence.

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**

**Text Books**


1. TIMOSHENKO S., "Vibration Problems in Engineering"- John Wiley and Sons, New York, 1993.
2. FUNG Y.C., "An Introduction to the Theory of Aeroelasticity" - John Wiley & Sons, New York, 1995


**Reference Books**


1. BISPLINGHOFF R.L., ASHELY H and HOGMAN R.L., "Aeroelasticity" - Addision Wesley Publication, New York.
2. TSE. F.S., MORSE, I.F., HUNKLE, R.T., "Mechanical Vibrations", - Prentice Hall, New York,
3. SCANLAN R.H. & ROSENBAUM R., "Introduction to the study of Aircraft Vibration &Flutter", John Wiley and Sons. New York.
4. BENSON H.TONGUE, "Principles of Vibration", Oxford University Press, 2000.


**Web links and Video Lectures (e-Resources):**

- https://nptel.ac.in/courses/101104005/
- https://nptel.ac.in/courses/112106072/
- https://www.acessystems.com/fundamentals-series-aviation-vibration/

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| INTRODUCTION TO AEROSPACE HISTORY | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE654A/BAS654A** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Learn the history and chronology of aviation and its development
- Understand the basic flight mechanics
- Compare the historical developments in aviation

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

Aerospace History, The first decade, World War I, Between the Wars, the advent of jets and missiles, the space age, growth of the aircraft industry, cooperation and consolidation in a global economy, The First Aeronautical Engineers, Internationalization, Mergers and divestitures

**Module-2**

The Aeronautical Triangle, The problem of Propulsion, Fundamental Physical Quantities of Flowing Gas, The source of all aerodynamics forces, Anatomy of Airplane, The NACA and NASA, The Standard Atmosphere, Basic Aerodynamics, Continuity, Momentum and Energy Equations

**Module-3**

Elementary Thermodynamics, Introduction to viscous flow, Historical Notes- Reynolds and His Number, Airfoils, Wings and Other Aerodynamic shapes

**Module-4**

Elements of Airplane Performance, Rate of Climb, Range and Endurance- Propeller-driven Airplane and Jet Airplane

**Module-5**

Principles of Stability and Control, History Note: The development of Flight Controls, Jet Propulsion

**Course outcome (Course Skill Set)**

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

1. Appreciate the history and chronology of aviation and its development
2. Apply the basic flight mechanics
3. Prepare for the new developments in aviation

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Text Books**

1. Flight: The Complete History of Aviation by R.G. Grant (Author), Smithsonian Institution (Contributor)
2. Introduction to Flight: Its Engineering and History by JD Anderson

**Reference Books**

1. Aviation History by Anne Marie Millbrooke
2. A Chronology of Aviation: A Day-by-day History of a Century by Jim Winchester

**Web links and Video Lectures (e-Resources):**

- https://archive.nptel.ac.in/courses/101/104/101104017/

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| INTRODUCTION TO HELICOPTERS | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE654B/BAS654B** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Understand the basic elements, kinematics of helicopter.
- Remember the equations of motions for helicopter.
- Gain knowledge on aerodynamics of propeller.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

Introduction, Elements of a helicopter, Performance, Components, Vectors and Vector Resolutions.

**Module-2**

Axis Systems, Kinematics and Flight Dynamics, Quaternions, Mass Properties, Equations of Motion.

**Module-3**

Applied forces and moments, Longitudinal Equations of Motion, Atmosphere, Bernoulli's Equation, Compressibility and Wing lift, Wing Drag.

**Module-4**

Aerodynamic Velocity, Inertial Velocity, Wash Velocity, and Gusts, Aerodynamics of Airfoils, Wings, and Fins.

**Module-5**

Aerodynamics of Propellers, Propeller Analysis, Introduction to Aeroelastic Rotor Models, Rotor Downwash Modelling, Aerodynamic Interference, Engines Drive Trains, Controls, Landing Gear, Trimming.

**Course outcome (Course Skill Set)**

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

1. Apply the basic elements, kinematics of helicopter.
2. Analyse the equations of motions for helicopter.
3. Implement aerodynamics of propeller.

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Text Books**

1. Introduction to Helicopter Aerodynamics by Wieslaw Zenon Stepniewski.
2. Fundamentals of Helicopter Dynamics by C. Venkatesan.

