R.V.COLLEGE OF ENGINEERING

(Autonomous Institution Affiliated to VTU, Belagavi)

R.V. Vidyaniketan Post, Mysore Road

Bengaluru – 560 059

Bachelor of Engineering (B.E)

Scheme and Syllabus for V & VI Semesters

2016 SCHEME

AEROSPACE ENGINEERING

Department Vision

Emerge as a centre of excellence in Aerospace Engineering, Imparting Quality Technical Education, Interdisciplinary Research & Innovation with a focus on Societal empowerment through Sustainable & Inclusive Technologies.

Department Mission

- Imparting Quality Technical Knowledge in Basic & Applied areas of Aerospace Engineering incorporating the principles of Outcome Based Education.
- Provide state-of-the art laboratories and infrastructure facilities, conducive to motivate Interdisciplinary Research and Innovation in Aerospace Engineering.
- Develop self motivated engineers with a blend of Discipline, Integrity, Engineering Ethics and Social Responsibility.
- Strengthening collaboration with industries, research organizations and institutes for Internships, Joint Research And Consultancy.
- Focus towards Integrating Sustainable and Inclusive Technologies for Societal Symbiosis.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: To provide opportunities for successful professional career with a sound fundamental knowledge in Mathematics, Physical Science & Aerospace Engineering.

PEO2: Motivate innovative research in specialized areas of Aerospace Engineering viz Aerospace structural design, Aerodynamics, Aerospace Propulsion and Guidance & Control systems.

PEO3: Promoting development of problem solving abilities by adopting analytical, numerical and experimental skills with awareness on societal impact.

PEO4: Imbibing sound communication skills, team working ability, professional ethics and zeal for lifelong learning.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO	Description
PSO1	Utilization of the fundamental knowledge and skills of Aerospace Engineering to develop pragmatic solutions for complex Aerospace Engineering problems.
PSO2	Apply Professional Engineering practices and strategies in the development of systems and subsystems for Aerospace Applications.
PSO3	Exhibit Effective Communication skills and a Zeal to function with multi-disciplinary teams
PSO4	Demonstrate Professional Ethics and Responsibilities in Engineering practices towards the achievement of societal symbiosis.

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2016 SCHEME

AEROSPACE ENGINEERING

ABBREVIATIONS

Sl. No.	Abbreviation	Meaning
1.	VTU	Visvesvaraya Technological University
2.	BS	Basic Sciences
3.	CIE	Continuous Internal Evaluation
4.	CS	Computer Science and Engineering
5.	CV	Civil Engineering
6.	CHY	Chemistry
7.	EC	Electronics and Communication Engineering
8.	EE	Electrical and Electronics Engineering
9.	ES	Engineering Science
10.	HSS	Humanities and Social Sciences
11.	ME	Mechanical Engineering
12.	PHY	Engineering Physics
13.	SEE	Semester End Examination
14.	MAT	Engineering Mathematics
15.	PCE	Professional Core Elective
16.	GE	Global Elective

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R V COLLEGE OF ENGINEERNG, BENGALURU-560 059
(Autonomous Institution Affiliated to VTU, Belagavi)

DEPARTMENT OF AEROSPACE ENGINEERING

FIFTH SEMESTER CREDIT SCHEME

Sl. No.	Course Code	Course Title	BoS	Credit Allocation				
				L	T	P	S	Total Credits
1	16HSI51	IPR & Entrepreneurship	HSS	3	0	0	0	3
2	16AS52	Flight Mechanics (Theory & Practice)	AS	3	0	1	1	5
3	16AS53	Gas Dynamics (Theory & Practice)	AS	3	0	1	0	4
4	16AS54	Mechanics of composite structures	AS	3	0	0	1	4
5	16AS55	Finite Element Methods	AS	3	0	1	0	4
6	16AS5AX	Elective A (PCE)	AS	3	0	0	1	4
7	16G5BXX	Elective B (GE)	Respective BOS	4	0	0	0	4
Total number of Credits				**22**	**0**	**3**	**3**	**28**
Total Number of Hours / Week				**22**	**0**	**6**	**12****	**40**

SIXTH SEMESTER CREDIT SCHEME

Sl. No.	Course Code	Course Title	BoS	Credit Allocation				
				L	T	P	S	Total Credits
1	16HEM61	Foundations of Management & Economics	HSS	2	0	0	0	2
2	16AS62	Aerospace Propulsion	AS	3	0	1	0	4
3	16AS63	Vibration Engineering	AS	3	0	1	1	5
4	16AS64	Aircraft Instrumentation	AS	3	0	1	1	5
5	16AS6CX	Elective C (PCE)	AS	3	0	0	1	4
6	16AS6DX	Elective D (PCE)	AS	4	0	0	0	4
7	16G6XX	Elective E(GE)	Respective BOS	3	0	0	0	3
8	16HSE68	Professional Practice-III (Employability Skills and Professional Development of Engineers)	HSS	0	0	1	0	1
Total number of Credits				**22**	**0**	**3**	**3**	**28**
Total Number of Hours / Week				**22**	**0**	**6**	**12****	**40**

** Non-contact hours

V Semester		
GROUP A: PROFESSIONAL CORE ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16AS5A1	Experimental Aerodynamics
2.	16AS5A2	Fatigue and Fracture Mechanics
3.	16AS5A3	Aerospace Reliability & Quality Control
4.	16AS5A4	Numerical Methods

GROUP B: GLOBAL ELECTIVES				
Sl. No.	**Host Dept**	**Course Code**	**Course Title**	**Credits**
1.	BT	16G5B01	Bioinformatics	4
2.	CH	16G5B02	Fuel Cell Technology	4
3.	CV	16G5B03	Geoinformatics	4
4.	CSE	16G5B04	Graph Theory	4
5.	ECE	16G5B05	Artificial Neural Networks & Deep Learning	4
6.	EEE	16G5B06	Hybrid Electric Vehicles	4
7.	IEM	16G5B07	Optimization Techniques	4
8.	E&I	16G5B08	Sensors & Applications	4
9.	ISE	16G5B09	Introduction To Management Information Systems	4
10.	ME	16G5B10	Industrial Automation	4
11.	TCE	16G5B11	Telecommunication Systems	4
12.	MAT	16G5B12	Computational Advanced Numerical Methods	4
13.	AE	16G5B13	Basics of Aerospace Engineering	4

VI Sem		
GROUP C: PROFESSIONAL CORE ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16AS6C1	Computational Fluid Dynamics
2.	16AS6C2	Cryogenics
3.	16AS6C3	Hydraulics & Pneumatics
4.	16AS6C4	Advanced Material Technology
5.	16AS6C5	Non Destructive Testing & Evaluation
GROUP D: PROFESSIONAL CORE ELECTIVES		
1.	16AS6D1	Boundary Layer Theory
2.	16AS6D2	Experimental Stress Analysis
3.	16AS6D3	Fundamentals of Astrophysics
4.	16AS6D4	Spacecraft Design
5.	16AS6D5	Combustion & Heat Transfer

GROUP E: GLOBAL ELECTIVES				
Sl. No.	**Host Dept**	**Course Code**	**Course Title**	**Credits**
1.	BT	16G6E01	Bioinspired Engineering	3
2.	CH	16G6E02	Green Technology	3
3.	CV	16G6E03	Solid Waste Management	3
4.	CSE	16G6E04	Introduction to Web Programming	3
5.	ECE	16G6E05	Automotive Electronics	3
6.	EEE	16G6E06	Industrial Electronics	3
7.	IEM	16G6E07	Project Management	3
8.	E&I	16G6E08	Virtual Instrumentation	3
9.	ISE	16G6E09	Introduction to Mobile Application Development	3
10.	ME	16G6E10	Automotive Engineering	3
11.	TCE	16G6E11	Mobile Network System and Standards	3
12.	MAT	16G6E12	Applied Partial Differential Equations	3
13.	AE	16G6E13	Aircraft Systems	3

V SEMESTER			
INTELLECTUAL PROPERTY RIGHTS AND ENTREPRENEURSHIP (Theory) (Common to AE, CSE, ECE, EEE, ISE, TE)			
Course Code: 16HSI51			**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:0			**SEE Marks:** 100
Hours: 36L			**SEE Duration:** 03Hrs
Course Learning Objectives: The students will be able to			
1	To build awareness on the various forms of IPR and to build the perspectives on the concepts and to develop the linkages in technology innovation and IPR.		
2	To equip students on the need to protect their own intellectual works and develop ethical standards governing ethical works.		
3	To motivate towards entrepreneurial careers and build strong foundations skills to enable starting, building and growing a viable as well as sustainable venture.		
4	Develop an entrepreneurial outlook and mind set along with critical skills and knowledge to manage risks associated with entrepreneurs.		

UNIT-I	
Introduction: Types of Intellectual Property, WIPO, WTO, TRIPS. **Patents:** Introduction, Scope and salient features of patent; patentable and non-patentable inventions, Patent Procedure - Overview, Transfer of Patent Rights; Biotechnology patents, protection of traditional knowledge, Infringement of patents and remedy, Case studies **Trade Secrets:** Definition, Significance, Tools to protect Trade secrets in India.	**07 Hrs**
UNIT-II	
Trade Marks: Concept, function and different kinds and forms of Trade marks, Registrable and non- registrable marks. Registration of trade mark; Deceptive similarity; Assignment and transmission; ECO Label, Passing off; Offences and penalties. Infringement of trade mark with Case studies	**04 Hrs**
UNIT-III	
Industrial Design: Introduction, Protection of Industrial Designs, Protection and Requirements for Industrial |Design. Procedure for obtaining Design Protection, Revocation, Infringement and Remedies, Case studies **Copy Right:** Introduction, Nature and scope, Rights conferred by copy right, Copy right protection, transfer of copy rights, right of broad casting organizations and performer's rights, Case Studies. **Intellectual property and cyberspace:** Emergence of cyber-crime; Grant in software patent and Copyright in software; Software piracy; Data protection in cyberspace	**09 Hrs**
UNIT-IV	
Introduction to Entrepreneurship – Learn how entrepreneurship has changed the world. Identify six entrepreneurial myths and uncover the true facts. Explore E-cells on Campus **Listen to Some Success Stories: -** Global legends Understand how ordinary people become successful global entrepreneurs, their journeys, their challenges, and their success stories. Understand how ordinary people from their own countries have become successful entrepreneurs. **Characteristics of a Successful Entrepreneur** Understand the entrepreneurial journey and learn the concept of different entrepreneurial styles. Identify your own entrepreneurship style based on your personality traits, strengths, and weaknesses. Learn about the 5M Model, each of the five entrepreneurial styles in the model, and how they differ from each other. **Communicate Effectively:** Learn how incorrect assumptions and limiting our opinions about people can negatively impact our communication. Identify the barriers which cause communication breakdown, such as miscommunication and poor listening, and learn how to overcome them. **Communication Best Practices.** Understand the importance of listening in communication and learn to listen actively. Learn a few body language cues such as eye contact and handshakes to strengthen communication. (Practical Application)	**08 Hrs**

UNIT-V	
Design Thinking for Customer Delight: - Understand Design Thinking as a problem-solving process. Describe the principles of Design Thinking. Describe the Design Thinking process. **Sales Skills to Become an Effective Entrepreneur: -** Understand what is customer focus and how all selling effort should be customer-centric. Use the skills/techniques of personal selling, Show and Tell, and Elevator Pitch to sell effectively. **Managing Risks and Learning from Failures: -** Identify risk-taking and resilience traits. Understand that risk-taking is a positive trait. Learn to cultivate risk-taking traits. (Practical Application) Appreciate the role of failure on the road to success, and understand when to give up. Learn about some entrepreneurs/risk-takers. (Practical Application). **Are You Ready to be an Entrepreneur: -** Let's ask "WHY" Give participants a real picture of the benefits and challenges of being an entrepreneur. Identify the reasons why people want to become entrepreneurs. Help participants identify why they would want to become entrepreneurs.	**08 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Comprehend the applicable source, scope and limitations of Intellectual Property within the purview of engineering domain.
CO2:	Knowledge and competence related exposure to the various Legal issues pertaining to Intellectual Property Rights with the utility in engineering perspectives.
CO3:	Enable the students to have a direct experience of venture creation through a facilitated learning environment.
CO4:	It allows students to learn and apply the latest methodology, frameworks and tools that entrepreneurs use to succeed in real life.

Reference Books	
1.	Law Relating to Intellectual Property, Wadehra B L,5th Edition, 2012, Universal Law Pub Co. Ltd.-Delhi, ISBN: 9789350350300
2.	Intellectual Property Rights: Unleashing Knowledge Economy, Prabuddha Ganguly, 1st Edition, 2001, Tata McGraw Hill Publishing Company Ltd., New Delhi, ISBN: 0074638602.
3.	Intellectual Property and the Internet, Rodney Ryder, 2002, Lexis Nexis U.K., ISBN: 8180380025, 9788180380020.
4.	Entrepreneurship, Rajeev Roy, 1st Edition, 2012, Oxford University Press, New Delhi, ISBN: 9780198072638.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**1**	**-**	**-**	**-**	**3**	**3**	**-**	**3**	**1**	**2**	**-**	**3**
CO2	**1**				**3**	**3**	**3**	**3**	**1**	**2**	**-**	**3**
CO3	**-**	**3**	**2**	**-**	**-**	**2**	**2**	**3**	**3**	**3**	**3**	**3**
CO4	**-**	**3**	**2**	**-**	**-**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

Low-1 Medium-2 High-3

Semester: V		
FLIGHT MECHANICS (Theory & Practice)		
Course Code: 16AS52		**CIE Marks:** 100+50
Credits: L:T:P:S: 3:0:1:1		**SEE Marks:** 100+50
Hours: 36L		**SEE Duration:** 3Hrs+3Hrs

Course Learning Objectives: To enable the students to:	
1	Understand the aircraft performance during unaccelerated flight
2	Formulate the steady aircraft performance during level flight and climb
3	Develop relations for estimating the Range, endurance, power, ceiling of Jet and propeller driven aircrafts
4	Develop relations for estimating the aircraft performance during accelerated flight-takeoff and climb
5	Study the aircraft performance during manoeuvres

Unit-I	
Introduction to Aircraft Performance-Force Systems of the Aircraft : Forces and moments acting on a flight vehicle, Equation of motion of a rigid flight vehicle, Variation of thrust, power and SFC with velocity and altitudes.	**07 Hrs**
Unit – II	
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. The fundamental Parameters: Thrust-to-weight ratio, Wing loading, Drag polar, and lift-to-drag ratio.	**07 Hrs**
Unit -III	
Steady Performance – Level Flight, Climb & Glide: Equation of motion for steady level flight, Performance of airplane in level flight, Maximum speed in level flight, Climb 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.	**08 Hrs**

Unit -IV	
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 and tail wind. **Take-off And Landing Performance:** Estimation of take-off distances. The effect on the take-off distance, of weight, wind, runway conditions, ground effect. Take-off performance safety factors. Estimation of landing distances.	**07 Hrs**
Unit -V	
Manoeuvre Performance: Turning performance: Level turn, load factor, Constraints on load factor, Minimum turn radius, Maximum turn rate, Pull-up and Pull-down manoeuvres, (Turning rate, turn radius), Limiting case for large load factor, The V-n diagram, Limitations of pull up and push over.	**07 Hrs**

LABORATORY EXPERIMENTS	
1. Introduction to MATLAB commands and functions 2. Atmosphere modeling and estimation of pressure, temperature and Lapse rate for change in altitude. 3. Determination of Airspeed-TAS,CAS 4. Estimation of Range and endurance for jet propelled aircraft 5. Estimation of Range and endurance for propeller powered aircraft 6. Estimation of thrust required and available with change in velocity and altitude for unaccelerated flight 7. Estimation of power required and available with change in velocity for unaccelerated flight 8. Estimation of take off distance of an aircraft 9. Estimation of Landing distance of an aircraft 10. Estimation of Climb rate and Sink rate of gliding flight 11. Estimation of Minimum turn radius and Maximum turn rate 12. Trajectory prediction of a meteorite	

Course Outcomes: At the end of this course the student will be able to :	
1	Appreciate and apply the principles of standard atmosphere on the flight performance.
2	Evaluate the parameters affecting the performance of an aircraft under various operating conditions.
3	Comprehend the complexities involved in achieving maximum range and endurance of an aircraft.
4	Evaluate and criticize the design strategy involved in the development of airplanes.

Reference Books	
1	Eshelby, M.E., Aircraft Performance-Theory and Practice, 1st Edition, 2000, Elsevier, AIAA Education Series, ISBN-13: 978-0340758977
2	Brandt, S.A, et. al., Introduction to Aeronautics: A Design Perspective, 3rd Edition, 2015, AIAA Education Series, AIAA, ISBN-13: 978-1563477010
3	Anderson, J.D. Jr., Aircraft Performance and Design, 1st Edition,1998, International edition, McGraw Hill, ISBN-13: 978-0070019713
4	Dole, C.E., Flight Theory and Aerodynamics: A Practical Guide for Operational Safety, 2nd Edition, 2000, Wiley Interscience, 1981, ISBN-13: 978-0471370062
5	McCormick, B.W, Aerodynamics, Aeronautics and Flight Mechanics, 2nd edition, 1995, John Wiley, ISBN-13: 978-0471575061

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total CIE for theory is 100.

Laboratory- 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150

Theory – 100 Marks

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**2**	**1**	**1**	**1**	**2**					**1**
CO2	**3**	**2**	**3**	**3**	**2**	**2**	**3**	**2**				**2**
CO3	**3**	**2**	**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: V		
GAS DYNAMICS (Theory & Practice)		
Course Code: 16AS53		**CIE Marks:** 100+50
Hours: L:T:P:S: 3:0:1:0		**SEE Marks:** 100+50
Hours: 36L		**SEE Duration:** 3Hrs+3Hrs

Course Learning Objectives: To enable the students to:	
1	Examine the basic properties of the compressible flows
2	Familiarize with the behavior of different types of shock waves encountered in compressible flows
3	Understand the behavior of compressible flows through mathematical models
4	Utilize various instrumentation to quantify the properties of compressible flows

Unit-I	
Basics of Compressible Flow through Varying Area Duct : Compressible flows, Stagnation pressure, temperature, density, reference velocities, Bernoulli's equation, Effect of Mach number on Compressibility, Isentropic flow with variable area-Area ratio as a function of Mach number, Impulse function, Mass flow rate, Flow through nozzle and diffuser.	**07 Hrs**
Unit – II	
Introduction to Shock Waves : Governing Equations of Normal Shock Wave, Prandtl relation and Rankine-Hugoniot equation, Oblique shocks and corresponding relations, Shock polar &Hodograph plane, Supersonic flow over a wedge, Supersonic compression and supersonic expansion, detached shocks, Mach reflection. Intersection of waves of same and opposite families, Prandtl-Meyer Expansion Function.	**07 Hrs**
Unit -III	
Fanno Flow : Flow with friction in constant area duct, Fanno lines, Fanno equation, Definition of friction constant, Friction loss, Effect of wall friction on flow properties, Friction Parameter, Local flow properties in terms of local Mach number. **Rayleigh Flow :** Flow with heating or cooling in ducts, Governing equations, Heating relations for a perfect gas, Slope of Rayleigh line, Entropy considerations. Maximum heat transfer.	**08 Hrs**

Unit -IV	
Similarity Principle and Compressible Aerodynamics : Subsonic, supersonic Prandtl-Glauret rule, Von Karman Transonic rule, Gothert's rule, Shock expansion theory over supersonic airfoil, compressible flow classical thin airfoil theory.	**07 Hrs**
Unit -V	
Differential Equations of Motion for Steady Compressible Flows : Basic Potential equation for compressible flow, Linearization of potential equation- Small perturbation theory, Methods for solution of nonlinear potential equation-Introduction, Boundary Conditions, Pressure coefficient expression.	**07 Hrs**

LABORATORY EXPERIMENTS	
1. Calibration of Hot wire anemometer. 2. Calibration of supersonic wind tunnel test section 3. Flow visualization over Forebody configurations. 4. Flow visualization over delta wing aircraft and measurement of surface pressure distribution at various angles of attack 5. Determination of oblique shock angle for over a wedge and measurement of surface	

pressure distribution. 6. Determination of oblique shock angle for over a cone and measurement of surface pressure distribution. 7. Determination of shock pattern and pressure distribution over a flat plate at various angles of attack 8. Determination of shock pattern and pressure distribution over a diamond shaped airfoils at various angles of attack. 9. Determination of shock pattern and pressure distribution over a biconvex airfoils at various angles of attack. 10. Supersonic flow studies over a varying concave ramp and determination of flowfield properties. 11. Supersonic flow studies over a varying convex ramp and determination of flowfield properties. 12. Estimation of aerodynamic characteristics of a missile configuration at various angles of attack.	

Course Outcomes:	
At the end of this course the student will be able to :	
1	Summarize the various properties of compressible flow
2	Conclude the behaviour of compressible flows for various aerospace applications
3	Justify the effect of compressible flows with suitable mathematical formulation
4	Evaluate the characteristics of the compressible flows through suitable measuring equipments

Reference Books	
1	Anderson, J. D., Modern Compressible Flow with Historical Perspective, 3rd Edition, 2002, McGraw-Hill Education, ISBN- 978-0072424430
2	Liepmann, H. W. and Roshko, A., Elements of Gas Dynamics, 8th Edition, 2002, Dover Publications, ISBN- 978-0486419633
3	John, J. E. A. and Keith, T., Gas Dynamics, 3rd Edition, 2006, Prentice Hall, ISBN- 978-0131206687
4	Zucker, R. D. and Biblarz, O., Fundamentals of Gas Dynamics, John Wiley & Sons; 2nd Revised Edition, 2002, ISBN- 978-0471059677
5	Saad, M. A., Compressible Fluid Flow, 2nd Edition, Prentice Hall (1992) ISBN- 978-0131613737

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total CIE for theory is 100.