**Reference Books**

1. Basic Helicopter Aerodynamics by J Seddon.

**Web links and Video Lectures (e-Resources):**

- https://archive.nptel.ac.in/courses/101/104/101104017/

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| INTRODUCTION TO UAV | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE654C** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Comprehend the basic evolution of Drones / UAV systems.
- Acquire the knowledge of basic aerodynamics, performance, stability and control.
- Understand the propulsion, loads and structures.
- Understand Regulations and Certification aspects

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

**Basics: I**ntroduction, History, UV types: UGV, UAV, USV, UUWV, Drones in India, Future scope.
Introduction to nano drones and Swarm Drones
Principles, Newton's Laws, Degrees of Freedom, Stick Movements, Flight Modes, Basic Manoeuvres, Take-off, Pitch, Roll, Yaw, Landing.

**Module-2**

**Components and Systems:** Basic components, Micro controllers, microprocessors, Sensors, Pre-Flight Checks, Flight Planning, Transmitter, Receiver.
Introduction to Arduino Sensors, Program Structures, Flight Controllers, Telemetry, Mission Planning, Camera, Binding, etc

**Module-3**

**Air Worthiness**: DGCA Rules and Regulations, Pilot Licensing requirements, NPNT Compliance. Certifications.

**Module-4**

**Basics of Structures:** Configurations, Payload Configurations, Design Considerations.

**Basics of Propulsion:** Batteries, Hybrid Propulsions, IC Engines, Mini Turbines, Solar,

**Module-5**

Tuning, Testing, Manufacturing Constraints, Simulator Training, Applications
CASE Studies:
Construction and testing of a basic drone.

**Course outcome (Course Skill Set)**

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

1. Apply the basic concepts of UAV systems.
2. Explain the basic aerodynamics, performance, stability and control required for UAV.
3. Select the propulsion system and materials for structures.
4. Understand Regulatory and Certification aspects

## 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Books**


1. Introduction to UAV Systems Paul Gerin, Fahlstrom, Thomas James Wiley Publication 4th Edition,2012
2. Unmanned Aerial Vehicles: DOD's Acquisition Efforts Alpha Editions.
3. Handbook of Unmanned Aerial Vehicles Valavanis, K., Vachtsevano S, George J Springer


**Web links and Video Lectures (e-Resources):**

- https://onlinecourses.nptel.ac.in/noc22_ae15/preview
- https://onlinecourses.nptel.ac.in/noc22_ae16/preview

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| INTRODUCTION TO FLIGHT SIMULATOR | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE654D** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 40hrs | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |
| Examination type (SEE) | Theory | | |

**Course objectives:** This course will enable students to

- Understand the basic principle of working of flight components
- Remember the names of components and their functions
- Think to simulate a flight

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

Historical Perspectives, The case for simulation, Engineering Flight Simulation, The changing role of simulation,

**Module-2**

The organisation of flight simulator, Equation of Motion, Aerodynamic model, Engine Model, Engine model, data acquisition model, Gear Model , weather model, Visual System, Sound System, Motion System, Controls, Instrument Display, Navigation Systems, Maintenance

**Module-3**

Principles of Flight Modeling , Newtonian Mechanics, Differential Equations, Numerical Integration, Real-time computing, Flight Data

**Module-4**

The atmosphere, forces, moments, Axes System, Quaternions, Equations of Motions, propulsion-Piston Engine, Jet Engine, the landing gear

**Module-5**

Simulation of flight control systems, the Laplace transform, PID control systems, Trimming, Aircraft Displays, Attitude Indicator, Altimeter, Airspeed Indicator, compass card, Automatic Direction Finding(ADF), VHF omnidirectional Range(VOR), Distance Measuring Equipment(DME),Instrument Landing Systems(ILS), GPS, Inertial Navigation System

**Course outcome (Course Skill Set)**

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

1. Apply the basic principle of working of flight components
2. Practise the names of components and their functions
3. Simulate a 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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous Internal Evaluation:**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester-End Examination:**

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

1. The question paper will have ten questions. Each question is set for 20 marks.
2. 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.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

**Suggested Learning Resources:**

**Text Books**

1. Principles of Flight Simulation by David Allerton, Wiley Publisher
2. Flight Dynamics, Simulation, and Control by Ranjan Vepa , CRC press

**Reference Books**

1. Flight Simulation by JM Rolfe and K J Staples, Cambridge University Press
2. In-flight Simulation-theory and Application by Edwin A. Kidd, Gifford Bull, Robert P. Harper

**Web links and Video Lectures (e-Resources):**

- http://helijah.free.fr/dev/Principles-of-Flight-Simulation.pdf
- https://apps.dtic.mil/sti/tr/pdf/ADA173875.pdf

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| FLIGHT SIMULATION LAB | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAEL606** | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P: S) | 0:0:2 | SEE Marks | 50 |
| Credits | 01 | Exam Hours | 100 |
| Examination type (SEE) | Practical | | |

**Course objectives:**

- Understand the root locus and bode plot.
- Understand the spring mass damper system and the servo mechanism system with feedback.
- Acquire the knowledge to use computational tools to model aeronautical vehicle dynamics.

| Sl.NO | Experiments |
|---|---|
| 1 | Draw Pole-Zero map of dynamic system model with plot customization option |
| 2 | Plot root locus with variables in transfer function & dynamic system through MATLAB |
| 3 | Draw Bode plot from a transfer function in MATLAB and explain the gain and phase margins |
| 4 | Simulate a spring- mass- damper system with and without a forcing function though SIMULINK |
| 5 | Simulate a simple servo-mechanism motion with feedback- in the time domain, and in `s` domain |
| 6 | Simulate a bomb drop from an aircraft on a moving tank in pure pursuit motion |
| 7 | Simulate aircraft Take-off and Landing with trajectory tracing |
| 8 | Simulate stall of aircraft and show the effect of variation in static margin on stalling characteristics |
| | **Demonstration Experiments ( For CIE )** |
| 9 | Simulate aircraft longitudinal motion and demonstrate the effect of static margin variation for a pulse input in pitch that is intended to bleed the airspeed. |
| 10 | Simulate aircraft longitudinal motion and demonstrate the effect of static margin variation for a doublet input in pitch. |
| 11 | Given a Quartic characteristic equation, determine two quadratics that shall result in poles of shortperiod oscillations and poles of Phugoid. Vary the coefficients of polynomial to study the movement of poles. |
| 12 | Given a Quartic characteristics equitation, determine Poles and Time constants for Roll mode, Spiral motion, and Dutch roll. Vary the coefficients of polynomial to study the movement of poles. |

**Course outcomes (Course Skill Set):**

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

- Plot the root locus and bode plot.
- Calculate the dynamics response of aircraft.
- Use computational tools to model aircraft trajectory.

**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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

**Continuous Internal Evaluation (CIE):**

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

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

- Each experiment is 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 are designed by the faculty who is handling the laboratory session and are 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 a test of 100 marks after the completion of all the experiments listed in the syllabus.
- In a 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 marks scored shall be 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 a test is the total CIE marks scored by the student.

**Semester End Evaluation (SEE):**

- SEE marks for the practical course are 50 Marks.
- SEE shall be conducted jointly by the two examiners of the same institute, examiners are appointed by the Head of the Institute.
- The examination schedule and names of examiners are informed to the university before the conduction of the examination. These practical examinations are to be conducted between the schedule mentioned in the academic calendar of 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 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 15% of Marks allotted to the procedure part are to be made zero.

The minimum duration of SEE is 02 hours

**Suggested Learning Resources:**

- https://www.mccormick.northwestern.edu/documents/students/undergraduate/introduction-to-matlab.pdf

| PROBABILITY AND STATISTICS FOR AEROSPACE ENGINEERING | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE657A/BAS657A** | CIE Marks | 50 |
| Teaching Hours/Week (L: T:P: S) | 1:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 15hrs | Total Marks | 100 |
| Credits | 01 | Exam Hours | 1 |
| Examination type (SEE) | Theory | | |

**Course objectives:**

- To study the basics of statistics, measure central tendency and dispersion.
- Develop statistical methods for correlation, regression analysis and curve fitting.
- Explore the principles of probability.

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT.
2. Assignment of Home/field work on real-life problem.
3. Adoption of Project-based/Activity Based learning.
4. Practising the foundational knowledge.

**Module-1**

Definitions of Probability, Basic Laws of Probability, Probability Distributions, Distribution (Population) Parameters,

**Module-2**

Chebyshev's Theorem, Simulation (Monte Carlo Methods). Estimation Theory, Point Estimation.

**Module-3**

Curve Fitting, Regression, and Correlation, Goodness-of-Fit Tests,

**Module-4**

Hypothesis/Significance Testing, Reliability and Life Testing, Error Propagation Law.