Laboratory- 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150

Theory – 100 Marks

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16

marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

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CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**3**
CO3	**1**	**2**	**3**	**3**	**2**							**3**
CO4	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**2**				**3**

High-3 : Medium-2 : Low-1

Semester: V		
MECHANICS OF COMPOSITE STRUCTURES (Theory)		
Course Code: 16AS54		**CIE Marks:** 100
Hours: L:T:P:S: 3:0:0:1		**SEE Marks:** 100
Hours: 36L		**SEE Duration:** 3Hours

Course Learning Objectives: To enable the students to:	
1	To develop an understanding of the linear elastic analysis of composite materials
2	Understand concepts such as anisotropic material behavior and the analysis of laminated plates
3	Apply constitutive equations of composite materials and understand mechanical behaviour at micro, macro level
4	Apply failure criteria and critically evaluate the results

Unit-I	
Introduction To Composite Materials: Introduction and Classification of composites, Overview of Advantages and Limitations of Composite Materials, Micro mechanics, Macro mechanics, Homogeneity, Heterogeneity, Inhomogeneity, Isotropy, Anisotropy/Orthotropy. General Anisotropic Material, Specially Orthotropic Material, Transversely Isotropic Material, Orthotropic Material Under Plane Stress, Isotropic Material.	**07 Hrs**
Unit – II	
Strength Of Unidirectional Lamina-Micro mechanics: Elasticity approach, Ultimate strength of unidirectional lamina, strength of materials approach, Semi empirical Models.	**07 Hrs**
Unit -III	
Strength Of Composite Lamina-Macro mechanics: Hooke's Law for Different Types of Materials, Hooke's Law for a Two-Dimensional Unidirectional Lamina, Hooke's Law for a Two-Dimensional Angle Lamina, Invariant Form of Stiffness and Compliance Matrices for an Angle Lamina, Strength Failure Theories of an Angle Lamina.	**08 Hrs**

Unit -IV	
Failure, Analysis, and Design of Laminates: Introduction, Special Cases of Laminates, Failure Criterion for a Laminate, Design of a Laminated Composite, Other Mechanical Design Issues.	**07 Hrs**
Unit -	
Experimental Methods For Testing Of Composite Materials: Characterization of Constituent Materials, Physical Characterization of Composite Materials, Determination of Tensile Properties of Unidirectional Lamina, Determination of Compressive Properties of Unidirectional lamina, Determination of Shear Properties of Unidirectional lamina.	**07 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Identify and explain the types of composite materials and their characteristic features
2	Understand the differences in the strengthening mechanism of composite and its corresponding effect on performance and application
3	Appreciate the theoretical basis of the experimental techniques utilized for failure mode of composites.
4	Develop expertise on the applicable engineering design of composite

Reference Books	
1	Robert M. Jones, Mechanics of Composite Materials, 2nd Edition, 1998, CRC Press, ISBN 9781560327127
2	Autar K Kaw, Mechanics of Composite Materials, 2nd Edition, 2005, CRC Press, ISBN 9781420058291
3	Madhujit Mukhopadhyay, Mechanics of Composite Materials and Structures, 4th Edition, 2005, Universities Press, , ISBN 978-8173714771
4	Carlos A. Mota Soares, Mechanics of Composite Materials and Structures, 2nd Edition, 2013, Springer Science & Business Media, ISBN 9789401144896

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**1**				**2**
CO2	**3**	**3**	**3**	**3**	**3**	**1**	**1**					**2**
CO3	**1**	**2**	**3**	**3**	**3**							**2**
CO4	**3**	**3**	**3**	**3**	**3**							**2**

High-H : Medium-M : Low-L

Semester: V		
FINITE ELEMENT METHODS (Theory & Practice)		
Course Code: 16AS55		**CIE Marks:** 100+50
Credits: L:T:P:S: 3:0:1:0		**SEE Marks:** 100+50
Hours: 36L		**SEE Duration:** 3Hours+3Hours

Course Learning Objectives: To enable the students to:	
1	To comprehend the basic fundamentals of Finite Element Method.
2	Build mathematical formulations utilizing Principle of virtual work and minimum potential energy
3	Understand the role and significance of shape functions in finite element
4	Apply the procedures of FEM to obtain the solutions for various real life problems.
5	Study the importance of lumped and consistent mass matrix in solving various structural problems

Unit-I	
Introduction: Introduction to FEM, Difference between discrete and continuous system, finite element method vs. Classical methods, Historical background, Classification of common methods, General description in FEM, Steps in FEM, Convergence criteria, Applications of FEM, Types of elements based on geometry, Gaussian elimination technique.	**05 Hrs**
Unit – II	
Mathematical Preliminaries and Basic Procedure: Introduction to Calculus of Variation, Principle of Virtual Work, Principle of Minimum Potential Energy, Rayleigh-Ritz Method, Obtaining the Variational form from a differential equation- 1d Bar Element, Numericals On 1d Bar Elements (Rayleigh-Ritz), Galerkin's Method.	**08 Hrs**
Unit -III	
Interpolation Models and Higher Order Elements : Interpolation polynomials, Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape Functions of 2, 3, and 4 Noded bar element, Serendipity family, Hexahedral elements, Lagrange family, Shape functions for Higher Order Elements.	**08 Hrs**

Unit -IV	
Solution of 1-D Bars and beams: Solutions of bars and stepped bars for displacements, reactions and stresses by using penalty approach and elimination approach. Iso-parametric, Sub parametric and Super parametric elements, Finite element method applied to 1-D bars and beams - Numericals.	**08 Hrs**
Unit -V	
Beams & Trusses: Hermite shape functions for beam element, Lumped and consistent mass matrix, Derivation of stiffness matrix, Numerical problems of beams carrying concentrated, UDL and linearly varying loads, trusses with one, two and three bar elements.	**07 Hrs**

LABORATORY EXPERIMENTS	
1. Computation of deflection of Bars with Constant Cross-sectional Area, Bars of Tapered Cross sectional Area and Stepped Bars using 1D elements 2. Analysis of a helical Spring System under compression load 3. Static analysis of a Simple Cantilever Beam (Using shell and Solid elements) 4. Rectangular plate with Cut-Out Uniformly compressed in one direction 5. Stress Analysis of an Aircraft wing C-Spar.	

6. Composite sandwich beam cantilever analysis for Displacement and Stress 7. Structural Modelling and Stress analysis of a fuselage Bulkhead 8. Computation of Deflection of an Aircraft Wing. 9. Free vibration analysis of a wing 10. Aerodynamic modelling and divergence analysis of uniform wing 11. Divergence speed prediction for tapered wing. 12. Flutter analysis of the wing.	

Course Outcomes: At the end of this course the student will be able to :	
1	Identify mathematical model for solution of common engineering problems.
2	Formulate simple problems into finite elements.
3	Solve structural problems and use professional-level finite element software to solve engineering problems in Solid mechanics.
4	Derive element matrix equation by different methods by applying basic laws in mechanics

Reference Books	
1	O. C. Zienkiewicz and Y. K. Cheung, The Finite Element Method in Structural and Soild Mechanics, 1st Edition, 1967, McGraw Hill, London
2	David V. Hutton, Fundamentals of Finite Element Analysis, 1st Edition, 2003, McGraw Hill, ISBN- 978-0072395365
3	Erik G. Thompson, Introduction to the Finite Element Method: Theory, Programming and Applications, 1st Edition, 2004, John Wiley, 978-0471267539
4	Irving H. Shames, Clive L. Dym, Energy and Finite Element Methods in Structural Mechanics, 4th Edition, 1995, New Age International, ISBN- 9788122407495

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total CIE for theory is 100.

Laboratory- 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150

Theory – 100 Marks

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**2**	**3**	**3**		**1**	**1**	**1**				**1**

High-3 : Medium-2 : Low-1

Semester: V		
EXPERIMENTAL AERODYNAMICS **(Group A: Professional Core Elective)**		
Course Code: 16AS5A1		**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:1		**SEE Marks:** 100
Hours: 36L		**SEE Duration:** 3Hours

Course Learning Objectives: To enable the students to:	
1	Distinguish wind tunnels on the basis of their construction and application
2	Familiarize with the exhaustive instrumentations employed for the measurement of flow properties
3	Interpret and incorporate various losses arising during wind tunnel testing
4	Understand different types of advanced non intrusive techniques used in flow measurements

Unit-I	
Wind Tunnels : Introduction to wind tunnels, Importance of wind tunnels, Classification of wind tunnels: open and closed circuit wind tunnels, construction and operation of subsonic, transonic, supersonic and hypersonic wind tunnels, Smoke Tunnel.	**07 Hrs**
Unit – II	
Wind Tunnels Measurement Techniques : Pressure measuring probe: Pitot static probe, three and five hole probes, Temperature measurement: Stagnation temperature probe (thermocouples), Resistance Temperature detectors (RTDs), Force measurement: Strut type and strain gauge balances, Velocity measurement: Hot wire anemometer-constant current and temperature types, Turbulence measurement: Sphere probe.	**07 Hrs**
Unit -III	
Model Sizing and Wind Tunnel Corrections : Geometrical and dynamic similarities, solid and wake blockage, calculation of percentage energy losses in various components of a wind tunnel: energy ratio, wall effect, fundamentals of model installations, flow losses in a wind tunnel.	**08 Hrs**

Unit -IV	
Flow Visualization Techniques : Introduction to flow visualization techniques, smoke and tuft visualization, Hydrogen bubble technique, oil flow visualizing, optical techniques: Schlieren technique, shadowgraph technique, interferometry.	**08 Hrs**
Unit -V	
Advanced Wind Tunnel Testing : Recent advances in wind tunnel testing, Principle of operation: Particle Image Velocimetry, Laser Doppler Velocimetry, Speckle Photography, Pressure Sensitive Paints.	**06 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Demonstrate the working of different types of wind tunnels employed in the aerospace industry
2	Explain the working principle of each measurement instruments based on chosen flow conditions
3	Estimate all possible losses incurred during the designing and testing of models in wind tunnel
4	Utilize various flow diagnostic techniques in predicting and estimating significant properties of fluids

Reference Books	
1	Ethirajan Rathakrishnan, Instrumentation, Measurements, and Experiments in Fluids, 1st Edition, 2007, CRC Press, ISBN-13: 978-0849307591
2	Stefano Discetti, Andrea Ianiro, Experimental Aerodynamics, 1st Edition, 2017, CRC Press

	ISBN: 978-1498704014
3	Rae, W.H. and Pope, Alan, Low Speed wind Tunnel Testing 3rd Revised Edition,1999, John Wiley & Sons, ISBN- 978-0471557746
4	R.C. Pankhurst (Author), D.W. Holder, Wind Tunnel Techniques, New impression Edition,1968, Pitman Publishing, ISBN- 978-0273433538
5	Pope, Alan & Goin High Speed Wind Tunnel Testing, 2nd Edition, 1978, Krieger Pub Co, ISBN- 978-0882757278
6	Gaydon, Alfred Gordon, Hurle, I. R, Shock Tubes in high temperature chemical physics, 2013, ISBN 978-1-5041-2171-2
7	Von S.M, Slezinger Gorlin, Wind Tunnels and their Instrumentation, Jerusalem, Israel Program for Scientific Translations (1966) ASIN: B007HFKVTG

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**				**2**

High-3 : Medium-2 : Low-1

Semester: V		
FATIGUE & FRACTURE MECHANICS **(Group A: Professional Core Elective)**		
Course Code: 16AS5A2		**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:1		**SEE Marks:** 100
Hours: 36L		**SEE Duration:** 3Hours

Course Learning Objectives: To enable the students to:	
1	Identify the various possible mechanisms of occurrence of fracture in materials and structures.
2	Interpret the behaviour of a crack growth under various loading conditions in brittle and ductile materials.
3	Demonstrate the various methods of arresting a potential crack in structures.
4	Analyse the effect of fatigue fracture on the life of a structure

Unit-I	
Fundamentals of Fracture Mechanics: Introduction to fracture Mechanics, Types and Characteristics of Brittle & Ductile Fractures, Brittle-Ductile transition, Fracture mechanics approach to design - Energy approach, Stress Intensity approach, Time dependent crack growth & damage tolerance, Crack in a structure, Modes of cracking, Fracture Toughness.	**07 Hrs**
Unit – II	
Linear Elastic Fracture Mechanics (LEFM): Griffith's Energy balance criterion, Energy release rate (ERR), Stability of crack growth-R curve, Stress intensity factor (SIF), Direction of crack propagation, mixed mode fracture, SIF for different geometries, Relationship between K and G, Experimental determination of Kc, Crack-tip plasticity Correction factor for plasticity effects.	**07 Hrs**
Unit -III	
Elastic–Plastic Fracture Mechanics: Introduction, J-integral, Relation between J-integral and CTOD, crack resistance curve, Experimental determination of Kc and J, Constraints effects in Fracture.	**06 Hrs**

Unit -IV	
Fatigue of Structures: S.N. curves, Stress-life approach, Strain-life approach, Mean stress effects, Goodman, Gerber and Soderberg relations, Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves.	**08 Hrs**
Unit -V	
Statistical Aspects of Fatigue Behaviour: Low cycle and high cycle fatigue - coffin - Manson's relation - Transition life - cyclic strain hardening and softening -Cycle counting techniques, Paris law, Miner's rule, Damage rule for irregular loads, Variable amplitude loading.	**08 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Demonstrate the phenomenon of formation of cracks in different structural materials.
2	Develop solutions to estimate the size of the cracks and its effect under different loading conditions.
3	Extend the life of a structure by applying various methods of crack arresting techniques.
4	Evaluate the fracture strength of materials by incorporating different testing methods for different loading environments.

Reference Books	
1	T.L. Anderson , Fracture Mechanics – Fundamentals and Application, 4th Edition, 2017, CRC press, ISBN- 9781498728140
2	David Broek, Martinus Nijhoff,, Elementary Engineering Fracture Mechanics, 5th Edition, 1999, London, ISBN 978-94-009-4333-9
3	Jayatilake , Fracture of Engineering Brittle Materials, 2nd Edition, 2001, Applied Science, London ISBN-9780853348252
4	Jaap Schijve, Fatigue of Structures and Materials, 2004, Kluwer Academic publishers, , ISBN-0792370139

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**				**1**
CO2	**3**	**2**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**3**	**2**	**3**	**3**	**3**	**1**	**3**	**3**				**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: V		
AEROSPACE RELIABILITY AND QUALITY CONTROL **(Group A: Professional Core Elective)**		
Course Code: 16AS5A3		**CIE marks:** 100
Hours/Week:L:P:T:S:3:0:0:1		**SEE Marks :**100
Hours : 36L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Analyze test data and predict reliability of components
2	Describe the quality control techniques for a production systems
3	Explain the importance of value addition to products through analysis
4	Prepare QC, FMEA,VA,VSM charts

Unit-I	
Introduction to Reliability Engineering : Failure Data Collection, Failure Distribution, Mean Time to Failure, MTBF and MTTF, Reliability Life Testing, Bath Tube Curve, Accelerated Life Testing, Fault Tree Analysis. **Failure Models:** Constant Failure Rate Models: Exponential Reliability Function, Redundancy and CFR model; Time Dependent Failure Models: Weibull distribution, Normal distribution and Log Normal Distribution.	**08 Hrs**

Unit -II	
Design for Reliability : Serial, parallel and combined configurations, system structure function, common mode failure, Three state devices Load Sharing Systems, Standby Systems, Reliability specifications.	**06 Hrs**

Unit -III	
Introduction: Total quality control concepts, categorization, goals, habits of improvements, process control, capacity scheduling, quality circles, TQC in Japan for Auto components. **Probability and Statistics in Quality** Events, sample space, probability rules, conditional probability, application of probability in SQC, Numericals.	**07 Hrs**

Unit -IV	
Gauges and Measurement Techniques : Review of types of tolerances, fits (shaft and hole basis); plug type gauges – plain single and double end, threaded, limitation of plug type gauges; Ring , snap, position gauges; Indicator type gauges, From tolerances, fixtures for measurement, part location and orientation. **Control Charts :** Statistical quality control, sample size, parameter selection, variable chart, X bar chart, R chart, Sigma chart, charts for attributes, computation of Cp and Cpk.	**08 Hrs**

Unit -V	
Value Analysis & Value Stream Mapping : Need for VA & VSM, Roles, Responsibility, Process, Procedures, Understanding current, ideal and future state, developing transformation plans and achieving them. **Failure Mode Effects Analysis :** Review of product or process, brainstorm failure modes and their effects, assign severity, occurrence, detection ranking, calculate RPN, prioritize and initiate action.	**07 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Recognize the importance of statistical and probability tools in QC.
2	Create control charts given a component, dimensions, production quality
3	Operate in teams to ensure higher value for a given product
4	Describe importance of Quality Control and Reliability Engineering
5	Evaluate the test data and determine the quality and reliability of the component

Reference Books	
1	Eugene Lodewick Grant Richard S. Leavenworth, Statistical Quality Control, 7th Edition, 1996, Mcgraw-Hill, ISBN- 978-0071142489
2	Besterfield D.H., Quality Control, International 2nd Revised Edition, 199, Prentice-Hall, ISBN-978-0130398284
3	Montgomery, Douglas, Statistical Quality Control, 5th Edition, 2005, John Wiley & Sons, Inc., Hoboken, NJ (ISBN 0-471-65631-3).
4	RC Gupta, Statistical Quality Control, 9th Edition, 2005, Khanna Publishers, New Delhi, ISBN-8174091114
5	Balagurusamy, E., Reliability Engineering, 1st Edition, 1984, Tata McGraw Hill publishing Co., New Delhi, ISBN 13: 9780070483392

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**2**	**2**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**3**	**3**	**2**	**2**	**3**	**3**	**3**	**3**				**2**
CO4	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: V		
NUMERICAL METHODS **(Group A: Professional Core Elective)**		
Course Code: 16AS5A4		**CIE marks:** 100
Hours/Week:L:P:T:S:3:0:0:1		**SEE Marks :**100
Hours : 36L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Execute interpolation techniques for the data provided
2	Apply the basic transformation techniques and mathematic tools for finding the roots
3	Demonstrate the usage of numerical techniques for integration and differentiation of some simple functions
4	Identify and demonstrate the usage of curve fitting techniques to interpret the behaviour of given data
5	Solve for non-linear system of equations by finding their roots using suitable technique

Unit-I	
Introduction to Numerical Methods: Introduction, Errors, System of linear equation, Solution for system of linear equation, Direct elimination method and Iterative method, Matrix Properties, Determinant, Gauss elimination method and Iterative method Numericals.	**08 Hrs**

Unit -II	
Interpolation and Approximation: Lagrangian Polynomials - Divided differences Interpolating with a cubic spline - Newton's forward and backward difference formulae.	**08 Hrs**

Unit -III	
Eigen Values and Eigen vectors: Motivation and Objectives/ The characteristics Polynominal/ Power Methods / Jacobi's Method/ Householder Transformation/ QR Method/ Danilevsky's Method/ Polynominal Roots.	**06 Hrs**

Unit -IV	
Numerical Differentiation and Integration: Derivative from difference tables - Divided differences and finite differences - Numerical integration by trapezoidal and Simpson's 1/3 and 3/8 rules - Two and Three point Gaussian quadrature formulas - Double integrals using trapezoidal and Simpson's rules.	**08 Hrs**

Unit -V	
Root Finding: Motivation and Objectives/ Bracketing methods/ Contraction Mapping Method/ Secant Method/ Muller's Method/ Newton's Method/ Polynomial Roots/ Nonlinear Systems of Equations.	**06 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Execute interpolation techniques for the data provided
2	Apply the basic transformation techniques and mathematic tools for finding the roots
3	Demonstrate the usage of numerical techniques for integration and differentiation of some simple functions
4	Identify and demonstrate the usage of curve fitting techniques to interpret the behaviour of given data
5	Solve for non-linear system of equations by finding their roots using suitable technique

Reference Books	
1	Germund Dahlquist, Ake Bjorck,, Numerical Methods, Reprint Edition, 2003, Dover Publications, ISBN 9780486428079
2	Steven Chapra, Numerical Methods for Engineers, 7th Edition, 2014, ISBN 9780077492168
3	D Vaughan Griffiths, I M Smith, Numerical Methods for Engineers, 2nd Edition, CRC Press, 1991, ISBN 9780849386107

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**2**	**1**	**3**	**1**		**2**	**2**	**1**				
CO2	**3**	**1**	**1**	**3**			**1**	**3**				**3**
CO3		**2**		**3**		**3**	**1**					**1**
CO4	**3**	**2**	**3**	**3**		**3**	**1**	**3**				**1**

High-3 : Medium-2 : Low-1

Semester: V		
BIOINFORMATICS **(Group B: Global Elective)**		
Course Code: 16G5B01		CIE Marks: 100
Credits :L:T:P:S: 4:0:0:0		SEE Marks: 100
Hours:04		SEE Duration: 3Hrs

Course Learning Objectives:	
1	Understand the underlying technologies of Bioinformatics and Programming
2	Explore the various algorithms behind the computational genomics and proteomic structural bioinformatics, modeling and simulation of molecular systems.
3	Apply the tools and techniques that are exclusively designed as data analytics to investigate the significant meaning hidden behind the high throughput biological data.
4	Analyze and evaluate the outcome of tools and techniques employed in the processes of biological data preprocessing and data mining.

Unit-I	
Biomolecules: Introduction to Biomolecules. Structure, Types and Functions of Carbohydrates, Lipids, Nucleic Acids and Proteins. Genetic code, Codon degeneracy, Genes and Genomes. **Bioinformatics & Biological Databases:** Introduction to Bioinformatics, Goals, Scope, Applications in biological science and medicine. Biological databases – Sequence, structure, Special Databases and applications - Genome, Microarray, Metabolic pathway, motif, and domain databases. Mapping databases – genome wide maps. Chromosome specific human maps.	**09 Hrs**
Unit – II	
Sequence Alignment: Introduction, Types of sequence alignments - Pairwise and Multiple sequence alignment, Alignment algorithms (Needleman & Wunch, Smith & Waterman and Progressive global alignment). Database Similarity Searching- Scoring matrices – BLOSSUM and PAM, Basic Local Alignment Search Tool (BLAST), and FASTA. Next Generation Sequencing – Alignment and Assembly. **Molecular Phylogenetics:** Introduction, Terminology, Forms of Tree Representation. Phylogenetic Tree Construction Methods - Distance-Based & Character-Based Methods and Phylogenetic Tree evaluation.	**09 Hrs**
Unit -III	
Predictive methods: Predicting secondary structure of RNA, Protein and Genes – algorithms to predict secondary structure of RNA, Protein and Gene. Prediction of Tertiary structure of Protein, Protein identity and Physical properties of protein. **Molecular Modeling and Drug Designing:** Introduction to Molecular Modeling. Methods of Molecular Modeling and Force Fields used in Molecular Modeling. Drug designing process - deriving Pharmacophore, Receptor Mapping, Estimating Receptor-Ligand interactions and Molecular Docking.	**09 Hrs**
Unit –IV	
Perl: Introduction to Perl, writing and executing a Perl program. Operators, Variables and Special variables. Data Types – Scalar, Array and Associative array. Regular Expressions (REGEX), Components of REGEX - Operators, Metacharacters and Modifiers. Subroutines – types of functions, defining and calling functions in Perl, calling function - call by value and call by reference. Object Oriented Programming in Perl–Class and object, Polymorphism, inheritance and encapsulation. Perl Package – writing and calling package. Perl Module – writing and calling module.	**09 Hrs**
Unit –V	
BioPerl: Introduction to BioPerl, BioPerl Modules, Applications of BioPerl – Sequence retrieval from Database and submission of sequence to online Database, Indexing and accessing local databases, Transforming formats of database record, Sequence alignments BioPerl and Sequence Analysis - Pair wise and Multiple sequence alignment, Restriction mapping. Identifying restriction enzyme sites, acid cleavage sites, searching for genes and other structures on genomic DNA, Parsing BLAST and FASTA results. BioPerl and	**09 Hrs**

phylogenetic analysis, BioPerl and Phylogenetic tree manipulation, creating graphics for Sequence display and Annotation.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the Architecture and Schema of online databases including structure of records in these databases.
CO2:	Explore the Mind crunching Algorithms, which are used to make predictions in Biology, Chemical Engineering, and Medicine.
CO3:	Apply the principles of Bioinformatics and Programming to the problems related to process simulation and process engineering in Biological system.
CO4:	Use Bioinformatics tools and Next Generation Technologies to model and simulate biological phenomenon.