**Module-5**

Application of Probability and Statistics in Aerospace Engineering – Various Examples.

**Course outcome (Course Skill Set)**

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

1. Elucidate the basic principles of statistics
2. Apply the correlation and regression analysis to engineering problem
3. Apply the principles of probability to engineering problems.

**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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous internal Examination (CIE)**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester End Examinations (SEE)**

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

OR

MCQ (Multiple Choice Questions) are preferred for 01 credit courses, however, if course content demands the general question paper pattern that followed for 03 credit course, then

1. The question paper will have ten questions. Each question is set for 10 marks.
2. There will be 2 questions from each module. Each of the two questions under a module may or may not have the sub-questions (with maximum sub-questions of 02, with marks distributions 5+5, 4+6, 3+7).
3. The students have to answer 5 full questions, selecting one full question from each module.

**Suggested Learning Resources:**

**Books**

1. Rheinfurth. MH, Probability and Statistics in Aerospace Engineering, University Press of the Pacific, 2006.

**Web links and Video Lectures (e-Resources):**

- https://ntrs.nasa.gov/api/citations/19980045313/downloads/19980045313.pdf

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| VIRTUAL AIRCRAFT SIMULATION | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE657B/BAS657B** | CIE Marks | 50 |
| Teaching Hours/Week (L: T:P: S) | 2:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 30hrs | Total Marks | 100 |
| Credits | 01 | Exam Hours | 1 |
| Examination type (SEE) | Theory | | |

**Course objectives:**

- Remember the terminologies of virtual aircraft simulation
- Understand the virtual aircraft simulation environment and settings
- Implement the skills of virtual flying

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

| **Module-1** |
|---|
| Introduction to virtual Aviation , Aviation rules and Organisation |
| **Module-2** |
| Air Traffic Control, Radio Communication from Pilot |
| **Module-3** |
| Flight Mode Annunciator mode English, Flight Instruments and their working principles |
| **Module-4** |
| Flight Instrument Essentials, Aviation Meteorology |
| **Module-5** |
| Practice of Flight Simulator X installation and Settings |

**Course outcome (Course Skill Set)**

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

1. Use the settings and controls of virtual aircraft simulation
2. Plan the new flying path for a specific situation
3. Fly an aircraft virtually

**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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous internal Examination (CIE)**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester End Examinations (SEE)**

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

OR

MCQ (Multiple Choice Questions) are preferred for 01 credit courses, however, if course content demands the general question paper pattern that followed for 03 credit course, then

1. The question paper will have ten questions. Each question is set for 10 marks.
2. There will be 2 questions from each module. Each of the two questions under a module may or may not have the sub-questions (with maximum sub-questions of 02, with marks distributions 5+5, 4+6, 3+7).
3. The students have to answer 5 full questions, selecting one full question from each module.

**Suggested Learning Resources:**

**Books**

1. Flight Simulation Virtual Environments in Aviation By Alfred T. Lee, ISBN 9781138246195 Published September 9, 2016 by Routledge
2. Principles of Flight Simulation, David Allerton, ISBN: 978-0-470-75436-8

**Web links and Video Lectures (e-Resources):**

- https://www.flightsimulator.com/
- https://www.youtube.com/watch?v=EOeDTr1x3XI

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| INTRODUCTION TO SWARM DRONE | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE657C** | CIE Marks | 50 |
| Teaching Hours/Week (L: T:P: S) | 1:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 15hrs | Total Marks | 100 |
| Credits | 01 | Exam Hours | 1 |
| Examination type (SEE) | Theory | | |

**Course objectives:**

- Understand what is Swarm Drone
- Learn the construction of Swarm
- Acquire skill of assembly and flying swarm

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

Introduction of swarm or fleet of Unmanned Aerial Vehicles (UAVs), Classification , Fully autonomous, semi-autonomous, single layered, multi-layered

**Module-2**

Vertically hover, take-off, and land (VTOL), remote control operations, or autonomously by using processors deployed on the drones, Military and Civil Application, Innovative Research and commercial application of Swarm

**Module-3**

Application Areas, Security, Survey, Monitoring, and Surveillance, Leisure Pursuit, Disaster Management, Environmental Mapping, Search and Rescue (S&R)

**Module-4**

Description of Sensors, Existing Control Approaches, Autonomous Swarms

**Module-5**

Battery Swapping/Recharging, Surveillance Systems, Swarm Design, Management, and Optimization

**Course outcome (Course Skill Set)**

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

1. Apply the concept of swarm drone design
2. Develop swarm of drone
3. Test fly the drone

**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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

**Continuous internal Examination (CIE)**

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester End Examinations (SEE)**

SEE paper shall be set for 50 questions, each of the 01 marks. The pattern of the question paper is MCQ (multiple choice questions). The time allotted for SEE is **01 hour.** The student has to secure a minimum of 35% of the maximum marks meant for SEE.

OR

MCQ (Multiple Choice Questions) are preferred for 01 credit courses, however, if course content demands the general question paper pattern that followed for 03 credit course, then

1. The question paper will have ten questions. Each question is set for 10 marks.
2. There will be 2 questions from each module. Each of the two questions under a module may or may not have the sub-questions (with maximum sub-questions of 02, with marks distributions 5+5, 4+6, 3+7).
3. The students have to answer 5 full questions, selecting one full question from each module.

**Suggested Learning Resources:**

**Books**


1. UAV Swarm Networks: Models, Protocols, and Systems, Edited By Fei Hu, DongXiu Ou, Xin-lin Huang, ISBN 9780367519988
2. Swarm Engineering, https://spie.org/news/swarm-engineering?SSO=1


**Web links and Video Lectures (e-Resources):**

- https://www.coursera.org/learn/robotics-flight
- https://www.geopoliticalmonitor.com/warfare-evolved-drone-swarms/
- https://www.forbes.com/sites/davidhambling/2021/03/01/what-are-drone-swarms-and-why-does-everyone-suddenly-want-one/

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.

| MULTI-DISCIPLINARY RESEARCH IN AERONAUTICAL ENGINEERING | | Semester | 6 |
|---|---|---|---|
| Course Code | **BAE657D** | CIE Marks | 50 |
| Teaching Hours/Week (L: T:P: S) | 1:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 15hrs | Total Marks | 100 |
| Credits | 01 | Exam Hours | 1 |
| Examination type (SEE) | Theory | | |

**Course objectives:**

- Understand the multi-disciplinary research
- Gather knowledge on multi-disciplinary research
- Articulate on the data collection, analysis and interpretation

**Teaching-Learning Process (General Instructions)**

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

1. Teaching in classroom through Chalk, Talk and ICT
2. Assignment of Home/field work on real-life problem
3. Adoption of Project-based/Activity Based learning
4. Practising the foundational knowledge

**Module-1**

Introduction to multi-disciplinary research

What to research and how to find out more, What is a research objective and a research question, How to formulate a research objective and a research question?

**Module-2**

Phases and methods of scientific research, Experimental/Study design, Data collection, Evaluation, validation and verification, Research ethics and human resource research ethics

**Module-3**

**Research method selection and study design:** Qualitative methods, Quantitative methods, Mixed method approaches

**Module-4**

**Data collection and analysis:** Data collection and data management, Data analysis (qualitative and quantitative), Data interpretation, How to validate and verify data

**Module-5**

Research management, documentation and publishing, Research plan writing

**Course outcome (Course Skill Set)**

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

1. Apply the concepts of the multi-disciplinary research
2. Examine the data collected
3. Implement the multi-disciplinary research

**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 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

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**Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.**

**Semester End Examinations (SEE)**

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OR

MCQ (Multiple Choice Questions) are preferred for 01 credit courses, however, if course content demands the general question paper pattern that followed for 03 credit course, then

1. The question paper will have ten questions. Each question is set for 10 marks.
2. There will be 2 questions from each module. Each of the two questions under a module may or may not have the sub-questions (with maximum sub-questions of 02, with marks distributions 5+5, 4+6, 3+7).
3. The students have to answer 5 full questions, selecting one full question from each module.

**Suggested Learning Resources:**

**Books**

1. Multi-Disciplinary Research & Innovation by Dr. Gajanan S. Futane (Author)
2. Contemporary Multi-Disciplinary Research Dimension by Wakil Kumar Yadav (Author)

**Web links and Video Lectures (e-Resources):**

- https://www.lawctopus.com/academike/multidisciplinary-research/
- https://research.ncsu.edu/rdo/the-difference-between-multidisciplinary-interdisciplinary-and-convergence-research/

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

- Experimentation – gathering knowledge through experience through lab.
- Exploration – gathering knowledge and attaining skills through active investigation.
- Expression – encouraging students to express their views through visual presentations.