Reference Books	
1	T. Christiansen, B. D. Foy, L. Wall, J. Orwant, Programming Perl: Unmatched power for text processing and scripting, O'Reilly Media, Inc., 4th Edition, 2012, ISBN-13: 978-0596004927
2	B. Haubold, T. Weihe, Introduction to Computational Biology: An Evolutionary Approach, new age publishers, Paperback Edition, 2009, ISBN-13: 978-8184890624
3	C. Bessant, I. Shadforth, D. Oakley, Building Bioinformatics Solutions: with Perl, R and MySQL, Oxford University Press, 1st edition, 2009, ISBN
4	D. C. Young. Computational Drug Design: A Guide for Computational and Medicinal Chemists,Wiley-Interscience, 1st edition, 2009, ISBN-13: 978-0470126851.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	2	3	2	3	3	-	-	1	2	-
CO2	3	3	3	2	3	3	2	-	2	-	-	-
CO3	3	2	2	2	2	1	1	-	-	-	1	-
CO4	1	2	3	3	3	2	1	-	-	2	-	-

High-3 : Medium-2 : Low-1

Semester: V		
FUEL CELL TECHNOLOGY **(Group B: Global Elective)**		
Course Code: 16G5B02		**CIE Marks:** 100
Credits: L:T:P:S:: 4:0:0:0		**SEE Marks:** 100
Hours: 45L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1	Recall the concept of fuel cells
2	Distinguish various types of fuel cells and their functionalities
3	Know the applications of fuel cells in various domains
4	Understand the characterization of fuel cells

UNIT-I	
Introduction: Fuel cell definition, historical developments, working principle of fuel cell, components of fuel cell, EMF of the cell, Fuel Cell Reactions, fuels for cells and their properties.	**09Hrs**
UNIT-II	
Fuel Cell Types: Classification of fuel cells, alkaline fuel cell, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cell, advantages and disadvantages of each .	**09Hrs**
UNIT-III	
Fuel Cell Reaction Kinetics: activation kinetics, open circuit voltage, intrinsic maximum efficiency, voltage efficiency, Faradaic efficiency, overall efficiency, over-voltages and Tafel equation.	**09Hrs**
UNIT-IV	
Fuel Cell Characterization: current – voltage curve, in-situ characterization, current – voltage measurement, current interrupt measurement, cyclic voltammetry, electrochemical impedance spectroscopy and ex-situ characterization techniques.	**09Hrs**
UNIT-V	
Applications of Fuel Cells: applications of fuel cells in various sectors, hydrogen production, storage, handling and safety issues.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Understand the fundamentals and characteristics of fuel cells
2	Apply chemical engineering principles to distinguish fuel cells from conventional energy systems
3	Analyze the performance of fuel cells using different characterization techniques
4	Evaluate the possibility of integrating fuel cell systems with conventional energy systems

Reference Books	
1.	Fuel Cells – Principles and Applications, Viswanathan and M Aulice Scibioh, 1st Edition, 2009, Universities Press, ISBN – 13: 978 1420 060287
2.	Fuel Cell Systems Explained, James Larminie and Andrew Dicks, 2nd Edition, 2003, John Wiley & Sons, ISBN – 978 0470 848579

3.	Fuel Cell Fundamentals, O 'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, 1st Edition, 2006, Wiley, New York, ISBN – 978 0470 258439
4.	Recent Trends in Fuel Cell Science and Technology, Basu. S, 1st Edition, 2007, Springer, ISBN – 978 0387 688152

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO - PO Mapping

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**
CO 1	**2**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**-**
CO 2	**2**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO 3	**-**	**3**	**-**	**-**	**-**	**-**	**3**	**-**	**2**	**-**	**-**	**-**
CO 4	**-**	**2**	**2**	**-**	**-**	**-**	**2**	**-**	**3**	**-**	**-**	**2**

High-3 : Medium-2 : Low-1

Semester: V		
GEOINFORMATICS **(Group B: Global Elective)**		
Course Code:16G5B03		CIE Marks: 100
Hrs/Week: L:T:P:S: 4:0:0:0		SEE Marks: 100
Credits: 48L		SEE Duration: 3Hrs

Course Learning Objectives: The students will be able to	
1	To understand concept of using photographic data to determine relative positions of points
2	To study the use of electromagnetic energy for acquiring qualitative and quantitative land information
3	To analyze the data gathered from various sensors and interpret for various applications
4	To understand the various applications of RS, GIS and GPS

UNIT-I	
Remote Sensing- Definition, types of remote sensing, components of remote sensing, Electromagnetic Spectrum, Black body, Atmospheric windows, energy interaction with earth surface features. spectral reflectance curve- physical basis for spectra reflectance curve, false color composite. Platforms and sensors. Sensor resolutions. Types of satellites- Indian and other remote sensing satellites (IRS, IKONS and Landsat). Concept of image interpretation and analysis - Principle of visual interpretation, recognition elements. Fundamentals of image rectification. Digital Image classification - supervised and unsupervised	**10 Hrs**
UNIT-II	
Photogrammetry: Introduction types of Photogrammetry, Advantages of Photogrammetry, Introduction to digital Photogrammetry. Locating points from two phases determination of focal length. **Aerial Photogrammetry:** Advantages over ground survey methods - geometry of vertical phographs, scales of vertical photograph. Ground coordination- relief displacement, scale ground coordinates – flight planning	**10 Hrs**
UNIT-III	
Geographic Information System- Introduction, Functions and advantages, sources of data for GIS. Database – Types, advantages and disadvantages. Data Management – Transformation, Projection and Coordinate systems. Data input methods, Data Analysis.- overlay operations, network analysis, spatial analysis. Outputs and map generation. . Introduction to GPS- components and working principles	**10 Hrs**
UNIT-IV	
Applications of GIS, Remote Sensing and GPS: Case studies on Water Resources engineering and management (prioritization of river basins, water perspective zones and its mapping), **Case studies on applications of GIS and RS in** highway alignment, Optimization of routes, accident analysis, Environmental related studies. **Case studies on applications of GIS and RS in** Disaster Management (Case studies on post disaster management - Earthquake and tsunami and pre disaster management - Landslides and floods) Urban Planning & Management - mapping of zones, layouts and infrastructures.	**09 Hrs**

UNIT-V	
Applications of GIS, Remote Sensing and GPS: Land use land cover (LULC) mapping. Case studies on infrastructure planning and management- Case studies on urban sprawl. Change detection studies – case studies on forests and urban area. Case studies on agriculture. **Applications of geo-informatics in natural resources management: Geo Technical case Studies**, site suitability analysis for various applications.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Understand the principle of Remote Sensing (RS) and Geographical Information Systems (GIS) data acquisition and its applications.

2	Apply RS and GIS technologies in various fields of engineering and social needs.
3	Analyze and evaluate the information obtained by applying RS and GIS technologies.
4	Create a feasible solution in the different fields of application of RS and GIS.

Reference Books	
1.	Geographic Information System-An Introduction, Tor Bernharadsen, 3rd Edition, Wiley India Pvt. Ltd. New Delhi , 2009.
2.	Principles of Remote sensing and Image Interpretation, Lillesand and Kiefer, 5th Edition, John Wiley Publishers, New Delhi, 2007.
3.	Remote Sensing and GIS, Bhatta B, Oxford University Press, New Delhi, 2008
4.	Remote Sensing, Robert A. Schowengerdt, 3rd Edition, Elsevier India Pvt Ltd, New Delhi, 2009

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	-	-	-	-	1	-	-	-	-	-	-
CO2	2	1	-	-	1	1	-	-	-	-	-	-
CO3	2	2	1	-	2	1	1	-	-	-	-	1
CO4	2	2	1	-	3	2	2	-	-	-	1	1

Low-1 Medium-2 High-3

Semester: V		
GRAPH THEORY **(Group B : Global Elective)**		
Course Code:16G5B04		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 45L		**SEE Duration: 3 Hrs**

Course Learning Objectives: The students will be able to	
1	Understand the basics of graph theory and their various properties.
2	Model problems using graphs and to solve these problems algorithmically.
3	Apply graph theory concepts to solve real world applications like routing, TSP/traffic control, etc.
4	Optimize the solutions to real problems like transport problems etc.,

UNIT-I	
Introduction to graph theory Introduction, Mathematical preliminaries, definitions and examples of graphs, degrees and regular graphs, sub graphs, directed graphs, in degrees and out degrees in digraphs. **Basic concepts in graph theory** Paths and cycles, connectivity, homomorphism and isomorphism of graphs, connectivity in digraphs.	**09 Hrs**
UNIT-II	
Graph representations, Trees, Forests Adjacency matrix of a graph, Incidence matrix of a graph, Adjacency lists, Trees and properties of trees, Characterization of trees, Centers of trees, Rooted trees, Binary threes, Spanning trees and forests, Spanning trees of complete graphs, An application to electrical networks, Minimum cost spanning trees.	**09 Hrs**
UNIT-III	
Fundamental properties of graphs and digraphs Bipartite graphs, Eulerian graphs, Hamiltonian graphs, Hamiltonian cycles in weighted graphs, Eulerian digraphs. **Planar graphs, Connectivity and Flows** Embedding in surfaces, Euler's formula, Characterization of planar graphs, Kuratowski's theorem, Dual of a planar graphs.	**09 Hrs**
UNIT-IV	
Matchings and Factors Min-Max theorem, Independent sets and covers, Dominating sets, maximum bipartite matching. **Coloring of graphs** The chromatic number of a graph, Results for general graphs, The chromatic polynomial of a graph, Basic properties of chromatic polynomial, chordal graphs, powers of graphs, Edge coloring of graphs	**09 Hrs**
UNIT-V	
Graph algorithms Graph connectivity algorithms, Breadth first search and Depth first search, Shortest path algorithms, Dijikstra's shortest path algorithm, Minimum cost spanning tree algorithms, Algorithm of Kruskal's and Prim's.	**09Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1.	Understand and explore the basics of graph theory.
CO2.	Analyse the significance of graph theory in different engineering disciplines
CO3.	Demonstrate algorithms used in interdisciplinary engineering domains.
CO4.	Evaluate or synthesize any real world applications using graph theory.

Reference Books	
1.	Introduction to graph theory, Douglas B. West, 2nd Edition, 2001, PHI, ISBN- 9780130144003, ISBN-0130144002.
2.	Graph Theory, modeling, Applications and Algorithms, Geir Agnarsson, Raymond Greenlaw, Pearson Education, 1st Edition,2008, ISBN- 978-81-317-1728-8.
3.	Introduction to Algorithms ,Cormen T.H., Leiserson C. E, Rivest R.L., Stein C. , 3rd Edition, 2010,PHI, ISBN:9780262033848

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**
CO2	**2**	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO3	**2**	**2**	**3**	**2**	**-**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO4	**2**	**2**	**3**	**2**	**-**	**1**	**-**	**-**	**2**	**2**	**-**	**1**

Low-1 Medium-2 High-3

Semester: V		
ARTIFICIAL NEURAL NETWORKS &DEEP LEARNING (Group B: Global Elective)		
Course Code: 16G5B05		**CIE Marks:** 100
Credits: L:T:P:S: 4:0:0:0		**SEE Marks:** 100
Hours: 46L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1	Define what is Neural Network and model a Neuron and Express both Artificial Intelligence and Neural Network
2	Analyze ANN learning, Error correction learning, Memory-based learning, Hebbian learning, Competitive learning and Boltzmann learning
3	Implement Simple perception, Perception learning algorithm, Modified Perception learning algorithm, and Adaptive linear combiner, Continuous perception, learning in continuous perception.
4	Analyze the limitation of Single layer Perceptron and Develop MLP with 2 hidden layers, Develop Delta learning rule of the output layer and Multilayer feed forward neural network with continuous perceptions,

UNIT-I	
Introduction to Neural Networks: Neural Network, Human Brain, Models of Neuron, Neural networks viewed as directed graphs, Biological Neural Network, Artificial neuron, Artificial Neural Network architecture, ANN learning, analysis and applications, Historical notes.	**08 Hrs**
UNIT-II	
Learning Processes: Introduction, Error correction learning, Memory-based learning, Hebbian learning, Competitive learning, Boltzmann learning, credit assignment problem, learning with and without teacher, learning tasks, Memory and Adaptation.	**10 Hrs**
UNIT-III	
Single layer Perception: Introduction, Pattern Recognition, Linear classifier, Simple perception, Perception learning algorithm, Modified Perception learning algorithm, Adaptive linear combiner, Continuous perception, Learning in continuous perception. Limitation of Perception.	**10 Hrs**
UNIT-IV	
Multi-Layer Perceptron Networks: Introduction, MLP with 2 hidden layers, Simple layer of a MLP, Delta learning rule of the output layer, Multilayer feed forward neural network with continuous perceptions, Generalized delta learning rule, Back propagation algorithm	**10 Hrs**
UNIT-V	
Introduction to Deep learning: Neuro architectures as necessary building blocks for the DL techniques, Deep Learning & Neocognitron, Deep Convolutional Neural Networks, Recurrent Neural Networks (RNN), feature extraction, Deep Belief Networks, Restricted Boltzman Machines, Autoencoders, Training of Deep neural Networks, Applications and examples (Google, image/speech recognition)	**08 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Model Neuron and Neural Network, and to analyze ANN learning, and its applications.
CO2:	Perform Pattern Recognition, Linear classification.
CO3:	Develop different single layer/multiple layer Perception learning algorithms
CO4:	Design of another class of layered networks using deep learning principles.

Reference Books	
1.	Neural Network- A Comprehensive Foundation , Simon Haykins, 2nd Edition, 1999, Pearson Prentice Hall, ISBN-13: 978-0-13-147139-9
2.	Introduction to Artificial Neural Systems, Zurada and Jacek M, 1992, West Publishing Company, ISBN: 9780534954604
3.	Learning & Soft Computing, Vojislav Kecman, 1st Edition, 2004, Pearson Education, ISBN:0-262-11255-8
4.	Neural Networks Design, M T Hagan, H B Demoth, M Beale, 2002, Thomson Learning, ISBN-10: 0-9717321-1-6/ ISBN-13: 978-0-9717321-1-7

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**
CO2	**3**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**1**
CO3	**3**	**3**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**
CO4	**3**	**3**	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**

Low-1 Medium-2 High-3

Semester: V		
HYBRID ELECTRIC VEHICLES **(Group B: Global Elective)**		
Course Code : 16G5B06		**CIE Marks : 100**
Credits : L:T:P:S 4:0:0:0		**SEE Marks : 100**
Hours : 45L		**SEE Duration : 3Hrs**

Course Learning Objectives: The students will be able to,	
1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2	Explain plug – in hybrid electric vehicle architecture, design and component sizing and the power electronics devices used in hybrid electric vehicles.
3	Analyze various electric drives suitable for hybrid electric vehicles and Different energy storage technologies used for hybrid electric vehicles and their control.
4	Demonstrate different configurations of electric vehicles and its components, hybrid vehicle configuration by different techniques, sizing of components and design optimization and energy management.

Unit-I	
Introduction: Sustainable Transportation, A Brief History of HEVs, Why EVs Emerged and Failed, Architectures of HEVs, Interdisciplinary Nature of HEVs, State of the Art of HEVs, Challenges and Key Technology of HEVs. **Hybridization of the Automobile:** Vehicle Basics, Basics of the EV, Basics of the HEV, Basics of Plug-In Hybrid Electric Vehicle (PHEV), Basics of Fuel Cell Vehicles (FCVs).	**07 Hrs**
Unit-II	
HEV Fundamentals: Introduction, Vehicle Model, Vehicle Performance, EV Powertrain Component Sizing, Series Hybrid Vehicle, Parallel Hybrid Vehicle, Wheel Slip Dynamics. **Plug-in Hybrid Electric Vehicles:** Introduction to PHEVs, PHEV Architectures, Equivalent Electric Range of Blended PHEVs, Fuel Economy of PHEVs, Power Management of PHEVs, Component Sizing of EREVs, Component Sizing of Blended PHEVs, Vehicle-to-Grid Technology.	**10 Hrs**
Unit-III	
Power Electronics in HEVs: Power electronics including switching, AC-DC, DC-AC conversion, electronic devices and circuits used for control and distribution of electric power, Thermal Management of HEV Power Electronics. **Batteries, Ultracapacitors, Fuel Cells, and Controls:** Introduction, Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Hydraulic Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System and Battery Management System.	**10 Hrs**
Unit-IV	
Electric Machines and Drives in HEVs: Introduction, BLDC motors, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motors, Doubly Salient Permanent Magnet Machines, Design and Sizing of Traction Motors, Thermal Analysis and Modelling of Traction Motors. **(only functional treatment to be given**)	**10Hrs**

Unit-V	
Integration of Subsystems: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems. **Energy Management Strategies:** Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy	**08Hrs**

strategies.	

Course Outcomes: After completing the course, the students will be able to	
1	Explain the basics of electric and hybrid electric vehicles, their architecture, technologies and fundamentals.
2	Evaluate the performance of electrical machines and power electronics converters in HEVs.
3	Analyse the different energy storage devices used for hybrid electric vehicles, their technologies and control and select appropriate technology
4	Design and evaluate the sizing of subsystem components and Energy Management strategies in HEVs.
Reference Books:	
1.	Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives, Mi Chris, Masrur A.and Gao D.W. Wiley Publisher, 1st Edition, 2011,*ISBN*:0-824-77653-5
2.	Ali, Modern Electric, Hybrid electric and Fuel Cell Vehicles, Ehsani Mehrdad, Gao Yimin, E. Gay Sebastien, Emadi CRC Press, 1st Edition, 2005, ISBN: *0-8493-3154-4.*
3.	Modern Electric Vehicle Technology, Chan, C.C.,Chau, K.T. Oxford University Press, 2001, ISBN 0 19 850416 0.
4.	Hybrid Electric Vehicles: Energy Management Strategies, Simona Onori, Lorenzo Serrao, Giorgio Rizzoni, *ISBN*: 978-1-4471-6779-2.

Continuous Internal Evaluation (CIE); Theory (100 Marks):
CIE is executed by way of Quizzes (Q), Tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks):
SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO/ PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**2**	**3**	**2**	**2**	**1**	**1**	**3**	**1**	**-**	**1**	**-**	**2**
CO2	**3**	**3**	**2**	**2**	**3**	**-**	**3**	**-**	**2**	**1**	**2**	**1**
CO3	**2**	**3**	**2**	**2**	**2**	**2**	**3**	**1**	**1**	**1**	**-**	**1**
CO4	**3**	**3**	**3**	**3**	**3**	**1**	**3**	**3**	**3**	**3**	**1**	**3**

High-3 : Medium-2 : Low-1

V Semester		
OPTIMIZATION TECHNIQUES **(Theory)** **(Open Elective B)**		
Course Code : 16G5B07		**CIE Marks : 100**
Credits : L: T: P: S:4:0:0:0		**SEE Marks : 100**
Hours : 44L		**SEE Duration : 03 Hrs**

Course Learning Objectives: The students will be able to	
1.	To understand the concepts behind optimization techniques.
2.	To explain the modeling frameworks for solving problems using optimization techniques.
3.	To design and develop optimization models for real life situations.
4.	To analyze solutions obtained using optimization methods.
5.	To compare models developed using various techniques for optimization.

UNIT – I	
Introduction: OR Methodology, Definition of OR, Application of OR to Engineering and Managerial problems, Features of OR models, Limitations of OR. **Linear Programming:** Definition, Mathematical Formulation, Standard Form, Solution Space, Types of solution – Feasible, Basic Feasible, Degenerate, Solution through Graphical Method. Problems on Product Mix, Blending, Marketing, Finance, Agriculture and Personnel. **Simplex methods:** Variants of Simplex Algorithm – Use of Artificial Variables.	**09 Hrs**
UNIT – II	
Duality and Sensitivity Analysis: Graphical sensitivity analysis, Algebraic sensitivity analysis - changes in RHS, Changes in objectives, Primal-Dual relationships, Economic interpretation of duality, Post optimal analysis - changes affecting feasibility and optimality, Revised simplex method	**09 Hrs**
UNIT – III	
Transportation Problem: Formulation of Transportation Model, Basic Feasible Solution using North-West corner, Least Cost, Vogel's Approximation Method, Optimality Methods, Unbalanced Transportation Problem, Degeneracy in Transportation Problems, Variants in Transportation Problems **Assignment Problem:** Formulation of the Assignment problem, solution method of assignment problem-Hungarian Method, Variants in assignment problem, Travelling Salesman Problem (TSP).	**08 Hrs**
UNIT – IV	
Queuing Theory: Queuing system and their characteristics, The M/M/I Queuing system, Steady state performance analyzing of M/M/1 queuing models. Introduction to M/M/C and M/Ek/1 queuing models **Game Theory**: Introduction, Two person Zero Sum game, Pure strategies, Games without saddle point - Arithmetic method, Graphical Method, The rules of dominance	**09Hrs**
UNIT – V	
Markov chains: Definition, Absolute and n-step transition probabilities, Classification of the states, Steady state probabilities and mean return times of ergodic chains, First passage times, Absorbing states. Applications in weather prediction and inventory management. Over view of OR software's used in practice.	**09 Hrs**

Course Outcomes: After going through this course the student will be able to	
CO1	Understand the various optimization models and their areas of application.
CO2	Explain the process of formulating and solving problems using optimization methods.
CO3	Develop models for real life problems using optimization techniques.
CO4	Analyze solutions obtained through optimization techniques.
CO5	Create designs for engineering systems using optimization approaches.

Reference Books:	
1.	Operation Research An Introduction, Taha H A, 8th Edition, 2009, PHI, ISBN: 0130488089.
2.	Principles of Operations Research – Theory and Practice, Philips, Ravindran and Solberg, 2nd Edition, 2000, John Wiley & Sons (Asia) Pte Ltd, ISBN 13: 978-81-265-1256-0
3.	Introduction to Operation Research, Hiller, Liberman, Nag, Basu, 9th Edition, 2012,Tata McGraw Hill, ISBN 13: 978-0-07-133346-7
4.	Operations Research Theory and Application, J K Sharma, 4th Edition, 2009, Pearson Education Pvt Ltd, ISBN 13: 978-0-23-063885-3.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2											
CO2	2	2		1	1							
CO3							1	1				
CO4	2		3		1							
CO5			2			1						1

Low-1 Medium-2 High-3

V Semester		
SENSORS & APPLICATIONS (Group B: Global Elective)		
Course Code:16G5B08		**CIE Marks:** 100
Credits/Week: L:T:P:S:4:0:0:0		**SEE Marks:** 100
Hours:44L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1	Impart the principles and working modes of various types of Resistive, Inductive, Capacitive, Piezoelectric and Special transducers.
2	Give an idea about the applications of various transducers and selection criteria of a transducer for a particular application.
3	Give an insight into the static and dynamic characteristics of different orders of instruments.
4	Describe different data conversion techniques and their applications.

UNIT-I	
Introduction: Definition of a transducer, Block Diagram, Active and Passive Transducers, Advantages of Electrical transducers. **Resistive Transducers:** Potentiometers: Characteristics, Loading effect, and problems. **Strain gauge:** Theory, Types, applications and problems. **Thermistor, RTD:** Theory, Applications and Problems.	**09 Hrs**
UNIT-II	
Thermocouple: Measurement of thermocouple output, compensating circuits, lead compensation, advantages and disadvantages of thermocouple. **LVDT:** Characteristics, Practical applications and problems. **Capacitive Transducers:** Capacitive transducers using change in area of plates, distance between plates and change of dielectric constants, Applications of Capacitive Transducers and problems.	**10 Hrs**
UNIT-III	
Piezo-electric Transducers: Principles of operation, expression for output voltage, Piezo-electric materials, equivalent circuit, loading effect, and Problems. **Special Transducers:** Hall effect transducers, Thin film sensors, and smart transducers: Principles and applications, Introduction to MEMS Sensors and Nano Sensors, Schematic of the design of sensor, applications.	**10 Hrs**
UNIT-IV	
Chemical sensors: pH value sensor, dissolved oxygen sensor, oxidation-reduction potential sensor. **Light sensors**: Photo resistor, Photodiode, Phototransistor, Photo-FET, Charge coupled device. **Tactile sensors:** Construction and operation, types.	**08 Hrs**
UNIT-V	
Data Converters: Introduction to Data Acquisition System, types of DAC, Binary Weighted DAC, R-2R ladder DAC, DAC-0800, Types of ADC, Single Slope ADC and Dual-slope integrated type ADC, Flash ADC, 8-bit ADC-0808, Programmable Gain Amplifier.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember and understand the basic principles of transducers and smart sensors.
CO2:	Apply the knowledge of transducers and sensors to comprehend digital instrumentation systems.
CO3:	Analyze and evaluate the performance of different sensors for various applications.

CO4:	Design and create a system using appropriate sensors for a particular application

Reference Books	
1	Electrical and Electronic Measurements and Instrumentation, A.K. Sawhney, 18th Edition, 2008, Dhanpat Rai and Sons, ISBN: 81-7700-016-0.
2	Sensor systems: Fundamentals and applications, Clarence W.de Silva, 2016 Edition, CRC Press, ISBN: 9781498716246.
3	Transducers and Instrumentation, D.V.S. Murthy, 2nd Edition 2008, PHI Publication, ISBN: 978-81-203-3569-1.
4	Introduction to Measurement and Instrumentation, Arun K. Ghosh, 3rd Edition, 2009, PHI, ISBN: 978-81-203-3858-6.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marksis executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO MAPPING												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO2	**2**	**3**	**-**	**-**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**
CO3	**1**	**2**	**2**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**2**
CO4	**-**	**-**	**-**	**-**	**1**	**1**	**-**	**-**	**-**	**3**	**-**	**1**

Low-1 Medium-2 High-3

Semester: V		
INTRODUCTION TO MANAGEMENT INFORMATION SYSTEMS (Group B: Global Elective)		
Course Code: 16G5B09		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours :45L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	To understand the basic principles and working of information technology.
2	Describe the role of information technology and information systems in business.
3	To contrast and compare how internet and other information technologies support business processes.
4	To give an overall perspective of the importance of application of internet technologies in business administration.

UNIT I	
Information Systems in Global Business Today: The role of information systems in business today, Perspectives on information systems, Contemporary approaches to information systems, Hands-on MIS projects. **Global E-Business and Collaboration** : Business process and information systems, Types of business information systems, Systems for collaboration and team work, The information systems function in business. A Case study on E business.	**09 Hrs**
UNIT II	
Information Systems, Organizations and Strategy: Organizations and information systems, How information systems impact organization and business firms, Using information systems to gain competitive advantage, management issues, **Ethical and Social issues in Information Systems**: Understanding ethical and Social issues related to Information Systems, Ethics in an information society, The moral dimensions of information society. A Case study on business planning.	**09 Hrs**
UNIT III	
IT Infrastructure and Emerging Technologies : IT infrastructure, Infrastructure components, Contemporary hardware platform trends, Contemporary software platform trends, Management issues**. Securing Information Systems**: System vulnerability and abuse, Business value of security and control, Establishing framework for security and control, Technology and tools for protecting information resources. A case study on cybercrime.	**09 Hrs**
UNIT IV	
Achieving Operational Excellence and Customer Intimacy: Enterprise systems, Supply Chain Management (SCM) systems, Customer relationship management (CRM) systems, Enterprise application. **E-commerce: Digital Markets Digital Goods**: E-commerce and the internet, E-commerce-business and technology, The mobile digital platform and mobile E-commerce, Building and E-commerce web site. A Case study on ERP.	**09 Hrs**
UNIT V	
Managing Knowledge: The knowledge management landscape, Enterprise-wide knowledge management system, Knowledge work systems, Intelligent techniques. **Enhancing Decision Making**: Decision making and information systems, Business intelligence in the enterprise. Business intelligence constituencies. **Building Information Systems**: Systems as planned organizational change, Overview of systems development.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and apply the fundamental concepts of information systems.
CO2:	Develop the knowledge about management of information systems.
CO3:	Interpret and recommend the use information technology to solve business problems.

CO4:	Apply a framework and process for aligning organization's IT objectives with business strategy.
Reference Books	
1	Management Information System, Managing the Digital Firm, Kenneth C. Laudon and Jane P. Laudon, 14th Global Edition, 2016, Pearson Education, ISBN:9781292094007
2	Management Information Systems, James A. O' Brien, George M. Marakas, 10th Edition, 2011, Global McGraw Hill, ISBN: 978-0072823110
3	Information Systems The Foundation of E-Business, Steven Alter, 4th Edition, 2002, Pearson Education, ISBN:978-0130617736
4	W.S. Jawadekar, Management Information Systems, Tata McGraw Hill, 2006, ISBN: 9780070616349

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	-	1	-	-	-	1	-	-	1	-
CO2	1	2	-	1	-	-	-	1	-	-	1	-
CO3	-	-	3	2	2	-	-	1	-	1	1	-
CO4	-	-	2	1	-	-	-	1	-	1	1	-

Low-1 Medium-2 High-3

Semester: V		
INDUSTRIAL AUTOMATION (Theory)		
Course Code: 16GB510		**CIE Marks: 100**
Credits: L:T:P:S : 4:0:0:0		**SEE Marks: 100**
Hours: 44L		**SEE Duration: 3 Hrs**

Course Learning Objectives: The students should be able to:	
1	Identify types of actuators, sensors and switching devices for industrial automation
2	Explain operation and controls of Hydraulic and Pneumatic systems
3	Understand fundamentals of CNC, PLC and Industrial robots
4	Define switching elements and sensors which are interfaced in an automation system
5	Describe functions of Industrial switching elements and Inspection technologies for automation
6	Select sensors to automatically detect motion of actuators
7	Develop manual part programs for CNC and Ladder logic for PLC
8	Develop suitable industrial automation systems using all the above concepts

UNIT-I	
Automation in Production Systems: Manufacturing support systems, Automation principles and strategies, Levels of Automation, Production Concepts and Mathematical models, Numericals **Automated Production Lines:** Fundamentals, Applications, Analysis with no storage, Analysis with storage buffer, Numericals	**08 Hrs**
UNIT-II	
Switching theory and Industrial switching elements Binary elements, binary variables, Basic logic gates, Theorems of switching algebra, Algebraic simplification of binary function, Karnough maps, Logic circuit design, problems. Electromechanical relays, Moving part logic elements, Fluidic elements, Timers, Comparisons between switching elements, Numericals **Industrial Detection Sensors and Actuators:** Introduction, Limit switches, Reed switches, Photoelectric sensors- methods of detection, Hall effect sensors, Inductive proximity sensors, Capacitive proximity sensors, Pneumatic back pressure sensors, Absolute encoder, Incremental encoder, Pressure switches and temperature switches; their working principles and applications, Brushless DC motors, Stepper motors and Servo motors	**08 Hrs**
UNIT-III	
Hydraulic Control circuits Components, Symbolic representations, Control of Single and Double Acting Cylinder, Regenerative Circuit application, Pump unloading circuit, Double Pump Hydraulic System, speed control circuits, accumulator circuits **Pneumatic Control circuits** Components, Symbolic representations as per ISO 5599, Indirect control of double acting cylinders, memory control circuit, cascading design, automatic return motion, quick exhaust valve circuit, and cyclic operation of a cylinder, pressure sequence valve and time delay valve circuits.	**10 Hrs**
UNIT-IV	
Introduction to CNC Numerical control, components of CNC, classification, coordinate systems, motion control strategies, interpolation, programming concepts **Industrial Robotics** Components of Robots, base types, classification of robots, end of arm tooling, robot precision of movement, programming, justifying the use of a robot, simple Numericals	**08 Hrs**

UNIT-V	
Programmable logic control systems Difference between relay and PLC circuits, PLC construction, principles of operation, latching, ladder diagrams, programming instructions, types of timers, forms of counters, writing simple ladder diagrams from narrative description and Boolean logic. **Programming exercises on PLC with Allen Bradley controller** Programming exercises on motor control in two directions, traffic control, annunciator flasher, cyclic movement of cylinder, can counting, conveyor belt control, alarm system, sequential process, and continuous filling operation on a conveyor.	**10 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Illustrate applications of sensors actuators, switching elements and inspection technologies in industrial automation
2	Build circuit diagrams for fluid power automation, Ladder diagrams for PLC and identify its application areas
3	Evaluate CNC programs for 2D complex profiles performed on machining and turning centres interfaced with Robots
4	Develop suitable industrial automated system integrating all of the above advanced automation concepts

Reference Books	
1.	Industrial automation - Circuit design and components , David W. Pessen, 1st Edition, 2011, Wiley India, ISBN –13–978–8126529889
2.	Pneumatic Controls , Joji P, 1st Edition, Wiley India, ISBN – 978–81–265–1542–4
3.	Fluid Power with Applications , Anthony Esposito, 7th Edition , 2013, ISBN – 13; 978– 9332518544
4.	Automation, Production systems and Computer Integrated Manufacturing , Mikell P. Groover, 3rd Edition , 2014 , ISBN – 978–81–203–3418–2

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**				**2**	**1**	**2**	**1**			**1**	**2**
CO2	**1**		**2**	**3**	**2**	**2**	**2**			**2**		
CO3		**1**		**2**	**1**					**2**		
CO4			**3**	**2**	**2**	**1**		**2**	**2**	**3**	**2**	**2**

Low-1 Medium-2 High-3

Semester: V		
TELECOMMUNICATION SYSTEMS **(Group B: Global Elective)**		
Course Code: 16G5B11		**CIE Marks: 100**
Credits: L:T:P:S: 4:0:0:0		**SEE Marks: 100**
Hours: 46L		**SEE Duration: 03Hrs**

Course Learning Objectives: The students will be able to	
1	Represent schematic of communication system and identify its components.
2	Classify satellite orbits and sub-systems for communication.
3	Analyze different telecommunication services, systems and principles.
4	Explain the role of optical communication system and its components.
5	Describe the features of wireless technologies and standards.

UNIT-I	
Introduction to Electronic Communication: The Significance of Human Communication, Communication Systems, Types of Electronic Communication, Modulation and Multiplexing, Electromagnetic Spectrum, Bandwidth, A Survey of Communication Applications. **The Fundamentals of Electronics**: Gain, Attenuation, and Decibels.	**09 Hrs**
UNIT-II	
Modulation Schemes: Analog Modulation: AM, FM and PM- brief review. **Digital Modulation:** PCM, Line Codes, ASK, FSK, PSK, and QAM. **Wideband Modulation:** Spread spectrum, FHSS, DSSS. **Multiplexing and Multiple Access Techniques:** Frequency division multiplexing, Time division multiplexing **Multiple Access**: FDMA, TDMA, CDMA, Duplexing.	**10 Hrs**
UNIT-III	
Satellite Communication: Satellite Orbits, Satellite Communication Systems, Satellite Subsystems, Ground Stations, Satellite Applications, Global Positioning System.	**09 Hrs**
UNIT-IV	
Optical Communication: Optical Principles, Optical Communication Systems, Fiber-Optic Cables, Optical Transmitters and Receivers, Wavelength-Division Multiplexing, Passive Optical Networks.	**09 Hrs**
UNIT-V	
Cell Phone Technologies: Cellular concepts, Frequency allocation, Frequency reuse. Advanced Mobile Phone System (AMPS) **Digital Cell Phone Systems:** 2G, 2.5G, 3G and 4G cell phone systems, Advanced Cell Phones. **Wireless Technologies:** Wireless LAN, PANs and Bluetooth, ZigBee and Mesh Wireless Networks, WiMAX and Wireless Metropolitan-Area Networks.	**09 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the basics of communication systems.
CO2	Analyze the importance of modulation and multiple access schemes for communication systems.
CO3	Compare different telecommunication generations, wired and wireless communication.
CO4	Justify the use of different components and sub-system in advanced communication systems.

Reference Books	
1.	Principles of Electronic Communication Systems, Louis E. Frenzel, 3rd Edition, 2008, Tata McGraw Hill, ISBN: 978-0-07-310704-2.

2.	Electronic Communication Systems, Roy Blake, 2nd Edition, 2002, Thomson/Delamar, ISBN: 978-81-315-0307-2.
3.	Electronic Communication Systems, George Kennedy, 3rd Edition, 2008, Tata McGraw Hill ISBN: 0-02-800592-9.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	1	---	1	1	---	---	---	1	---	---	---
CO2	2	1	---	1	1	---	---	---	1	---	---	---
CO3	2	1	---	1	1	---	---	---	2	---	---	---
CO4	1	1	---	1	1	1	---	---	1	---	---	---

Low-1 Medium-2 High-3

Semester: V		
COMPUTATIONAL ADVANCED NUMERICAL METHODS (Group B: Global Elective)		
Course Code:16G5B12		**CIE Marks:** 100
Credits: L:T:P:S: 4:0:0:0		**SEE Marks:** 100
Hours: 44L		**SEE Duration:** 3Hrs

Course Learning Objectives:	
1	Adequate exposure to learn alternative methods and analyze mathematical problems to determine the suitable numerical techniques.
2	Use the concepts of interpolation, eigen value problem techniques for mathematical problems arising in various fields.
3	Solve initial value and boundary value problems which have great significance in engineering practice using ordinary differential equations.
4	Demonstrate elementary programming language, implementation of algorithms and computer programs to solve mathematical problems.

Unit-I	
Algebraic and Transcendental equations: Roots of equations in engineering practice, Polynomials and roots of equations, Fixed point iterative method, Aitken's process, Muller's method, Chebychev method.	**08 Hrs**
Unit – II	
Interpolation: Introduction to finite differences, Finite differences of a polynomial, Divided differences and Newton's divided difference interpolation formula, Hermite interpolation, Spline interpolation–linear, quadratic and cubic spline interpolation.	**08 Hrs**
Unit -III	
Ordinary Differential Equations: Solution of second order initial value problems–Runge-Kutta method, Milne's method, Boundary value problems (BVP's)–Shooting method, Finite difference method for linear and nonlinear problems, Rayleigh-Ritz method.	**09 Hrs**
Unit –IV	
Eigen value problems: Eigen values and Eigen vectors, Power method, Inverse Power method, Bounds on Eigen values, Greschgorin circle theorem, Jacobi method for symmetric matrices, Givens method.	**09 Hrs**
Unit –V	
Computational Techniques: Algorithms and Matlab programs for Fixed point iterative method, Aitken's–process, Muller's method, Chebychev method, Newton's divided difference method, Hermite interpolation, Spline interpolation, Power method, Inverse Power method, Runge-Kutta method, Milne's method, Shooting method, Rayleigh-Ritz method, Jacobi method and Givens method.	**10 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify and interpret the fundamental concepts of polynomial equations, Interpolation, Eigen value problems, Differential equations and corresponding computational techniques.
CO2:	Apply the knowledge and skills of computational techniques to solve algebraic and transcendental equations, Ordinary differential equations and eigen value problems.
CO3:	Analyze the physical problem and use appropriate method to solve roots of equations, Interpolating the polynomial, Initial and boundary value problems, Eigen value problems numerically using computational techniques.
CO4:	Distinguish the overall mathematical knowledge gained to demonstrate and analyze the problems of finding the roots of equations, Interpolation, Differential equations, Eigen value problems arising in engineering practice.

Reference Books	
1	Numerical methods for scientific and engineering computation, M. K. Jain, S. R. K. Iyengar and R. K. Jain, New Age International Publishers, 6th Edition, 2012, ISBN-13: 978-81-224-2001-2.
2	Numerical Analysis, Richard L. Burden and J. Douglas Faires, Cengage Learning, 9th Edition, 2012, ISBN-13: 978-81-315-1654-6.
3	Introductory Methods of Numerical Analysis, S. S. Sastry, PHI Learning Private Ltd., 4th Edition, 2011, ISBN: 978-81-203-2761-0.
4	Numerical Methods for Engineers, Steven C Chapra, Raymond P Canale, Tata Mcgraw Hill, 5th Edition, 2011, ISBN-10: 0-07-063416-5.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO2	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO3	**2**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
CO4	**3**	**3**	**1**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**3**

High-3: Medium-2: Low-1

Semester: V		
GLOBAL ELECTIVE-B		
BASICS OF AEROSPACE ENGINEERING (Theory)		
Course Code: 16GE5B13		**CIE Marks:** 100
Credits: L:T:P:S: 4:0:0:0		**SEE Marks:** 100
Hours: 44L		**SEE Duration:** 3Hours

Course Learning Objectives: To enable the students to:	
1	Understand the history and basic principles of aviation
2	Demonstrate and explain foundation of flight, aircraft structures, material, aircraft propulsion
3	Comprehend the importance of all the systems and subsystems incorporated on a air vehicle
4	Appraise the significance of all the subsystems in achieving a successful flight

Unit-I	
Introduction to Aircraft : History of aviation, International Standard atmosphere, Atmosphere and its properties, Temperature, pressure and altitude relationships, Classification of aircrafts, Anatomy of an aircraft & Helicopters, Basic components and their functions, Introduction to Unconventional and Autonomous Air vehicles.	**09 Hrs**
Unit – II	
Basics of Aerodynamics : Bernoulli's theorem, Aerodynamic forces and moments on an Airfoil, Lift and drag, Types of drag, Centre of pressure and its significance, Aerodynamic centre, Aerodynamic Coefficients, Wing Planform Geometry, Airfoil nomenclature, Basic characteristics of airfoils, NACA nomenclature, Simple problems on lift and drag.	**10 Hrs**
Unit -III	
Aircraft Propulsion : Introduction, Classification of powerplants, Piston Engine: Types of reciprocating engines, Principle of operation of turbojet, turboprop and turbofan engines, Introduction to ramjets and scramjets, Comparative merits and demerits of different types Engines.	**08 Hrs**

Unit -IV	
Introduction to Space Flight : History of space flight, Evolution of Indian Space Technology, The upper atmosphere, Introduction to basic orbital mechanics, some basic concepts, Kepler's Laws of planetary motion, Orbit equation, Space vehicle trajectories**.** **Rocket Propulsion :** Principles of operation of rocket engines, Classification of Rockets, Types of rockets.	**09 Hrs**
Unit -V	
Aerospace Structures and Materials : Introduction, General types of construction, Monocoque, Semi-Monocoque and Geodesic structures, Typical wing and fuselage structure; Metallic and non-metallic materials for aircraft application. Use of aluminum alloy, titanium, stainless steel and composite materials, Low temperature and high temperature materials.	**08 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Appreciate and apply the basic principles of aviation
2	Apply the concepts of fundaments of flight, basics of aircraft structures, aircraft propulsion and aircraft materials during the development of an aircraft
3	Comprehend the complexities involved during development of flight vehicles.

4	Evaluate and criticize the design strategy involved in the development of airplanes

Reference Books	
1	John D. Anderson, Introduction to Flight, 7th Edition, 2011, McGraw-Hill Education, ISBN 9780071086059.
2	Sutton G.P., Rocket Propulsion Elements, 8th Edition, 2011, John Wiley, New York, ISBN:1118174208, 9781118174203.
3	Yahya, S.M, Fundamentals of Compressible Flow, 5th Edition, 2016, New Age International, ISBN: 8122440223
4	T.H.G Megson, Aircraft structural Analysis, 2010, Butterworth-Heinemann Publications, ISBN: 978-1-85617-932-4

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**2**	**2**	**3**	**2**	**1**	**1**	**1**				**1**
CO3	**1**		**3**	**3**								**1**
CO4	**2**	**2**	**3**	**3**		**2**	**2**	**2**				**1**

High-3 : Medium-2 : Low-1

VI SEMESTER **FOUNDATIONS OF MANAGEMENT AND ECONOMICS** **(Theory)** **(Common to AE, CSE, ECE, EEE, ISE, TE)**		
Course Code: 16HEM61		**CIE Marks:** 50
Credits: L:T:P:S: 2:0:0:0		**SEE Marks:** 50
Hours: 23L		**SEE Duration:** 02Hrs

Course Learning Objectives: The students will be able to	
1	Understand the evolution of management thought.
2	Acquire knowledge of the functions of Management.
3	Gain basic knowledge of essentials of Micro economics and Macroeconomics.
4	Understand the concepts of macroeconomics relevant to different organizational contexts.

UNIT-I	
Introduction to Management: Management Functions, Roles & Skills, Management History – Classical Approach: Scientific Management & Administrative Theory, Quantitative Approach: Operations Research, Behavioural Approach: Hawthorne Studies, Contemporary Approach: Systems & Contingency Theory.	**04 Hrs**
UNIT-II	
Foundations of Planning: Types of Goals & Plans, Approaches to Setting Goals & Plans, Strategic Management Process, Corporate & Competitive Strategies.	**02 Hrs**
Organizational Structure & Design: Overview of Designing Organizational Structure: Work Specialization, Departmentalization, Chain of Command, Span of Control, Centralization & Decentralization, Formalization, Mechanistic & Organic Structures.	**03 Hrs**
UNIT-III	
Motivating Employees: Early Theories of Motivation: Maslow's Hierarchy of Needs Theory, McGregor's Theory X & Theory Y, Herzberg's Two Factor Theory, Contemporary Theories of Motivation: Adam's Equity & Vroom's Expectancy Theory.	**03 Hrs**
Managers as Leaders: Behavioural Theories: Ohio State & University of Michigan Studies, Blake & Mouton's Managerial Grid, Contingency Theories of Leadership: Hersey & Blanchard's Situational Leadership, Contemporary Views of Leadership: Transactional & Transformational Leadership.	**03 Hrs**
UNIT-IV	
Introduction to Economics: Concept of Economy and its working, basic problems of an Economy, Market mechanism to solve economic problems, Government and the economy, **Essentials of Micro Economics:** Concept and scope, tools of Microeconomics, themes of microeconomics, Decisions: some central themes, Markets: Some central themes, Uses of Microeconomics.	**04 Hrs**
UNIT-V	
Essentials of Macroeconomics: Prices and inflation, Exchange rate, Gross domestic product(GDP) , components of GDP, the Labour Market, Money and banks, Interest rate, Macroeconomic models- an overview, Growth theory, The classical model, Keynesian cross model, IS-LM-model, The AS-AD-model, The complete Keynesian model, The neo-classical synthesis, Exchange rate determination and the Mundell-Fleming model	**04 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain the principles of management theory & recognize the characteristics of an organization.
CO2:	Demonstrate the importance of key performance areas in strategic management and design appropriate organizational structures and possess an ability to conceive various organizational dynamics.
CO3:	Select & Implement the right leadership practices in organizations that would enable systems orientation.
CO4:	Understand the basic concepts and principles of Micro economics and Macroeconomics

Reference Books	
1.	Management, Stephen Robbins, Mary Coulter & Neharika Vohra, 10th Edition, 2001, Pearson Education Publications, ISBN: 978-81-317-2720-1.
2.	Management, James Stoner, Edward Freeman & Daniel Gilbert Jr, 6th Edition, 1999, PHI, ISBN: 81-203-0981-2.
3.	Microeconomics, Douglas Bernheim B & Michael D Whinston, 5th Edition, 2009, TMH Pub. Co. Ltd, ISBN: 13:978-0-07-008056-0.
4.	Macroeconomics: Theory and Policy, Dwivedi.D.N, 3rd Edition, 2010, McGraw Hill Education; ISBN-13: 978-0070091450.
5.	Essentials of Macroeconomics, (www.bookboon.com), Peter Jochumzen, 1st Edition. 2010, e-book, ISBN:978-87-7681-558-5.

Continuous Internal Evaluation (CIE); Theory (50 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 05 marks adding up to 15 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 25 marks each and the sum of the marks scored from three tests is reduced to 30. The marks component for Assignment is 05. The total marks of CIE are 50.

Semester End Evaluation (SEE); Theory (50 Marks)

SEE for 50 marks are executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 10 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 08 marks adding up to 40 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	1		2	2			1			2	2	
CO3	1							2	2	2	1	
CO4	1	2				2						2

Low-1 Medium-2 High-3

Semester: VI		
AEROSPACE PROPULSION (Theory & Practice)		
Course Code: 16AS62		**CIE Marks:** 100+50
Credits: L:T:P:S: 3:0:1:0		**SEE Marks:** 100+50
Hours: 36L		**SEE Duration:** 3Hrs+3Hrs

Course Learning Objectives: To enable the students to:	
1	Understand the operating principles of Aerospace engines and their subsystems
2	Outline the various parameters that affect the design of propulsion systems
3	Identify the critical parameters that influence the performance of a propulsion system
4	Analyse the performance of a propulsion system and its subsystems

Unit-I	
Fundamentals of Aerospace propulsion : Introduction, Brayton Cycle: Ideal & Real, Illustration of working of gas turbine engine, Various configurations of a simple gas turbine engine, Working principle and characteristics of Turbojet, Turboprop and Turbofan Engines, Thrust equation for Airbreathing Engines, Factors affecting thrust, Airbreathing Engine Performance Parameters, Numericals.	**09 Hrs**

Unit -II	
Aircraft Propulsion Systems : Aircraft Inlets, Types of Inlets: Subsonic & Supersonic Inlets, Compressors: Centrifugal & Axial Types, Combustion Chambers: Principle of operation, Classification of Combustion Chambers, Turbines: Operating Principle, Nozzles: Converging & Converging-Diverging Nozzles, Thrust Augmentation: Water Injection, Bleed Burn Cycle, Afterburner Techniques, (Without Numericals).	**09 Hrs**

Unit -III	
Ramjet Engines : Operating principle, Characteristics of Ramjet Engines, Sub critical, critical and supercritical operation, Combustion in ramjet engine, Ramjet performance, Integral ram- rocket. **Scramjet Engines :** Introduction to scramjet engines, Working principle of a scramjet engine, Preliminary concepts in supersonic combustion.	**06 Hrs**

Unit -IV	
Rocket Propulsion : Comparison between Airbreathing & Non-Airbreathing engines, Classification of rocket propulsion, Types of rocket propulsion systems, Liquid propellants: Types, Properties, Propellant feed systems, Solid propellants: Types, Properties, Combustion parameters, Thrust profiles, Grain configurations, Rocket Nozzles: Nozzle configurations.	**06 Hrs**

Unit -V	
Rocket Performance : Rocket equation, Performance Parameters: Thrust, Total Impulse, Specific Impulse, Specific propellant consumption, Effective Exhaust Velocity, Characteristic Velocity, Mass Ratio, Propellant Mass Fraction, Impulse to weight ratio, Thrust to weight ratio, Numerical examples.	**06 Hrs**

LABORATORY EXPERIMENTS	
1. Performance analysis of a micro gas turbine/jet propulsion system 2. Determination of Compressor characteristics and a typical compressor map for a given axial flow compressor 3. Performance analysis of a gas turbine combustion chamber/Fuel Injection	

characteristics of a gas turbine engine 4. Measurement of burning velocity of a pre-mixed flame in a gas turbine combustion chamber 5. Determination of turbine characteristics and a typical turbine map for a given axial flow turbine 6. Determination of pressure and velocity variation of a supersonic exhaust jet flowing out of a convergent-divergent nozzle 7. Determine the pressure and velocity variation of an exhaust gas flowing out of a convergent nozzle 8. Study of flow through an axial cascade compressor blade row 9. Study of flow through an axial cascade turbine blade row 10. Determination of Performance characteristics of a fixed/variable pitch aircraft propeller 11. Performance analysis of a rocket engine 12. Determination of Thrust of a ramjet/pulsejet engine	

Course Outcomes: At the end of this course the student will be able to :	
1	Familiarize with the working of different Air-Breathing and Non Air-breathing Engines and their subsystems
2	Illustrate the important parameters that affect the design of each subsystems
3	Analyze the effect of external and internal parameters affecting the performance of a propulsion system
4	Design, estimate and evaluate the efficiency of a given propulsion system

Reference Books	
1	Jack D Mattingly, Elements of Propulsion: Gas Turbines and Rockets, 5th Edition, 2006, American Institute of Aeronautics and Astronautics (AIAA), ISBN: 1563477793.
2	Sutton G P, Rocket Propulsion Elements, 8th Edition, 2010, John Wiley, New York, ISBN:9781118174203
3	Saravanamuttoo Prof Gordon Rogers, Prof Henry Cohen, Gas Turbine Theory, 6th Edition, 2008, prentice Hall, 2001, ISBN-10: 013015847X
4	Yahya, S.M.Fundamentals of Compressible Flow, 5th Edition, 2016, New Age International, ISBN: 8122440223
5	V Ganesan, Gas Turbines, 3rd Edition, 2017, McGraw Hill Education, ISBN-10: 0070681929

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total CIE for theory is 100.

Laboratory- 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150

Theory – 100 Marks

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: VI		
VIBRATION ENGINEERING (Theory & Practice)		
Course Code: 16AS63		**CIE marks**: 100+50
Hours/Week:L:T:P:S:3:0:1:1		**SEE Marks :**100+50
Hours : 36L		**SEE:** 3Hours+3Hours

Course Learning Objectives: To enable the students to:	
1	State and classify the principle of vibrations
2	Analyse and solve the problems associated with damped and un-damped vibrations
3	Demonstrate the effect of external excitation on a 1D system and identify their critical parameters
4	Evaluate a 2D system for modes of vibration and appreciate the effect of dampers
5	Apply numerical techniques for solving multi DOF systems

Unit-I	
Introduction : Types of vibrations, Definitions, Simple Harmonic Motion (S.H.M.), Work done by harmonic force, Principle of super position applied to SHM, Beats, Fourier theorem and problems.	**07 Hrs**

Unit -II	
Damped and Undamped Vibrations : Derivations for spring mass systems, Methods of Analysis, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations and Problems. Derivations for over, critical and under damped systems, Logarithmic decrement and Problems.	**07 Hrs**

Unit -III	
Forced Vibrations (1DOF) : Introduction, Analysis of forced vibration with constant harmonic excitation - magnification factor, rotating and reciprocating unbalances, excitation of support (relative and absolute amplitudes), force and motion transmissibility, Energy dissipated due to damping and Problems.	**07 Hrs**

Unit -IV	
Systems with two degrees of Freedom : Principle modes of vibrations, Normal mode and natural frequencies of systems (without damping) – Masses on tightly stretched strings, double pendulum, torsional systems, combined rectilinear and angular systems, Undamped dynamic vibration absorber and Problems.	**08 Hrs**

Unit -V	
Numerical Methods for multi degree freedom of systems : Introduction, Maxwell's reciprocal theorem, Influence coefficients, Rayleigh's method, Dunkerley's method, Stodola method, Holzer's method, Orthogonality of principal modes, method of matrix iteration and Problems.	**07 Hrs**

LABORATORY EXPERIMENTS	
1. Static and Dynamic balancing of rotating masses. 2. Determination of direction and magnitude of gyroscopic couple in relation to rotor spin directions. 3. Determination of relationship between centrifugal force, mass and its distance from axis of rotation. 4. Determination of acceleration due to gravity using a simple pendulum compound pendulum and kater (reversible) pendulum.	

5. Determination of moment of inertia of a horizontal rectangular drop bar about its center of mass using the bifilar suspension technique. 6. Calculation of natural frequency and damping ratio of a spring-mass system. 7. To determine the natural frequency of undamped torsional vibration of single and two rotor shaft system with viscous damping. 8. Study on the transverse vibration of a beam with attached bodies. 9. Study on forced vibration of rigid body-spring system with negligible damping 10. Study on the free damped vibrations of a rigid body – spring system 11. Study on the forced damped vibration of a rigid body – spring system 12. Components subjected to Random, sinusoidal and shock vibration test	

Course Outcomes: At the end of this course the student will be able to :	
1	State and classify the principle of vibrations
2	Analyse and solve the problems associated with damped and un-damped vibrations
3	Demonstrate the effect of external excitation on a 1D system and identify their critical parameters
4	Evaluate a 2D system for modes of vibration and appreciate the effect of dampers
5	Identify and apply suitable numerical technique for solving multi DOF systems

Reference Books	
1	Singiresu S. Rao, Mechanical Vibrations, 5th Edition, 2003, Addison Wesley Longman ISBN-978-0132128193.
2	Benson H Tongue, Principles of Vibration, 2nd edition, 2002, Oxford University Press, ISBN-978-0195142464
3	Thomson, W.T., Theory of Vibration with Applications, 2002 CBS Publishers and Distributers, NewDelhi, ISBN 13: 9788123908830
4	Kelly, Fundamentals of Mechanical Vibrations, 2nd Edition, 2000, McGraw Hill Publications, ISBN- 978-0072300925
5	Rao, J. S., and Gupta K., Ind. Course on Theory and Practice Mechanical Vibration, 2nd Edition, 2005, New Age International (P) Ltd, ISBN- 978-8122412154

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total CIE for theory is 100.

Laboratory- 50 Marks

The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150

Theory – 100 Marks

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I,

IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Laboratory- 50 Marks

Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**
CO5	**3**	**3**	**3**	**2**	**2**							**3**

High-3 : Medium-2 : Low-1

Semester: VI		
AIRCRAFT INSTRUMENTATION (Theory & Practice)		
Course Code: 16AS64		**CIE Marks:** 100+50
Credits: L:T:P:S: 3:0:1:1		**SEE Marks:** 100+50
Hours: 36L		**SEE Duration:** 3 Hours+3 Hours

Course Learning Objectives: To enable the students to:	
1	List the various systems involved in the design of an aircraft
2	Demonstrate the technical attributes of all the subsystems of an aircraft
3	Explain the significance of each systems and its subsystems for developing an airplane
4	Demonstrate the integration of the systems with the airplane

Unit-I	
Aircraft Hydraulic & Pneumatic Systems: Components of a typical Hydraulic system, Working of Hydraulic system, Power packs, Hydraulic actuators. Aircraft, Landing gear and Wheel Braking and Anti-Skid & Shimmy System, Shock absorbers-Retraction mechanism. Pneumatic system and components, Use of bleed air. Hydraulic & Pneumatic system Instruments	**07 Hrs**

Unit -II	
Aircraft Fuel Systems : Characteristics of aircraft fuel system, Fuel system and its components, Gravity feed and pressure feed fuel systems, Fuel pumps-classification. **Fuel Quantity and Indicating system:** Capacitance type systems, measurement of fuel quantity by weight, basic fuel quantity indicating systems, effects of fuel temperature changes, Fuel flow measurements and indication system.	**07 Hrs**

Unit -III	
Aero Engine Systems : Types of Starting and Ignition systems, Engine starting sequence, Engine Oils and a typical Engine Lubricating system. Engine Fuel System & functioning of a typical engine fuel control unit **Aero Engine Instruments:** Pressure measurements & indicating systems, pressure switches, Temperature measurements & Indicating systems: Variable resistance systems, sensor units, Wheatstone bridge system.	**08 Hrs**

Unit -IV	
Air Data Systems: Pitot-static Sensing probes, Air Speed Indicator, Altimeter, Vertical speed indicator, Angle of Attack Sensing & indication, Mach meter, Basic Air Data System and its functioning with respect to FBW system, Air data alerting system, Stall warning, Mach warning, Altitude alerting system. **Gyroscopic Flight Instruments:** The gyroscope and its properties, Properties of Gyroscope-Rigidity & Precession, limitations of gyroscope, gyro horizon, erection systems for gyro horizons, errors due to acceleration and turning, direction indicator, Turn and Bank indicator. Direct Reading Compasses, Terrestrial magnetism, Compass construction, errors in indication, aircraft magnetism, components of magnetism.	**08 Hrs**

Unit -V	
Flight Control Systems : Primary and secondary flight controls, Conventional Flight control linkage System, Power Assisted and fully powered flight controls. Fly By Wire	**06 Hrs**

Control System & Fly By Light control system.	

LABORATORY EXPERIMENTS	
1. Testing of Aircraft pressure & Temperature sensors using sensor test Bed 2. Testing of Flow Transmitter & Quantity Measurements using sensor Test Bed 3. Testing of Electromechanical accelerometer & Gyro Sensor using Test Bed 4. Measurement of Angle Using RVDT 5. Measuring of Landing Gear Operation timing using Hydraulic actuation system 6. Measuring Indicated Airspeed and altitude using pitot static probe 7. Measuring Angle of Attack using Angle of Attack Probe 8. Measurement of Fuel flow in aircraft engine using fuel flow transmitter 9. Measurement of Aircraft heading using Magnetic Compass or gyromagnetic compass 10. Study of pitch and roll movement of an aircraft using Artificial Horizon 11. Design of logic circuit for hydraulic/ Pneumatic for actuation 12. Design of logic circuit for Aircraft Electrical System	

Course Outcomes: At the end of this course the student will be able to :	
1	Categorise the various systems required for designing a complete airplane
2	Comprehend the complexities involved during development of flight vehicles.
3	Explain the role and importance of each systems for designing a safe and efficient flight vehicle
4	Demonstrate the different integration techniques involved in the design of an air vehicle

Reference Books	
1	E.H.J.Pallet, Aircraft Instruments, 1st Revised Edition, 1992, Prentice Hall of India, ISBN-9780273015390
2	John D. Anderson, Introduction to Flight, 7th Edition, 2011, McGraw-Hill Education, ISBN 9780071086059.
3	Moir, I. and Seabridge, A.,Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, 3rd Edition, 2008, Wiley Publications, ISBN- 978-0470059968
4	Harris, D., Blackwell Science, Ground Studies for Pilots: Flight Instruments and Automatic Flight Control Systems, sixth edition 2004, ISBN 0
5	Nelson R.C., "Flight stability and automatic control", McGraw-Hill International Editions, 1998. ISBN 9780071158381.
6	Moir, I. and Seabridge, Civil Avionics Systems, AIAA (American Institute of Aeronautics & Astronautics) Wiley; 2 edition (October 14, 2013), ISBN

Continuous Internal Evaluation (CIE): Total marks: 100+50=150

Theory – 100 Marks

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total CIE for theory is 100.

Laboratory- 50 Marks
The Laboratory session is held every week as per the time table and the performance of the student is evaluated in every session. The average of marks over number of weeks is considered for 40 marks. At the end of the semester a test is conducted for 10 marks. Total marks for the laboratory is 50.

Semester End Evaluation (SEE): Total marks: 100+50=150
Theory – 100 Marks

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.
Laboratory- 50 Marks
Experiment Conduction with proper results is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**1**	**3**	**1**	**3**	**1**	**1**	**1**				**2**
CO2	**3**	**2**	**3**	**1**	**2**	**2**						**1**
CO3	**3**	**3**	**3**	**2**	**3**	**1**						**2**
CO4	**3**	**1**	**1**	**1**	**1**	**1**	**1**	**1**				**1**

High-3 : Medium-2 : Low-1

Semester: VI		
COMPUTATIONAL FLUID DYNAMICS **(Group C: Professional Core Elective)**		
Course Code: 16AS6C1		**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:1		**SEE Marks:** 100
Hours: 36L		**SEE Duration:** 3Hours

Course Learning Objectives: To enable the students to:	
1	State and identify different forms of conservation equations
2	Derive solutions for differential equations and appreciate discretization methods
3	Discuss finite volume method in relation with diffusion problems
4	Experiment with the algorithms associated with discretization
5	Derive solutions for the differential equations, governing practical problems

Unit-I	
Fundamentals : Application of CFD, Models of flows, Substantial derivative, Divergence of velocity, Continuity, Momentum and Energy equations, derivation in various forms, Integral versus Differential form of equations, Comments on governing equations.	**07 Hrs**
Unit – II	
Mathematical Behaviour of Partial Differential Equations : Classification of partial differential equations, Cramer rule and Eigen value method, Hyperbolic, parabolic and elliptic forms of equations, Impact on physical and computational fluid dynamics, case studies: steady inviscid supersonic flow, unsteady inviscid flow, steady boundary layer flow and unsteady thermal conduction.	**07 Hrs**
Unit -III	
Discretization & Transformations : Introduction, Finite differences, difference equations, Explicit and implicit approaches, Errors and analysis of stability (FTCS, CTCS & Dufort-Frankel). **Transformations:** Introduction, transformation of the governing partial differential equations, Matrices and the Jacobian of transformation.	**07 Hrs**

Unit -IV	
Finite Volume Techniques & Solving Techniques : Finite Volume Discretization - Cell Centered Formulation, High resolution finite volume upwind Scheme, Runge - Kutta Time Stepping, Multi - Time –Step Integration scheme, Cell Vertex Formulation, LAX-WENDROFF Technique, Relaxation technique, Point iterative method, Successive over-relaxation/under relaxation, Aspects of numerical dissipation and dispersion, artificial viscosity, The Alternating-Direction- (ADI) Implicit Technique, Approximate factorization scheme, Upwind schemes, Flux vector splitting.	**08 Hrs**
Unit -V	
Grid Generation : Body–fitted coordinate system, Need for grid generation, Essential properties of grids, Various grid generation techniques - Algebraic, and Numerical grid generation, Elliptic grid generation, Structured, Un-structured grids, Adaptive grids, Grid Stretching.	**07 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	State and identify different forms of conservation equations
2	Derive solutions for differential equations and appreciate discretization methods
3	Discuss finite volume method in relation with diffusion problems
4	Experiment with the algorithms associated with discretization

5	Derive solutions for the differential equations, governing practical problems

Reference Books	
1	John D Anderson Jr., Computational Fluid Dynamics, the Basics with Applications, 1st July, McGraw Hill International Edn, ISBN: 978-1259025969
2	S. V. Patankar, Numerical Heat Transfer and Fluid Flow, 1st Edition, 1980, CRC Press, ISBN: 978-0891165224
3	T J Chung - Computational Fluid Dynamics, 2nd Edition, 2008, Cambridge University Press, ISBN- 978-1107425255
4	F. Wendt (Editor), Computational Fluid Dynamics - An Introduction, 1992, Springer-Verlag, Berlin, ISBN- 78-3-540-85056-4
5	Charles Hirsch, Numerical Computation of Internal and External Flows, Vols. I and II., 2001, John Wiley & Sons, New York, ISBN- 978-0471923855

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**				**2**

High-3 : Medium-2 : Low-1

Semester: VI		
CRYOGENICS **(Group C: Professional Core Elective)**		
Course Code: 16AS6C2		**CIE marks:** 100
Hours/Week:L:P:T:S:3:0:0:1		**SEE Marks :**100
Hours : 36L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Outline the important concepts involved in low temperature engineering and applications
2	Demonstrate various possible cycles used in achieving gas liquefaction and separation
3	Understand different methods of gas purification and vacuum production methods
4	Interpret the criticality involved in producing, storing and insulating cryogenic materials

Unit-I	
Introduction to Cryogenic Systems : Properties of materials at low temperature, Properties of Cryogenic Fluids, Air and Gas Liquefication Systems, Thermodynamically ideal system, Production of low temperatures, Liquefication systems for gases other than Neon, Hydrogen and Helium, liquefication systems for Neon, Hydrogen and Helium, Cryogenic Refrigeration System.	**08 Hrs**
Unit – II	
Gas Separation and Gas Purification Systems : The thermodynamically ideal separation system properties of mixtures, Principles of gas separation, air separation systems, Hydrogen, Argon, Helium air separation systems, Gas purification methods.	**07 Hrs**
Unit -III	
Vacuum Techniques : System for production of high vacuum such as mechanical, diffusion, ion and cryopumps. **Cryogenics measurement systems:** Temperature pressure, flow rate, liquid level measurement, Introduction to Cryocoolers.	**07 Hrs**

Unit -IV	
Gas Purification Systems : Gas purification method: Physical Adsorption, Refrigeration Purification, Chemical Purification. (Without Numericals) **Vacuum Production Techniques :** System for production of high vacuum: Mechanical, Diffusion, Ion and Cryopumps.	**07 Hrs**
Unit -V	
Cryogenic Fluid Storage Systems : Introduction, Basic Storage Vessels, Inner Vessel, Outer Vessel Design, Piping, Access Manways, Safety Device. **Cryogenic insulations :** Expanded Foam Insulations, Gas Filled Powders & Fibrous Insulations, Vacuum Insulations, Evacuated Powder & Fibrous Insulations, Opacified Powder Insulation, Multilayer Insulations, Liquid Shielded Vessels, Vapour Shielded Vessels.	**07 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Summarize the important parameters required in achieving low temperature environment addressing certain areas of engineering applications
2	Construct technically suitable thermodynamic cycles to liquefy and separate gas such as hydrogen, helium, neon etc
3	Adopt feasible techniques for technically and economically producing cryogenic materials
4	Explain the importance of storing and insulating cryogenic materials

Reference Books	
1	Randall F. Barron, Cryogenics Systems, 2nd Edition, 1985, Oxford University Press, New York ISBN- 978-0195035674.
2	Thomas M. Flynn, Cryogenic Engineering, 2nd Edition, 2005 CRC press, New York, ISBN-978-8126504985
3	A. Bose and P. Sengupta, Cryogenics: Applications and Progress, 1987, Tata McGraw Hill, ISBN- 978-0074600368
4	Timmerhaus, Flynn, Cryogenic Process Engineering, 1989Plenum Press, New York, ISBN- 978-1-4684-8756-5

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**1**	**3**	**1**		**2**	**2**					**2**
CO2	**1**	**1**	**3**	**3**		**1**	**1**					**2**
CO3	**3**	**2**	**3**	**1**		**1**	**1**					**1**
CO4	**3**	**2**	**3**	**1**		**2**	**2**					**1**

High-3 : Medium-2 : Low-1

Semester: VI		
HYDRAULICS & PNEUMATICS **(Group C: Professional Core Elective)**		
Course Code: 16AS6C3		**CIE marks:** 100
Hours/Week:L:P:T:S:3:0:0:1		**SEE Marks :**100
Hours : 36L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Analyze and differentiate between different hydraulic power producing devices
2	Explain the performances of actuators and power input sources
3	Justify the usage of hydraulic system components used in hydraulic circuits
4	Analyze and differentiate between pneumatic power control devices and actuators
5	Justify the usage of pneumatic control valves used in pneumatic circuits

Unit-I	
Introduction to Hydraulic Power: Pascal's law, Structure of hydraulic control system, Classification of pumps, Pumping theory, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, Pump selection factors, problems on Pascal's law, pumps **Hydraulic Actuators and Motors :** Classification cylinder and hydraulic motors, Linear Hydraulic Actuators [cylinders], single and double acting cylinder, Mechanics of Hydraulic Cylinder Loading, special types of cylinders, Hydraulic Motor Theoretical Torque, Power and Flow Rate, Hydraulic Motor Performance, problems on cylinders and motors	**08 Hrs**
Unit – II	
Control Components in Hydraulic Systems: Classification of control valves, Directional Control Valves, actuation methods – manual, pilot, solenoid, constructional features of poppet, sliding spool valves, Pressure control valves - types, direct operated types and pilot operated types. Flow Control Valves - compensated and non-compensated FCV, problems. **Graphic Symbols and representation of a hydraulic System** Symbolic representations, Circuit diagram for Control of single acting and double acting cylinder, bidirectional motor, pump unloading circuit, Counterbalance circuit, double pump hydraulic system, problems.	**07 Hrs**
Unit -III	
Hydraulic Control Circuits Regenerative circuit – drilling machine application (problems), Speed control of hydraulic cylinders and motors(problems), cylinder synchronising circuits in series and parallel (problems), Hydraulic cylinder sequencing, locked cylinder using pilot check valves, Two hand safety control circuit, Accumulator as an auxiliary power source, leakage compensator, emergency power source.	**08 Hrs**
Unit -IV	
Introduction to Pneumatic Control: Applications and choice of working medium. Characteristics of compressed air, working principles of air compressors, Structure of Pneumatic control System, FRL unit. End position cushioning of cylinders, Basic construction of directional control valves, quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, and solenoid operated valve, Step and timing diagram for multiple actuators.	**07 Hrs**
Unit -V	
Pneumatic Control Circuits: Symbols of ISO 1219 and ISO5599, port markings, designation of pneumatic system components, Simple Pneumatic Control: Direct and	**06 Hrs**

indirect actuation pneumatic cylinders, applications of memory and quick exhaust valves, logics in pneumatic circuit design – practical applications of AND logic, OR logic, Moving part logic elements, practical applications of time dependent and pressure dependent control, cascading principle, signal conflict elimination circuit using cascading.	

Course Outcomes: At the end of this course the student will be able to :	
1	Analyze and differentiate between different hydraulic power producing devices
2	Explain the performances of actuators and power input sources
3	Justify the usage of hydraulic system components used in hydraulic circuits
4	Analyze and differentiate between pneumatic power control devices and actuators
5	Justify the usage of pneumatic control valves used in pneumatic circuits

Reference Books	
1	Anthony Esposito, Fluid Power with Applications, 6th Edition, 2000, Pearson Education, Inc, ISBN: 978-0135136904
2	Andrew Parr, Pneumatics and Hydraulics, 3rd Edition, 2011, Jaico Publishing Co., , ISBN: 978-0080966748
3	Harry L. Stewart, Hydraulic & Pneumatic Power for Production, 3rd Edition, 1970, Industrial Press Inc. US, , ISBN: 978-0831110642
4	S. R. Majumdar, Pneumatic Systems, 1st Edition, 1995, Tata McGraw Hill Publishers, ISBN: 978-0074602317
5	Michael J Pinches & John G Ashby, Power Hydraulics, 1989, Prentice Hall, ISBN: 978-0136874430

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**2**	**2**	**3**	**2**	**2**	**1**	**1**				**1**
CO5	**1**	**1**	**2**	**2**	**1**	**1**		**2**				**1**

High-3 : Medium-2 : Low-1

Semester: VI		
ADVANCED MATERIAL TECHNOLOGY **(Group C: Professional Core Elective)**		
Course Code: 16AS6C4		**CIE marks:** 100
Hours/Week:L:P:T:S:3:0:0:1		**SEE Marks :**100
Hours : 36L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Understand the behaviour of materials subjected to high temperatures
2	Study the characteristics and processing of ceramic materials
3	Determine the importance of metallic materials and super alloys in aerospace application
4	Familiarize with the advancements in the field of nanomaterials and its impact on aerospace components

Unit-I	
Creep : Characteristics of materials at elevated Temperatures, Mechanical Properties at Elevated Temperatures, Factors Affecting Creep Life of a Component, Stages of Creep, Effect of Stress, Temperature and Strain Rate on Creep Characteristics, Design of Transient Creep Time, Rupture Life of Creep, Monkman - Grant Relationship, Applications in Thermal Protection Systems.	**08 Hrs**

Unit -II	
Ceramics : Ceramic materials, Classification, Crystal structure, Properties, Characterisation and applications, Ceramic materials, polymer derived ceramics, ceramic fibers, ceramic matrix composites, thermal barrier coatings, thermal protection systems, porous ceramics and ceramic foams, Ultrahigh temperature ceramics, materials with zero thermal expansion-glass ceramics.	**08 Hrs**

Unit -III	
Metallic Materials : Aluminium Alloys, Age Hardening Treatments, Magnesium & Beryllium Alloys, Titanium Alloys, Superplasticity, Structural Titanium Alloys, Intermetallics, High Steel Strength Alloys, Functionally Gradient Materials, Materials for Extreme Environment, Materials processing and Manufacturing in Zero Gravity.	**06 Hrs**

Unit -IV	
Superalloys : Metallurgical Considerations, Iron Base, Nickel Base and Cobalt Base Super Alloys, Composition Control, Solution and Precipitation Strengthened Superalloys, Bonding of Superalloys, Protective Coatings for Superalloys.	**08 Hrs**

Unit -V	
Nanomaterials : Properties of Nanomaterials, Surface Characteristics and Stabilization; Quantum Confinement, Zero Dimensional, One Dimensional and Two Dimensional Nanostructures, Manufacturing of Nanomaterials, Structural Applications of Nanomaterials.	**06 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Assess the behavior of materials when exposed to elevated temperatures
2	Familiarize with the various techniques associated with the production and processing of ceramics
3	Explain the importance of incorporating metallic materials and superalloys in aerospace structural applications

4	Analyze the significance of employing nanomaterials for light weight applications in aerospace industry

Reference Books	
1	Bressers. J., Creep and Fatigue in High Temperature Alloys, 1981, Elsevier Science Ltd, ISBN-978-0853349471
2	W.D. Callister, D.G. Rethwisch, Materials science and Engineering: An Introduction, 8th Edition, 2010, John Wiley & Sons, ISBN- 978-0470419977
3	P. Boch, J-C. Nièpce, Ceramic Materials: Processes, Properties, and Applications, 2007, Wiley-ISTE, 2007 ISBN- 978-1905209231
4	Campbell, F. C., Manufacturing Technology for Aerospace Structural Materials, 1st Edition, 2006, Elsevier, ISBN- 9781493303892
5	G. Cao, Nanostructures and Nanomaterials - Synthesis, Properties and Applications, 2004, Imperial College Press, ISBN- 978-1860944802

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: VI		
NON DESTRUCTIVE TESTING & EVALUATION **(Group C: Professional Core Elective)**		
Course Code: 16AS6C5		**CIE marks:** 100
Hours/Week:L:P:T:S:3:0:0:1		**SEE Marks :**100
Hours : 36L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Provide basic understanding of various non destructive techniques
2	Study the basic principles of radiographic testing and their extent of applications
3	Understand the nature of ultrasonic light and its application in NDE of materials and structures
4	Familiarize with various surface inspection techniques

Unit-I	
Introduction : Overview on Non Destructive techniques, Factors influencing the Reliability of NDE, Defects in materials, Defects in composites, NDT methods used for evaluation of materials and composites	**08 Hrs**

Unit -II	
Radiographic Inspection X –Ray radiograph : Principles of X – ray radiography, equipment, Production of X -rays, absorption, scattering, X-ray film processing; industrial radiographic practice, micro-radiography. **Gamma ray radiography :** Radioactivity, gamma ray sources, film radiography, application, examples, General radiographic procedures, Reading and Interpretation of Radiographs, Defects in welding.	**08 Hrs**

Unit -III	
Ultrasonic Inspection : Principle of wave propagation, Ultrasonic equipment, Variables affecting an ultrasound test, Basic methods and general considerations, Testing of products, Ultrasonic testing of composites, Ultrasonic application for thickness measurement, Types of scanning, types of indication, Welding inspection, tube inspection, test standards, determination of elastic constants.	**06 Hrs**

Unit -IV	
Liquid Penetrant and Magnetic Particle Test : Basic concept, Test equipment, Test Parameters & Procedure, Safety precaution, Methods of generating magnetic field. Demagnetization of materials, Magnetic particle test: Principles, Test Equipment and Procedure, Interpretation and evaluation.	**06 Hrs**

Unit -V	
Thermal Inspection : Principles, equipment, inspection methods**,** applications **Optical Holography :** Principles, applications, holographic recording interferometer techniques of inspection **Acoustic Emission Inspection :** Principle, comparison with other NDT methods, applicability, acoustic emission waves and propagation, Instrumentation principles.	**08 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Differentiate various defect types and select the appropriate NDT methods for the specimen.
2	Have a complete theoretical and practical understanding of the radiographic testing, interpretation and evaluation
3	Demonstrate knowledge regarding the utilization, calibration and evaluation of ultrasonic

	testing
4	Select and Utilize various surface inspection techniques

Reference Books	
1	ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing
2	Paul E Mix, Introduction to Non-destructive testing: a training guide, 2nd Edition, 2005, Wiley-Interscience, New Jersey, , ISBN- 978-0471420293
3	Charles, J. Hellier, Handbook of Nondestructive evaluation, 2nd Edition, 2012, McGraw Hill, New York, ISBN-978-0071777148
4	J Prasad and C G Krishnadas Nair, Non-Destructive Test and Evaluation of Materials, 2nd Edition, 2008, Tata McGraw-Hill Publishing Co. Ltd. ISBN- 9780070707030
5	Baldev Raj, T. Jayakumar, M. Thavasimuthu, Nondestructive Testing, 3rd Edition, 1997, Narosa Publishing House, ISBN- 978-81-7319-797-0

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: VI		
BOUNDARY LAYER THEORY **(Group D: Professional Core Elective)**		
Course Code: 16AS6D1		**CIE marks:** 100
Hours/Week:L:P:T:S:4:0:0:0		**SEE Marks :**100
Hours : 44L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Outline the basic aspects related to boundary layer theory
2	Mathematically quantify the properties of boundary layer
3	Establish governing equations to determine the boundary layer growth over various configuration of bodies
4	Study the behaviour of boundary layer in incompressible and compressible flows

Unit-I	
Fundamentals of Viscous Flows : Qualitative Aspects, Viscosity and Thermal Conduction, The Navier-Stokes Equations, The Viscous Flow Energy Equation, Similarity Parameters.	**08 Hrs**

Unit -II	
Laminar Boundary Layers : Boundary-Layer Properties, Boundary-Layer Equations, Laminar Boundary Layer, Displacement and Momentum Thickness, Incompressible Flow over a Flat Plate: The Blasius Solution, Boundary layer temperature profiles for constant plate temperature.	**10 Hrs**

Unit -III	
Steady State Two-Dimensional Boundary Layer: Exact Solutions : Flow Past Wedge, Flow in a Convergent Channel, Flow Past Cylinder (Symmetrical), Boundary Layer for Potential Flow, Flow in Wake of Flat Plate at Zero Incidence, Two Dimensional Laminar Jet, Parallel Streams in Laminar Flow.	**08 Hrs**

Unit -IV	
Incompressible Turbulent Mean Flows : Physical and Mathematical Description of Turbulent Flows, Turbulent Kinetic Energy and Reynolds Stress Equation, Two-Dimensional Turbulent Boundary Layer Equation, Turbulent Boundary Layer Integral Equation, Velocity Profiles, Turbulent boundary Layer on a Flat Plate,	**10 Hrs**

Unit -V	
Free Turbulence : Jets, Wakes and Mixing Layers, Turbulent Convective Heat Transfer. **Compressible Viscous Flows :** Similarity Solutions for Compressible Laminar Flows, Compressible Turbulent Boundary Layer Equations.	**08 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Comprehend the fundamental properties related to boundary layer growth
2	Estimate the magnitude of the momentum and displacement thickness of boundary layer
3	Formulate quantitative equations to estimate the boundary layer growth over various shaped bodies
4	Examine the effect of boundary layer in compressible and incompressible flows in

Reference Books	
1	Anderson J .D., Fundamentals of Aerodynamics, 5th Edition, 2011, McGraw-Hill International Edition, New York, ISBN:9780073398105
2	Schlichting H., Boundary Layer Theory, McGraw-Hill, 2nd English Edition, 1968, Clarendon Press, Oxford, Recent Literature ISBN-13: 978-3540662709
3	Frank M. White,Viscous Fluid Flow, 3rd Edition, 2006, McGraw-Hill Series of Mechanical Engineering, ISBN-13: 978-1259002120
4	Stephen B Pope, Turbulent Flows, Cambridge University Press, 2009, Cambridge University Press, ISBN-13: 978-0521177849

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: VI		
EXPERIMENTAL STRESS ANALYSIS **(Group D: Professional Core Elective)**		
Course Code: 16AS6D2		**CIE marks:** 100
Hours/Week:L:P:T:S:4:0:0:0		**SEE Marks :**100
Hours : 44L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Understand underlying principles in using strain gages.
2	Design strain gage-based transducers for measuring specific loads.
3	Understand basic principles of photo elasticity, and use it as an analysis tool.
4	Recognize the various techniques available to measure the stress and Strains using different sources.

Unit-I	
Electrical Resistance Strain Gages: Strain sensitivity in metallic alloys, Gage construction, Adhesives and mounting techniques, Gage sensitivity and gage factor, Performance Characteristics, Environmental effects, Strain Gage circuits. Potentiometer, Wheatstone's bridges, Constant current circuits.	**10 Hrs**

Unit -II	
Strain Analysis Methods: Two element, three element rectangular and delta rosettes, Correction for transverse strain effects, Stress gage, Plane shear gage, and Stress intensity factor gage.	**07 Hrs**

Unit –III	
Photo-elasticity: Nature of light, Wave theory of light - optical interference , Stress optic law–effect of stressed model in plane and circular polariscopes, Isoclinics & Isochromatics, Fringe order determination Fringe multiplication techniques, Calibration photo elastic model materials.	**09 Hrs**

Unit –IV	
Measurements And Extensometers: Principles of measurements, Accuracy, Sensitivity and range of measurements. Mechanical, Optical Acoustical and Electrical extensometers and their uses, Advantages and disadvantages.	**09 Hrs**

Unit –V	
Moiré Methods: Moiré fringes produced by mechanical interference. Geometrical approach, Displacement field approach to moiré fringe analysis, out of plane displacement measurements, Out of plane slope measurements.	**09 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Understand the overall concepts of stress/strain analysis by experimental means.
2	Familiar with the theory and practice of common experimental stress analysis methods including moiré methods, photo elasticity
3	To acquire skills for experimental investigations an accompanying laboratory course is desirable
4	Undertake experimental investigations to verify predictions by other methods.

Text Books	
1	James W. Dally, Experimental stress analysis, 2nd Edition, 1978, McGraw-Hill, ISBN 9780070152045
2	Jindal, Experimental Stress Analysis, 1st Edition, 2013, Pearson Education India, ISBN 9789332501249
3	G. S. Holister, Experimental Stress Analysis: Principles and Methods, 1967, CUP Archive, ISBN 9780521053129
4	James F. Doyle, Modern Experimental Stress Analysis: Completing the Solution of Partially Specified Problems, 2004, John Wiley & Sons, ISBN 9780470861578

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: VI		
FUNDAMENTALS OF ASTROPHYSICS **(Group D: Professional Core Elective)**		
Course Code: 16AS6D3		**CIE marks:** 100
Hours/Week:L:P:T:S:4:0:0:0		**SEE Marks :**100
Hours : 44L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Familiarize with the various celestial bodies and the laws governing their behavior
2	Understand the fundamental concepts of relativity and establish the relation between light and matter
3	Study the methods used to identify and investigate the nature of different stellar bodies
4	Determine the characteristic features of any star by understanding its spectral properties
5	Contemplate the complex system of the milky way galaxy and its components

Unit-I	
Fundamental concepts in Astronomy : Major constituents of the universe, Solar System, Planets - laws of motion of planets, inner planets, outer planets, Extrasolar planets, Methods of detection of extrasolar planets, Geocentric Universe, Retrograde Motion of planets, Brief introduction to the Copernican Revolution, Positions of the Celestial Sphere: Altitude-Azimuth Coordinate System, Equatorial Coordinate System, Stellar Parallax, Magnitude Scale, Blackbody radiation, Connection between Colour and Temperature.	**10 Hrs**

Unit -II	
Theory of Special Relativity : Galilean Transformations, Failure of Galilean Transformations, Lorentz Transformations, Derivation, Time & Space in Special Relativity, Momentum & Energy in Relativity. **Light and Matter :** Spectral Lines, Bohr Model of Atom, de Broglie's Wavelength and Frequency, Heisenberg's Uncertainty Principle.	**09 Hrs**

Unit -III	
Stellar Astrophysics : Classification of Binary Stars, Mass Determination using Visual Binaries, Eclipsing Spectroscopic Binaries, Formation of Spectral Lines, Boltzman-Saha Equation, The Hertzsprung-Russel Diagram, Optical Telescopes, Radio Telescopes.	**09 Hrs**

Unit -IV	
Spectral Characterization of Stars : Description of the Radiation Field, Stellar Opacity, Transfer Equation, Profile of Spectral Lines.	**08 Hrs**

Unit -V	
Galaxy Astronomy : The Milky way Galaxy, Counting the Stars, Historical Models, Differential & Integrated Star Counts, Distance to the Galactic Centre, Galactic Coordinate System, Classification of Galaxies, Introduction to Elliptical galaxies, Irregular galaxies, Dwarf galaxies.	**08 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Contemplate the nature of our universe by identifying and studying the behavior of celestial bodies
2	Explain the usefulness of the theory of relativity, light and matter in establishing the fundamental behavior of stellar bodies

3	Utilize various techniques to discover the components of our universe and conclude their celestial properties
4	Interpret the spectral properties of any astronomical body to illustrate its properties
5	Inspect the milky way galaxy to identify the proponents and their characteristic features

Reference Books	
1	Carroll, Bradley W., and Dale A. Ostlie. An Introduction to Modern Astrophysics. Reading, 2nd Edition, 1995, MA: Addison-Wesley Pub, ISBN: 9780201547306
2	Shu, F., The Physical Universe, New Edition, 1982, University of California, ISBN- 978-0935702057.
3	Harwit, M. Astrophysical Concepts, 3rd Edition, 2000, Springer-verlag, ISBN- 978-0387949437
4	Padmanabhan, T., Theoretical Astrophysics, Vols.1-3, 2005, Cambridge University Press, ISBN- 9780521016278
5	Shapiro, Stuart L., and Saul A. Teukolsky. Black Holes, White Dwarfs, and Neutron Stars, 1st Edition, 1983, Wiley, ISBN: 9780471873167.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: VI		
SPACECRAFT DESIGN **(Group D: Professional Core Elective)**		
Course Code: 16AS6D4		**CIE marks:** 100
Hours/Week:L:P:T:S:4:0:0:0		**SEE Marks :**100
Hours : 44L		**SEE:** 3 Hours

Course Learning Objectives: To enable the students to:	
1	Study the payload and mission requirements and understand the effects of celestial atmosphere on the design and performance of a spacecraft
2	Appreciate the importance of incorporating attitude control systems in achieving the stability of a spacecraft
3	Summarize the functioning of various control systems incorporated on a satellite
4	Understand the design prerequisites of various types of spacecraft based on their applications

Unit-I	
Introduction : Payloads & Missions, Objectives & Requirements of a Spacecraft, Overview of Spacecraft Subsystems. **Effect of Space Environment on Design :** Introduction, Pre-operational Spacecraft Environments, Operational Spacecraft Environments, Environmental Effects on Design.	**10 Hrs**

Unit -II	
Attitude Control Systems : Introduction, Overview of ACS, ACS block diagram, Torques And Torquers, Attitude Measurement, Measurement system fundamentals, Types of reference sensor & Inertial sensors.	**08 Hrs**

Unit -III	
Thermal Control Systems : The Thermal Environment: Types of Thermal Sources, Thermal Balance. **Electrical Power Systems :** Power System Elements, Primary & Secondary Power Systems.	**08 Hrs**

Unit -IV	
Telecommunication Systems : Role of Communication Systems, Radio Communications: Modulation, Multiple Access, Noise, Radio Propagation, Antennas, Communication Payload: Transponder System. **Telemetry :** System Architecture, Base Band Telemetry system, Modulation, TT&C RF system, Telecommand system, Ground Control Systems.	**08 Hrs**

Unit -V	
Small Satellite Engineering & Applications : Introduction, Small-satellite Design Philosophy, Small-satellite System Design, COTS Components in the Space Environment, Microsatellite Platforms, Minisatellite Platforms and Nanosatellite Platforms, Affordable Launches for Small Satellites, In-orbit Operations, Small-satellite Applications, Picosatellites and Recent Advances in Miniaturization.	**10 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Assess and Evaluate the design and mission requirements of a spacecraft based on the application
2	Estimate the internal and external factors affecting the stability of a spacecraft and apply the techniques in controlling them

3	Demonstrate the working principles of different types of control systems incorporated on a spacecraft
4	Combine various control systems in developing a spacecraft for a given application

Reference Books	
1	Peter Fortescue, John Stark and Graham Swinerd , Spacecraft Systems Engineering, 4th Edition, 2011, Wiley publications, ISBN : 978-0-470-75012-4
2	James R.Wertz and Wiley J.Larson,, Space Mission Analysis and Design, 3rd Edition, 1999, Microcosm, ISBN- 978-1881883104
3	James R.Wertz, Spacecraft Attitude Determination and Control, 1988, Kluwer Academic Publisher, 1988.
4	Marcel J.Sidi, Spacecraft Dynamics and Control, Reprint Edition, 2000, Cambridge University press, ISBN- 978-0521787802

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**3**	**3**	**3**		**2**	**1**	**2**				**2**

High-3 : Medium-2 : Low-1

Semester: VI		
COMBUSTION & HEAT TRANSFER **(Group D: Professional Core Elective)**		
Course Code: 16AS6D5		**CIE Marks:** 100
Credits: L:T:P:S: 4:0:0:0		**SEE Marks:** 100
Hours: 44L		**SEE Duration:** 3Hours

Course Learning Objectives: To enable the students to:	
1	Analyze and differentiate between different modes of heat transfer
2	Explain and interpret the factors influencing the conduction mode of heat transfer in practical applications
3	Describe and execute the problem solving methodology related to convective heat transfer
4	Understand the phenomenon of radiation heat transfer
5	Comprehend the chemical kinetics of combustion process

Unit-I	
Introduction: Modes of heat transfer-conduction, convection and radiation, Material properties of importance in heat transfer, Thermal conductivity, Specific heat capacity **Conduction Heat Transfer:** Derivation of general three dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems (No derivation), Numericals	**10 Hrs**
Unit – II	
Heat Transfer from Extended Surfaces: Heat transfer through rectangular fin: Long fin, short fin with insulated tip and convective tip. Fin efficiency and effectiveness, Numerical problems	**08 Hrs**
Unit -III	
Transient Conduction: Lumped parameter analysis, Use of Transient temperature charts (Heisler's charts) for transient conduction in slab, long cylinder and sphere, Numerical problems **Convective Heat Transfer:** Principle of heat flow in fluids, heat transfer coefficient, overall heat transfer coefficient, Velocity boundary layer, Thermal Boundary layer, Significance of dimensionless numbers for internal and external flow (discussion only), Numerical problems	**10 Hrs**

Unit -IV	
Forced Convection: Momentum and Energy equations for hydrodynamic and thermal boundary layer over a flat plate, Dimensional analysis for forced and natural convection, Numerical problems **Natural Convection:** Empirical correlations of flow around flat vertical plate, horizontal flat surface, horizontal cylinder, sphere and enclosure, Numerical problems	**08 Hrs**
Unit -V	
Introduction to Combustion: Introduction, Applications of Combustion, Types of fuels and various modes of combustion, review of basic thermodynamics, thermodynamic properties, Stoichiometry, Thermo-chemistry, adiabatic temperature, chemical equilibrium, Numerical problems	**08 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Distinguishing different modes of heat transfer
2	Interpreting the factors influencing the conduction mode of heat transfer
3	Executing the problem solving methodology related to convective heat transfer
4	Analyzing the factors influencing radiation heat transfer

5	Apply the principles of combustion in designing efficient propulsion systems

Reference Books	
1	Holman B.K.,Heat Transfer, 9th Edition, 2002, McGraw Hill, ISBN: 978-0078447853
2	Necati Ozisik, Heat Transfer: A Basic Approach, .2012, McGraw-Hill Inc, ISBN-13: 978-0070479821.
3	Chapman, A.J, Heat Transfer, 4th Edition, 1984, Maxwell Macmillan International Edition, ISBN: 978-0023214509
4	D.P. Mishra, Fundamentals of Combustion, 1st Edition, 2008, Prentice Hall of India, New Delhi, ISBN: 978-8120333482
5	Stephan R Turns, Introduction to combustion, 3rd Edition, 2011, McGraw-Hill Education; ISBN-13: 978-0073380193

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**2**
CO3	**1**		**3**	**3**								**2**
CO4	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**				**2**
CO5	**3**	**3**	**2**	**2**	**2**							**2**

High-3 : Medium-2 : Low-1

Semester: VI		
BIOINSPIRED ENGINEERING **(Group E: Global Elective)**		
Course Code: 16G6E01		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives:	
1	To familiarize engineering students with basic biological concepts
2	Utilize the similarities noted in nature for a particular problem to bring inspiration to the designer.
3	Explain applications such as smart structures, self-healing materials, and robotics relative to their bio logical analogs
4	To gain an understanding that the design principles from nature can be translated into novel devices and structures and an appreciation for how biological systems can be engineered by human design

Unit-I	
Introduction to Biology: Biomolecules-Proteins, carbohydrates, lipids and Nucleic acids. Cell types- Microbial, plant, animal.Organ system- Circulatory, digestive, respiratory, excretory and nervous system. Sense organs. Plant process- Photosynthesis.	**06 Hrs**
Unit – II	
Introduction to Biomimetics: Wealth of invention in nature as inspiration for human innovation: Mimicking and inspiration of nature- synthetic life. Nature as a model for structure and tools: Biological clock, honey comb as strong light weight structure. Materials and processes in biology- Spider web, honey bee as a multi-material producer, fluorescent materials in fire flies. Bird and insect as source of inspiring flight. Robotics as beneficiary for biomimetic technologies.	**08 Hrs**
Unit -III	
Biological materials in Engineering mechanisms: Introduction, Comparison of biological and synthetic materials: Silk processing and assembly by insects and spiders- High performance fibers from nature, Seashells- High performance organic and inorganic composites from nature. Shark skin- Biological approaches to efficient swimming via control of fluid dynamics, Muscles- Efficient biological conversion from chemical to mechanical engineering.	**08 Hrs**
Unit –IV	
Biological inspired process and products: Artificial neural networks, genetic algorithms, medical devices. Biosensors. Plant as Bioinspirations: Energy efficiency, Biomimetic super hydrophobic surfaces- lotus leaf effect. Bionic leaf and Photovoltaic cells.	**08 Hrs**
Unit –V	
Implants in Practice: Artificial Support and replacement of human organs-Introduction, Artificial kidney, liver, blood, lung, heart, skin and pancreas. Total joint replacements- Visual prosthesis -artificial eye. Sense and sensors: Artificial tongue and nose, Biomimetic echolation. Limitations of organ replacement systems.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember and explain the fundamentals of Biology
CO2:	Describe the basic principles of design in biological systems.
CO3:	Differentiate biological phenomena to support inspiration for visual and conceptual design problems
CO4:	Create engineered solutions to customer needs utilizing a variety of bio-inspiration techniques.

Reference Books	
1	Jenkins, C.H. Bioinspired Engineering, NY: Momentum press, 2012 ISBN: 97816066502259
2	C.C.Chatterjee, Human Physiology Volume 1 (11th Edition), 2016, ISBN 10: 8123928726 / ISBN 13: 9788123928722
3	Yoseph Bar-Cohen, Biomimetics: Biologically Inspired technologies, 2005, CRC press, ISBN: 9780849331633
4	Donald Voet, Charlotte W. Pratt. Principles of Biochemistry: International Student Version. Wiley John and Sons, 2012. ISBN: 1118092449.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	1	1	1	1	1	1	1	2
CO2	2	1	2	1	1	1	1	1	1	1	1	2
CO3	3	3	3	2	1	1	1	1	1	1	1	3
CO4	3	3	3	1	1	1	1	1	1	1	1	2

High-3 : Medium-2 : Low-1

Semester: VI		
GREEN TECHNOLOGY **(Group E: Global Elective)**		
Course Code: 16G6E02		**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:0		**SEE Marks:** 100
Hours: 36L		**SEE Duration:** 3Hrs

Course Learning Objectives:	
1	Learn the tools of green technology
2	Know various forms of renewable energy
3	Study the environmental consequences of energy conversation
4	Understand energy audits and residential energy audit
5	Understand the application of green technology in various industries

Unit-I	
Current Practices and Future Sustainability: Need for green technology, fundamentals of energy and its impact on society and the environment, the mechanics, advantages and disadvantages of renewable energy sources, energy conservation and audits, zero waste technology, life cycle assessment, extended product responsibility, concept of atom economy, tools of Green technology **Cleaner Production:** Promoting cleaner production, benefits and obstacles of cleaner production, cleaner production technologies.	**07 Hrs**
Unit – II	
Solar Radiation and Its Measurement: Solar constant, solar radiation at the earth's surface, solar radiation geometry, solar radiation measurements **Applications of Solar Energy**: Introduction, solar water heating, space-heating (or solar heating of buildings), space cooling (or solar cooling of building), solar thermal electric conversion, agriculture and industrial process heat, solar distillation, solar pumping, solar cooking **Geothermal Energy:** Resource identification and development, geothermal power generation systems, geothermal power plants case studies and environmental impact assessment.	**08 Hrs**
Unit -III	
Energy From Biomass (Bio-Energy): Introduction, biomass conversion technologies, wet Processes, dry Processes, biogas generation, factors affecting biodigestion, types of biogas plants (KVIC model & Janata model), selection of site for biogas plant **Bio Energy (Thermal Conversion):** Methods for obtaining energy from biomass, thermal gasification of biomass, classification of biomass gasifiers, chemistry of the gasification process, applications of the gasifiers.	**07 Hrs**
Unit –IV	
Wind Energy: Introduction, basic components of WECS (Wind Energy Conversion system), classification of WEC systems, types of wind machines (Wind Energy Collectors), horizontal-axial machines and vertical axis machines. **Ocean Thermal Energy**: OTEC-Introduction, ocean thermal electric conversion (OTEC), methods of ocean thermal electric power generation, open cycle OTEC system, the closed or Anderson, OTEC cycle, Hybrid cycle **Energy from Tides**: Basic principles of tidal power, components of tidal power plants, operation methods of utilization of tidal energy, advantages and limitations of tidal power generation	**07 Hrs**

Unit –V	
Hydrogen, Hydrogen Energy: Introduction, methods of hydrogen production (principles only), storage transportation, utilization of hydrogen gas, hydrogen as alternative fuel for motor vehicle, safety and management, hydrogen technology development in India **Application of Green Technology:** Electronic waste management, bioprocesses, green composite materials, green construction technology **Sustainability of industrial waste management:** Case studies on cement industry, iron and steel industry, petroleum sectors, marble and granite industry, sugar industry	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Recall the fundamentals of various forms of energy
CO2:	Explain the principles of various forms of renewable energy
CO3:	Apply the concept of zero waste, atom economy for waste management
CO4:	Create a waste management plan incorporating tools of green technology in various industries

Reference Books	
1	Non-Conventional Energy Sources, G.D.Rai, 5th Edition, 2016, Khanna Publications, ISBN: 8174090738
2	Renewable Energy-Power for a Sustainable Future, Edited by Godfrey Boyle, 3rd Edition, 2012, Oxford University Press, ISBN: 9780199545339
3	Energy Systems and Sustainability: Power for a Sustainable Future, Godfrey Boyle, Bob Everett, and Janet Ramage, 2nd Edition, 2012, Oxford University Press, ISBN: 0199593744
4	Renewable Energy resources , John Twidell and Tony Weir, 3rd Edition, 2015, Routledge publishers, ISBN:0415584388

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

Semester: VI		
SOLID WASTE MANAGEMENT (Theory)		
Course Code:16G6E03		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	Impart the knowledge of present methods of solid waste management system and to analyze the drawbacks.
2	Understand various waste management statutory rules.
3	Analyze different elements of solid waste management, design and develop recycling options for biodegradable waste by composting.
4	Identify hazardous waste, e-waste, plastic waste and bio medical waste and their management systems.

UNIT-I	
Introduction: Land Pollution. Scope and importance of solid waste management. Present solid waste disposal methods. Merits and demerits of open dumping, feeding to hogs, incineration, pyrolysis, composting, sanitary landfill. Definition and functional elements of solid waste management. **Sources**: Sources of Solid waste, types of solid waste, composition of municipal solid waste, generation rate, Numerical Problems. **Collection and transportation of municipal solid waste:** Collection of solid waste-services and systems, Municipal Solid waste (Management and Handling) 2000 rules with 2016 amendments. Site visit to collection system.	**08 Hrs**
UNIT-II	
Composting Aerobic and anaerobic composting - process description, process microbiology, Vermicomposting, Site visit to compost plant, Numerical problems. **Sanitary land filling**: Definition, advantages and disadvantages, site selection, methods, reaction occurring in landfill- Gas and Leachate movement, Control of gas and leachate movement, Site visit to landfill site.	**08 Hrs**
UNIT-III	
Hazardous waste management: Definitions, Identification of hazardous waste, Classification of hazardous waste, onsite storage, collection, transfer and transport, processing, disposal, hazardous waste (Management and handling) rules 2008 with amendments. Site visit to hazardous landfill site	**06 Hrs**
UNIT-IV	
Bio medical waste management: Classification of bio medical waste, collection, transportation, disposal of bio medical waste, Bio medical waste (Management and Handling) rules 1998 with amendments. Site visit to hospital to see the collection and transportation system and visit to biomedical waste incineration plant.	**06 Hrs**
UNIT-V	
E-waste management: Definition, Components, Materials used in manufacturing electronic goods, Recycling and recovery integrated approach. E- waste (management and handling) rules 2011.Site visit to e- waste processing facility. **Plastic waste management:** Manufacturing of plastic with norms. Plastic waste management. Plastic manufacture, sale & usage rules 2009 with amendments.	**06 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Understand the existing solid waste management system and to identify their drawbacks.
2	Analyze drawbacks in the present system and provide recycling and disposal options for each type of waste.
3	Distinguish Hazardous waste, Biomedical waste, E waste and to provide scientific management

	system.
4	Evaluate and monitor the Biomedical waste, Hazardous waste, E waste, Plastic and Municipal waste management as per the rules laid by Ministry of Environment & Forest.

Reference Books	
1.	Integrated Solid Waste Management : Engineering principles and management issues George Tchobanoglous, Hilary Theisen , Samuel A Vigil, published by M/c Graw hill Education . Indian edition 2014. ISBN – 13: 978- 9339205249, ISBN-10 : 9339205243
2.	Environmental Engineering, Howard S Peavy, Donald R Rowe and George Tchobanoglous, Tata Mcgraw Hill Publishing Co ltd., 2013, ISBN-13 9789351340263.
3.	Electronic waste management, R.E. Hester, Roy M Harrison,, Cambridge, UK, RSC Publication, 2009, ISBN 9780854041121
4.	Municipal Solid waste (Management & Handling Rules) 2000. Ministry of Environment & Forest Notification, New Delhi, 25th Sept 2000 and 2016 amendments.
5.	Hazardous waste (management, handling) rules 2008.Ministry of Environment and Forest Notification, New Delhi, 25th February 2009.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	-	-	-	-	1	-	-	-	-	-	-
CO2	2	1	-	-	1	1	-	-	-	-	-	-
CO3	2	2	1	-	2	1	1	-	-	-	-	1
CO4	2	2	1	-	3	2	2	-	-	-	1	1

Low-1 Medium-2 High-3

Semester :VI		
INTRODUCTION TO WEB PROGRAMMING (Group E : Global Elective)		
Course Code:16G6E04		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 36L		**SEE Duration: 3 Hrs**

Course Learning Objectives: The students will be able to	
1	Understand the basic concepts used in web programming.
2	Learn the definitions and syntax of different web technologies.
3	Utilize the concepts of JavaScripts, XML and PHP.
4	Design and develop web pages which are quick, easy and well-presented using different techniques such as CSS,XML and JavaScripts.

UNIT-I	
Introduction to Web Concepts Fundamentals of Web, HTML 5 - Core HTML attributes, headings, paragraphs and breaks, divisions and centering, quotations, preformatted text, lists, horizontal rules, block-level elements, text-level elements.XHTML – 1: Internet, WWW, Web Browsers and Web Servers, URLs, MIME, HTTP, Security, the Web Programmers Toolbox. XHTML: Basic syntax, Standard structure, Basic text markup, Images, Hypertext Links.XHTML (continued): Lists, Tables, Forms, Frames.	**07 Hrs**
UNIT-II	
Cascading Style Sheets (CSS): Introduction, Levels of style sheets, Style specification formats, Selector forms, Property value forms, Font properties, List properties, Color, Alignment of text, The box model, Background images, The and tags, Conflict resolution. **The Basics of JavaScript:** Overview of JavaScript; Object orientation and JavaScript; General syntactic characteristics; Primitives, operations, and expressions; Screen output and keyboard input; Control statements	**09 Hrs**
UNIT-III	
JavaScript (continued): Object creation and modification; Arrays; Functions; Constructor; Pattern matching using regular expressions; Errors in scripts. **JavaScript and HTML Documents:** The JavaScript execution environment; The Document Object Model; Element access in JavaScript; Events and event handling; Handling events from the Body elements, Button elements, Text box and Password elements; The DOM 2 event model; The navigator object; DOM tree traversal and modification.	**09 Hrs**
UNIT-IV	
Dynamic Documents with JavaScript: Introduction to dynamic documents; Positioning elements; Moving elements; Element visibility; Changing colors and fonts; Dynamic content; Stacking elements; Locating the mouse cursor; Reacting to a mouse click; Slow movement of elements; Dragging and dropping elements. **Introduction to PHP:** Origins and uses of PHP; overview of PHP; General syntactic characteristics; Primitives, Operations and Expressions; Output; Control statements; Arrays; Functions; Pattern Matching; Form Handling; Files; Cookies; Session Tracking.	**06 Hrs**

UNIT-V	
XML: Introduction; Syntax; Document structure; Document Type definitions; Namespaces; XML schemas; Displaying raw XML documents; Displaying XML documents with CSS; XSLT Style sheets; XML processors; Web services.	**05 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1.	Understand and explore internet related concepts that are vital for web development.
CO2.	Apply HTML tags for designing static web pages and forms using Cascading Style Sheet.
CO3.	Utilize the concepts of XML, JavaScripts along with XHTML for developing web pages.
CO4.	Design and develop web based applications using JavaScripts, CSS, XHTML, PHP and XML.

Reference Books	
1.	Programming the World Wide Web – Robert W. Sebesta, 7th Edition, 2013,Pearson Education, ISBN-13:978-0132665810
2.	Web Programming Building Internet Applications , Chris Bates, 3rd Edition, , 2006, Wiley India, ISBN : 978-81-265-1290-4
3.	Internet & World Wide Web How to H program , M. Deitel, P.J. Deitel, A. B. Goldberg, 3rd Edition,2004, Pearson Education / PHI, ISBN-10: 0-130-89550-4
4.	Thomas A Powell, The Complete Reference to HTML and XHTML, 4th Edition, 2003, Tata McGraw Hill publisher. ISBN: 978-0- 07-222942- 4.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**1**	**-**	**2**	**-**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**1**
CO2	**-**	**-**	**2**	**-**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**
CO3	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**-**	**2**	**-**	**-**	**2**
CO4	**-**	**-**	**3**	**-**	**2**	**-**	**-**	**-**	**2**	**-**	**-**	**2**

Low-1 Medium-2 High-3

Semester: VI		
AUTOMOTIVE ELECTRONICS **(Group D: Global Elective)**		
Course Code: 16G6E05		**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:0		**SEE Marks:** 100
Hours:36L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1	Understand the application of principles of sensing technology in automotive field
2	Apply control systems in the automotive domain
3	Understand automotive specific communication protocols / techniques
4	Analyze fault tolerant real time embedded systems

UNIT-I	
Power Train Engineering and Fundamentals of Automotive: Fundamentals of Petrol, diesel and gas engines, electric motors and control systems. Basic Automotive System, System Components, Evolution of Electronics in Automotive. Alternators and charging, battery technology, Ignition systems. Working principles of various electronic components and accessories used in Automotive. Developments in existing engine forms and alternatives. Hybrid designs (solar power, electric/gasoline, LPG, CNG, fuel cells). Basic Transmission systems.	**08 Hrs**
UNIT-II	
Sensor Technologies in Automotive: In-vehicle sensors: Working principles, Characteristics, limitations and use within the automotive context of the following: Temperature sensing e g. coolant, air intake. Position sensing e.g. crankshaft, throttle plate. Pressure sensing e.g. manifold, exhaust differential, tyre. Distance sensing e.g. anti-Collision, Velocity sensing e.g. speedometer, anti-skid. Torque sensing e.g. automatic transmission. Vibration sensing e.g. Airbags. flow sensing and measurement e.g. fuel injection. Interfacing principles: Operation, topologies and limitations of all sensors covered in the above to in-vehicle processing or communications nodes. Use of Actuators: Types, working principle, Characteristics, limitations and use within the automotive context of each type.	**07 Hrs**
UNIT-III	
Automotive Control Systems: Control system approach in Automotive: Analog and Digital control methods, stability augmentation, control augmentation. Transmission control, System components and functions. Cruise control, traction control, actuator limiting, wind-up, gain scheduling, adaptive control. Special Control Schemes: Vehicle braking fundamentals, Antilock systems. Variable assist steering and steering control. Controls for Lighting. Wipers, Air conditioning /heating. Remote keyless Entry and Anti-theft System, Emission Course-system control. Control techniques used in hybrid system. Electronic Engine control: Motion equations, modeling of linear and non-linear systems, numerical methods, system responses Objective of Electronic Engine control. Spark Ignition and Compression Ignition Engines and their electronic controls. Engine management testing: Engine management system strategies and implementation. Simulation and implementation methods. Methods of improving engine performance and efficiency. Model Based Development (MBD) Technology. AUTOSAR: Objectives and Architecture.	**07 Hrs**
UNIT-IV	
Automotive Communication Systems: Communication interface with ECU's: Interfacing techniques and interfacing with infotainment gadgets. Relevance of internet protocols, such as TCP/IP for automotive applications. Wireless LANs standards, such as Bluetooth, IEEE802.11x. Communication protocols for automotive applications. Automotive Buses: Use of various buses such as CAN, LIN, Flex Ray. Recent trends in automotive buses (Such as OBDI1. MOST, IE, IELI.I, D2B and DSI). Application of Telematics in Automotive: Global Positioning Systems (GPS) and General Packet Radio Service (GPRS), for use in an automotive environment. Vehicle to Vehicle Communication Higher End Technology: Comparative Study and applications of ARM Cortex-Ascries/M-scries. ARM 9 and ARM11.	**07 Hrs**

UNIT-V	
Diagnostics and Safety in Automotive: Fundamentals of Diagnostics: Basic wiring system and Multiplex wiring system. Preliminary checks and adjustments, Self-Diagnostic system. Fault finding and corrective measures. Electronic transmission checks and Diagnosis, Diagnostic procedures and sequence. On board and off board diagnostics in Automotive. Safety in Automotive: Safety norms and standards. Passenger comfort and security systems. Future trends in Automotive Electronics.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Acquire the knowledge of automotive domain fundamentals and need of electronics in Automotive systems
CO2:	Apply various sensors and actuators for Automotive applications
CO3:	Analyze different control systems and communication interfaces used in automotive systems.
CO4:	Evaluate the performance of telematics Diagnostics and safety norms in Automotive Systems.

Reference Books	
1.	Understanding Automotive Electronics, Williams. B. Ribbens, 6th Edition, 2003, Elsevier science, Newness publication, ISBN-9780080481494.
2.	Automotive Electronics Handbook, Robert Bosch, 2004, John Wiley and Sons,
3.	Automotive Embedded Systems Handbook, Nicolas Navet, F Simonot-Lion, Industrial Information Technology Series, CRC press.
4.	Automotive Control Systems Engine, Driveline and vehicle, Uwekiencke and lars Nielsen, Springer, 2nd Edition, 2005, ISBN 0-387-95368X

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**1**	**2**	**1**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**1**
CO2	**3**	**2**	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**1**	**-**	**1**
CO3	**3**	**2**	**2**	**1**	**-**	**1**	**-**	**-**	**2**	**-**	**1**	**1**
CO4	**3**	**1**	**2**	**1**	**2**	**1**	**-**	**-**	**1**	**-**	**-**	**-**

Low-1 Medium-2 High-3

Semester: VI		
INDUSTRIAL ELECTRONICS **(Group E: Global Elective)**		
Course Code:		**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:0		**SEE Marks:** 100
Hours: 36L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1	Explain the working of the devices used in power electronic circuits in industrial applications
2	Analysing and designing power electronic circuits which handle the electrical energy efficiently and economically and Identify the typical practical problems with industrial exposure acquired
3	Use basic concepts of design and working of electronic circuits for conversion and control of electrical energy.
4	Apply the knowledge to work as part of teams on multidisciplinary projects and to discuss industrial problems with regard to application of Power Electronics.

Unit-I	
Power semi-conductor Devices and static characteristics: Construction, working & characteristics of MOSFET, SCR, IGBT. Comparison of Power BJT, MOSFET, SCR, IGBT. Turn on methods of Power BJT, MOSFET and IGBT. Design of R, R-C, and UJT (pulse train) Gate triggering methods of SCR.	**08 Hrs**
Unit-II	
Thyristor Dynamic characteristics, Specifications and Protection: Gate characteristics of SCR, Dynamic characteristics of SCR. Design of Snubber circuit for SCR, Line Commutation and Forced Commutation circuits with design, Gate protection & overvoltage protection of SCR.	**07 Hrs**
Unit-III	
Converters: **1.** Single Phase Controlled Convertor- Full wave Half and Fully controlled line commutated bridge converters, Derivation of average load voltage and current. Three phase converters –Six pulse converters- with R load- Active inputs to the convertors with and without Freewheeling diode, Derivation of average load voltage and current. **Converter applications:** **2.** Industrial Applications of Half and Fully controlled converters to DC drives (Control of DC drives)	**06 Hrs**
Unit-IV	
3. Choppers – Step down, Step up Chopper, Step up/Down Chopper, Time ratio control and Current limit control strategies –Derivation of load voltage and currents with R, RL of Step down, Step up Chopper, Step up/Down Chopper – load voltage expression. **4.** Application of choppers to subway cars, Industrial drives , battery operated vehicles.	**07 Hrs**
Unit-V	
Classification of Choppers and Applications: Type A, Type B, Type C, Type D, Type E choppers and their industrial Applications, AC Chopper –phase control type. 5. Inverters – Single phase inverter – Basic series inverter – Basic parallel Capacitor inverter, bridge inverter(single phase) – Voltage control techniques for inverters Pulse width modulation techniques. – UPS-online, offline (Principle of operation only	**08 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the comprehensive working of different devices and their applications.
CO2:	Analyze the application of skills in controlling and conversion of electrical energy.
CO3:	Evaluate and distinguish the performance of converters and inverters.

CO4:	Ability to implement their knowledge and skills in design of applications.

Reference Books	
1.	Power Electronics, M. D. Singh & K. B. Kanchandhani, Tata Mc Graw – Hill Publishing company, ISBN : 978-0-07-058389-4, 2008
2.	Power Electronics : Circuits, Devices and Applications, M. H. Rashid, Prentice Hall of India, 2nd Edition, ISBN : 0131228153, 9780131228153, 2004
3.	Power Electronics, P.C. Sen, Tata McGraw-Hill Publishing, ISBN: 978-0-07-462400-5, 2008.
4	Power Electronics P S Bimbra P.S Bimbra ,Khanna Publication ,ISBN:978-7409-279-3,5th Edition.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping															
CO/PO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	2	1	2	2	1	1	2	0	1	3	2	2
CO2	3	2	2	3	3	0	1	0	0	0	2	1	3	2	2
CO3	3	2	2	3	2	2	0	1	0	0	1	2	3	2	2
CO4	3	3	3	3	2	3	2	0	1	0	0	1	3	3	3

High-3: Medium-2: Low-1

Semester: VI		
PROJECT MANAGEMENT **(Group E: Global Elective)**		
Course Code : 16G6E07		**CIE Marks : 100**
Credits : L: T: P: S:3:0:0:0		**SEE Marks : 100**
Hours : 33L		**SEE Duration : 03 Hrs**

Course Learning Objectives: The students will be able to

1. To understand the principles and components of project management.
2. To appreciate the integrated approach to managing projects.
3. To explain the processes of managing project cost and project procurements.

Unit – I	
Introduction: What is project, what is project management, relationships among portfolio management, program management, project management, and organizational project management, relationship between project management, operations management and organizational strategy, business value, role of the project manager, project management body of knowledge.	**06 Hrs**
UNIT – II	
Organizational influences & Project life cycle: Organizational influences on project management, project state holders & governance, project team, project life cycle. **Project Integration Management:** Develop project charter, develop project management plan, direct & manage project work, monitor & control project work, perform integrated change control, close project or phase.	**08 Hrs**
UNIT – III	
Project Scope Management: Project scope management, collect requirements define scope, create WBS, validate scope, control scope. **Project Time Management:** Plan schedule management, define activities, sequence activities, estimate activity resources, estimate activity durations, develop schedule, control schedule.	**07 Hrs**
UNIT – IV	
Project Cost management: Project Cost management, estimate cost, determine budget, control costs. **Project Quality management:** Plan quality management, perform quality assurance, control quality.	**06 Hrs**
UNIT – V	
Project Risk Management: Plan risk management, identify risks, perform qualitative risk analysis, perform quantitative risk analysis, plan risk resources, control risk. **Project Procurement Management:** Project Procurement Management, conduct procurements, control procurements, close procurement.	**06 Hrs**

Course Outcomes: After going through this course the student will be able to	
CO1	Understand the concepts, tools and techniques for managing large projects.
CO2	Explain various sub processes in the project management frameworks.
CO3	Analyze and evaluate risks in large and complex project environments.
CO4	Develop project plans for various types of organizations.

Reference Books:

1. A Guide to the Project Management Body of Knowledge(PMBOK Guide), Project Management Institute, 5th Edition, 2013, ISBN: 978-1-935589-67-9
2. Project Planning Analysis Selection Financing Implementation & Review, Prasanna Chandra, 7th Edition, 2010, Tata McGraw Hill Publication, ISBN 0-07-007793-2.

3. Project Management A System approach to Planning Scheduling & Controlling, Harold Kerzner, 10th Edition, 2009, CBS Publishers and Distributors, ISBN 047027806.
4. Strategic Project Management Made Simple: Practical Tools for Leaders and Teams, Terry Schmidt, 1st Edition, 2009, John Wiley & Sons, ISBN: 978-0470411582

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2											
CO2	2	2		1	1							
CO3							1	1				
CO4	2		3		1							

Low-1 Medium-2 High-3

Semester: VI		
VIRTUAL INSTRUMENTATION **(Group E: Global Elective)**		
Course Code:16G6E08		**CIE Marks:** 100
Credits/Week: L:T:P:S: 3:0:0:0		**SEE Marks:** 100
Hours:35L		**SEE Duration:** 3Hrs

Course Learning Objectives: The students will be able to	
1	Understand the difference between conventional and graphical programming, basic data acquisition concepts.
2	Differentiate the real time and virtual instrument.
3	Develop ability for programming in LabVIEW using various data structures and program structures.
4	Analyze the basics of data acquisition and learning the concepts of data acquisition with LabVIEW.

UNIT-I	
Graphical Programming Environment: Basic of Virtual Instrumentation, Conventional and Graphical Programming. Introduction to LabVIEW, Components of LabVIEW and Labels. **Fundamentals:** Data Types, Tool Pallets, Arranging Objects, Color Coding, Code Debugging, Context Help, Creating Sub-VIs Boolean, Mechanical action- switch, and latch actions, String data types, enum, ring, Dynamics.	**06 Hrs**
UNIT-II	
Fundamentals of Virtual Instrumentation Programming: For Loop, While Loop, shift registers, stack shift register, feedback node, and tunnel. **Timing function**: Timing VI, elapsed time, wait function. Case structures, formula node, Sequence structures, Arrays and clusters, visual display types-graphs, charts, XY graph. Local and Global variables.	**09 Hrs**
UNIT-III	
Error Handling- error and warning, default error node, error node cluster, automatic and manual error handling. **String Handling:** Introduction, String Functions, LabVIEW String Formats. **File Input/ Output:** Introduction, File Formats, File I/O Functions and file Path functions. **Design patterns:** Producer/consumer, event handler, derived design pattern, Queued message handler, Producer/consumer (events), Producer/consumer (state machine).	**08 Hrs**
UNIT-IV	
Data Acquisition: Introduction to data acquisition, Analog Interfacing Connecting signal to board, Analog Input/output techniques digital I/O, counters, NI-DAQmx tasks. **DAQ Hardware configuration:** Introduction, Measurement and Automation Explorer, DAQ Assistants, Analysis Assistants. **Interfacing Instruments: GPIB and RS232:** Introduction, RS232 Vs. GPIB, Handshaking, GPIB Interfacing, RS232C/RS485 Interfacing, and VISA.	**06 Hrs**
UNIT-V	
Advanced Topics In LabVIEW: Use of analysis tools and application of VI: Fourier transforms Power spectrum, Correlation methods, windowing & filtering. Inter-Process Communication, Notifier, Semaphore, Data Sockets. **Simulation of systems using VI:** Development of Control system, Image acquisition and processing.	**06 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember and Understand the fundamentals of Virtual Instrumentation and data Acquisition.
CO2:	Apply the theoretical concepts to realize practical systems.

CO3:	Analyze and evaluate the performance of Virtual Instrumentation Systems.
CO4:	Create a VI system to solve real time problems using data acquisition.

Reference Books	
1	Virtual instrumentation Using LabVIEW, Jovitha Jerome, 4th Edition, 2010, PHI Learning Pvt. Ltd., ISBN: 978-812034035.
2	Virtual Instrumentation Using LabVIEW, Sanjay Gupta & Joseph John, 2nd Edition, New Delhi, 2010,Tata McGraw Hill Publisher Ltd., ISBN: 978-0070700284
3	LabVIEW for Everyone: Graphical Programming made easy and fun,Jeffrey Travis, Jim Kring, 3rd Edition, 2006, Prentice Hall,ISBN: 978-0131856721.
4	Data Acquisition using LabVIEW,Behzad Ehsani, 1st Edition,2017, Packt Publishing, ISBN: 978-1782172161.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marksis executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO MAPPING												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**2**	**1**	**1**	**1**	**2**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO2	**1**	**1**	**1**	**1**	**2**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO3	**1**	**-**	**1**	**1**	**2**	**-**	**-**	**-**	**2**	**2**	**-**	**1**
CO4	**2**	**1**	**1**	**2**	**3**	**-**	**-**	**-**	**2**	**2**	**-**	**2**

Low-1 Medium-2 High-3

Semester: VI		
INTRODUCTION TO MOBILE APPLICATION DEVELOPMENT (Group E: Global Elective)		
Course Code: 16G6E09		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours : 36L		**SEE Duration: 3Hrs**

Course Learning Objectives: The students will be able to	
1	Learn Android application development platform for mobile devices and use it.
2	Understand mobile application architecture and its components.
3	Define Android specific programming concepts such as activities, intents, fragments, services, broadcast receivers and content providers.
4	Describe sensors like motion sensors, environmental sensors, and positional sensors; most commonly embedded in Android devices along with their application programming interface.

UNIT I	
Overview of Software platforms and Development: Mobile OS: Android development platform and tools, Programming language, Emulator, SDK and Development Environments **Creating Applications and Activities:** Introducing the Application Manifest File; Creating Applications and Activities; Architecture Patterns (MVC); Android Application Lifecycle.	**07 Hrs**
UNIT II	
User Interface Design: Fundamental Android UI Design; Introducing Layouts; Introducing Fragments. **Intents and Broadcasts**: Introducing Intents; Creating Intent Filters and Broadcast Receivers.	**07 Hrs**
UNIT III	
Database and Content Providers: Introducing Android Databases; Introducing SQLite; Content Values and Cursors; Working with SQLite Databases; Creating Content Providers; Using Content Providers; Case Study: Native Android Content Providers.	**07 Hrs**
UNIT IV	
Location Based Services, Telephony and SMS: Using Location-Based Services; Using the Emulator with Location-Based Services; Selecting a Location Provider; Using Proximity Alerts; Using the Geocoder; Example: Map-based activity; Hardware Support for Telephony; Using Telephony; Introducing SMS and MMS.	**08 Hrs**
UNIT V	
Hardware Support and Devices (AUDIO, VIDEO, AND USING THE CAMERA): Using Sensors and the Sensor Manager; Monitoring a Device's Movement and Orientation; Introducing the Environmental Sensors; Playing Audio and Video; Using Audio Effects; Using the Camera; Recording Video	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Assess the basic framework and usage of SDK to build GUI and apply advanced technologies in developing Android mobile applications.
CO2:	Differentiate techniques for persisting user data, such as shared preferences, traditional file systems (internal and external storage), and SQLite database
CO3:	Articulate the communication programming features and capabilities of Android platforms.
CO4:	Design and create innovative, sophisticated mobile applications using Android platform.

Reference Books	
1.	Professional Android 4 Application Development, Reto Meier, WROX Press, 2012, Wiley Publishing, ISBN: 9781118102275
2.	Android Application Development: Programming with the Google SDK, John Lombardo, Blake Meike, Rick Rogers and Zigurd Mednieks, 2009, O'Reilly Media, Inc. ISBN: 9788184047332

3.	Hello Android, Introducing Google's Mobile Development Platform, Ed Burnette, 3rd Edition, Pragmatic Programmers, LLC.ISBN: 9781934356562
4.	Android Studio Development Essentials - Android 6, Neil Smyth, 2015, Createspace Independent Publishing Platform, ISBN: 9781519722089

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Self-Study(S). A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 50. The marks component for Self-study is 20. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	3	-	-	3	-	-	-	-	-	-	2
CO2	3	3	3	-	3	1	-	-	-	2	-	2
CO3	-	3	3	-	3	2	-	-	-	2	1	3
CO4	3	3	3	2	3	2	2	2	2	2	1	3

Low-1 Medium-2 High-3

Semester: VI		
AUTOMOTIVE ENGINEERING (Group E: Global Elective)		
Course Code:	16G6E10	**CIE Marks: 100**
Credits: L:T:P:S	**3:0:0:0**	**SEE Marks: 100**
Hours:	**36L**	**SEE Duration: 3Hrs**
Course Learning Objectives: The students will be able to		
1	Identify the different sub-systems in automobiles.	
2	Describe the functions of each of the sub-systems and its effect.	
3	Discuss fuel injection, transmission, braking, steering, suspension, air intake and exhaust systems.	
4	Explain the importance of selection of suitable sub-system for a given performance requirement.	

UNIT-I	
Automobile Engines Classifications of Internal Combustion Engines based on no. of cylinders, Arrangement of cylinders, Type of fuel and no. of strokes**.** Engine construction and nomenclature. Thermodynamic principles of Otto and Diesel cycle. Operation in a 4 stroke engine. Direct and indirect injection. Combustion stages in engines. Fuels: Gasoline, Diesel, LPG and Natural Gas For automotive applications. Fuel properties- Octane number and Cetane number. Pollutants and Emission norms- Regulated pollutants and its effects, Regulations as per emission norms.	**06 Hrs**
UNIT-II	
Engine Auxiliary Systems: AirIntake and Exhaust System- Working principle ofAir filters, Intake manifold, Turbocharger, Intercooler, Exhaust manifold, Catalytic convertor, Exhaust Gas Recirculation system, Muffler. Cooling system- Components, working principle, Coolant. Lubrication system- Components, Properties of lubricating oil, Viscosity numbers. Fuel system- Working principle of Fuel Injection Pump, Injector, Nozzle, Fuel filter. Working of ignition system, Battery, Immobilizer.	**08 Hrs**
UNIT-III	
Transmission: Clutch- Classification and working, Gear box- Classification, Working of sliding mesh and Synchromesh transmission, Automatic transmission. Propeller shaft, Differential assembly and rear axle- Working. Wheels and Tyres- Wheel alignment and balancing classification of tyres, Radial, Tubeless.	**08 Hrs**
UNIT-IV	
Vehicular Auxiliary Systems: Suspension- Front and rear suspension working, Types of springs. Brake- Classification and Components - Disc and drum brakes, Hydraulic, parking brake, Front and rear wheel brakes. Antilock Braking Systems. Steering- components and operation of power steering. Vehicle frame and body classification- Hatchback, Sedan, SUV. Safety systems- Passive safety systems, Active safety systems- Principle of Electronic Stability Program, Air bags, Crash testing methods.	**06 Hrs**
UNIT-V	
Demonstrations of Automobile Systems: Engine performance measurement in terms of Brake power, Emission measurement and principle, Drawing Valve Timing Diagram for multi-cylinder engine, Production and properties of biodiesel.	**06 Hrs**

Course Outcomes: After completing the course, the students will be able to	
1	Describe the different types of automotive systems. (L1- L2)
2	Construct the Valve Timing Diagram for multi-cylinder engines. (L3)
3	Detect the automotive exhaust pollutants using gas analyzer. (L4)
4	Evaluate the performance of engines by determining Brake Power. (L6)

Reference Books	
1.	Automotive Engineering Fundamentals, Richard Stone and Jeffrey K. Ball, 2004 , SAE International , ISBN: 0768009871
2.	Bosch Automotive Handbook, Robert Bosch, 9th Edition, 2004, ISBN: 9780768081527.
3.	Automotive Engineering e-Mega Reference, David Crolla, Butterworth-Heinemann, 1st Edition , 2009 , ISBN: 9781856175784.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**1**	**1**		**1**			**2**		**2**			**1**
CO2		**2**										
CO3		**2**	**1**			**2**		**1**			**2**	**1**
CO4	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**2**	**2**	

Low-1 Medium-2 High-3

Semester: VI		
MOBILE NETWORK SYSTEMS AND STANDARDS (GROUP E: GLOBAL ELECTIVE)		
Course Code: 16G6E11		**CIE Marks: 100**
Credits: L:T:P:S: 3:0:0:0		**SEE Marks: 100**
Hours: 34L		**SEE Duration: 03Hrs**

Course Learning Objectives: The students will be able to	
1	Understand land mobile concepts, radio link design and cellular network.
2	Compare the standards of WPAN, WLAN and WMAN.
3	Analyze WPAN, WLAN and WMAN standards and their architecture.
4	Design and demonstrate wireless networks for various applications.

UNIT-I	
Cellular Wireless Networks: Principles of cellular Networks, cellular system components and Operations, channel assignment, Attributes of CDMA in cellular system.	**06 Hrs**
UNIT-II	
Second generation Cellular Networks: GSM architecture, IS-95, GPRS, EDGE.	**08 Hrs**
UNIT-III	
Third generation cellular systems: WCDMA, IMT 2000 and LTE, Convergence in the network.	**06 Hrs**
UNIT-IV	
Wireless Personal Area Networks: Network architecture, components, Applications, Zigbee, Bluetooth. **Wireless Local Area networks:** Network Architecture, Standards, Applications.	**08 Hrs**
UNIT-V	
Wireless Metropolitan Area Networks: IEEE 802.16 standards, advantages, WMAN Network architecture, Protocols, Applications.	**06 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the architectures and characteristics of different mobile networks. (L1- L2)
CO2	Apply the Network standards to a suitable application (L3)
CO3	Analyze the operation of various network technologies and standards (L4)
CO4	Evaluate the performance of various network technologies (L5)

Reference Books	
1	Wireless Communication, Upena Dalal, 1st Edition , 2009, Oxford higher Education, ISBN-13:978-0-19-806066-6.
2	Wireless and Mobile Networks Concepts and Protocols, Dr. sunil Kumar s Manvi, 2010, Willey India Pvt. Ltd., ISBN: 978-81-265-2069-5.
3	Wireless Communications Principles and practice, Theodore S Rappaport, 2nd Edition, Pearson, ISBN 97881-317-3186-4.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	---	2	---	---	2	---	2	---	1
CO2	3	3	2	---	2	---	---	2	---	2	---	1
CO3	3	3	3	---	2	---	---	2	---	2	---	2
CO4	3	3	3	---	3	---	---	2	---	2	---	2

Low-1 Medium-2 High-3

Semester: VI		
APPLIED PARTIAL DIFFERENTIAL EQUATIONS (Group E: Global Elective)		
Course Code:16G6E12		**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:0		**SEE Marks:** 100
Hours: 35L		**SEE Duration:** 3Hrs

Course Learning Objectives:

1	Adequate exposure to learn basics of partial differential equations and analyze mathematical problems to determine the suitable analytical technique.
2	Use analytical techniques and finite element technique for the solution of elliptic, parabolic and hyperbolic differential equations.
3	Solve initial value and boundary value problems which have great significance in engineering practice using partial differential equations.
4	Identify and explain the basics of partial differential equations and use the same to analyze the behavior of the system.

Unit-I	
Partial Differential Equations of first order: Introduction to formation of partial differential equations, Cauchy problem, Orthogonal surfaces, First order non-linear partial differential equations-Charpit's method, Classification and canonical forms of partial differential equations.	**07 Hrs**
Unit – II	
Elliptic Differential Equations: Derivation of Laplace and Poisson equation, Separation of variable method, Dirichlet problem, Neumann problem, Solution of Laplace equation in cylindrical and spherical coordinates.	**07 Hrs**
Unit -III	
Parabolic Differential Equations: Formation and solution of Diffusion equation, Dirac-Delta function, Separation of variable method, Solution of Diffusion equation in cylindrical and spherical coordinates.	**07 Hrs**
Unit –IV	
Hyperbolic Differential Equations: Formation and solution of one dimensional wave equation, D'Alembert's solution, vibrating string, Forced vibration, Periodic solution of one dimensional wave equation in cylindrical and spherical coordinates, Vibration of Circular membrane.	**07 Hrs**
Unit –V	
Numerical solutions of Partial Differential Equations: Finite difference method for Elliptic, Parabolic and Hyperbolic partial differential equations, Introduction to the finite element method-simple problems.	**07 Hrs**

Course Outcomes: After completing the course, the students will be able to

CO1:	Identify and interpret the fundamental concepts of formation and solution of parabolic, hyperbolic and elliptic differential equations using analytical and numerical methods.
CO2:	Apply the knowledge and skills of analytical and numerical methods to solve the parabolic, hyperbolic and elliptic differential equations arising in the field of science and engineering.
CO3:	Analyze the physical problem to establish mathematical model and use appropriate method to solve and optimize the solution using the appropriate governing equations.
CO4:	Distinguish the overall mathematical knowledge to demonstrate and analyze the solution of parabolic, hyperbolic and elliptic differential equations arising in practical situations.

Reference Books	
1	Partial Differential Equations, K. Sankara Rao, Prentice-hall of India, 3rd Edition, 2012, ISBN: 978-81-203-3217-1.
2	Advanced Engineering Mathematics, Erwin Kreyszig, Wiley, 10th Edition, 2016, ISBN: 978-81-265-5423-2.
3	Numerical methods for scientific and engineering computation, M K Jain, S. R. K. Iyengar, R. K. Jain, New Age International Publishers, 6th Edition, 2012, ISBN-13: 978-81-224-2001-2.
4	An Introduction to the finite element method, J. N. Reddy, McGraw Hill, 3rd Edition, 2005, ISBN 13: 9780072466850.

Continuous Internal Evaluation (CIE); Theory (100 Marks)

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Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**2**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO2	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**
CO3	**2**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**
CO4	**3**	**3**	**1**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**3**

High-3: Medium-2: Low-1

Semester: VI		
GLOBAL ELECTIVE-E		
AIRCRAFT SYSTEMS (Theory)		
Course Code: 16G6E13		**CIE Marks:** 100
Credits: L:T:P:S: 3:0:0:0		**SEE Marks:** 100
Hours: 36L		**SEE Duration:** 3Hrs

Course Learning Objectives: To enable the students to:	
1	List the various systems involved in the design of an aircraft
2	Demonstrate the technical attributes of all the subsystems of an aircraft
3	Explain the significance of each systems and its subsystems for developing an airplane
4	Demonstrate the integration of the systems with the airplane

Unit-I	
Flight Control Systems : Primary and secondary flight controls, Flight control linkage system, Conventional Systems, Power assisted and fully powered flight controls.	**07 Hrs**
Unit – II	
Aircraft Hydraulic & Pneumatic Systems : Components of a typical Hydraulic system, Working or hydraulic system, Power packs, Hydraulic actuators. Pneumatic system and components, Use of bleed air, Landing gear and braking, Shock absorbers-Retraction mechanism.	**08 Hrs**
Unit -III	
Aircraft Fuel Systems : Characteristics of aircraft fuel system, Fuel system and its components, Gravity feed and pressure feed fuel systems, Fuel pumps-classification, Fuel control unit.	**07 Hrs**

Unit -IV	
Environmental Control Systems : Air-conditioning system, vapour cycle system, de-icing and anti-icing system, Fire detection- warning and suppression. Crew escape aids. **Engine Systems :** Engine starting sequence, Starting and Ignition systems, Engine oils and a typical lubricating system.	**07 Hrs**
Unit -V	
Aircraft Instruments : Instruments displays, panels & layouts, Instrumentation grouping, Navigation instruments, Radio instruments, Hydraulic and Engine instruments. **Air Data Instruments :** Basic air data system and probes, Mach meter, Air speed indicator, Vertical speed indicator, Barometric pressure sensing, Altimeter, Air data alerting system- angle of attack sensing, stall warning, Mach warning, altitude alerting system.	**07 Hrs**

Course Outcomes: At the end of this course the student will be able to :	
1	Categorise the various systems required for designing a complete airplane
2	Comprehend the complexities involved during development of flight vehicles.
3	Explain the role and importance of each systems for designing a safe and efficient flight vehicle
4	Demonstrate the different integration techniques involved in the design of an air vehicle

Reference Books	
1	John D. Anderson, Introduction to Flight, 7th Edition, 2011, McGraw-Hill Education, ISBN 9780071086059.
2	Moir, I. and Seabridge, A.,Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, 3rd Edition, 2008, Wiley Publications, ISBN- 978-0470059968

Continuous Internal Evaluation (CIE); Theory (100 Marks)

CIE is executed by way of quizzes (Q), tests (T) and Assignment. A minimum of three quizzes are conducted and each quiz is evaluated for 10 marks adding up to 30 marks. All quizzes are conducted online. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three also. The three tests are conducted for 50 marks each and the sum of the marks scored from three tests is reduced to 60. The marks component for assignment is 10. The total marks of CIE are 100.

Semester End Evaluation (SEE); Theory (100 Marks)

SEE for 100 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the complete syllabus. Part – B consists of five main questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have sub questions. The question from Units I, IV and V have no internal choice. Units II and III have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**3**	**3**	**1**	**1**	**3**	**2**	**2**				**1**
CO2	**2**	**3**	**3**	**3**	**1**	**1**	**1**	**1**				**1**
CO3	**2**	**2**	**3**	**3**	**1**							**2**
CO4	**3**	**3**	**3**	**3**	**1**	**2**	**1**	**2**				**1**

High-3 : Medium-2 : Low-1

Semester: VI		
PROFESSIONAL PRACTICE – III **EMPLOYABILITY SKILLS AND PROFESSIONAL DEVELOPMENT OF ENGINEERS**		
Course Code: 16HS68		**CIE Marks:** 50
Credits: L:T:P:S: 0:0:1:0		**SEE Marks:** NA
Hours: 18 Hrs		**CIE Duration:** 02 Hrs

Course Learning Objectives: The students will be able to	
1	Improve qualitative and quantitative problem solving skills.
2	Apply critical and logical thinking process to specific problems.
3	Ability to verbally compare and contrast words and arrive at relationships between concepts, based on verbal reasoning.
4	Applying good mind maps that help in communicating ideas as well as in technical documentation

V Semester	
UNIT-I	
Aptitude Test Preparation- Importance of Aptitude tests, Key Components, Quantitative **Aptitude** – Problem Solving, Data Sufficiency, Data Analysis - Number Systems, Math Vocabulary, fraction decimals, digit places etc. **Reasoning and Logical Aptitude,** - Introduction to puzzle and games organizing information, parts of an argument, common flaws, arguments and assumptions. Analytical Reasoning, Critical Reasoning.	**06 Hrs**
UNIT-II	
Verbal Analogies - What are Analogies, How to Solve Verbal Analogies & developing Higher Vocabulary, Grammar, Comprehension and Application, Written Ability. Non-Verbal Reasoning, Brain Teasers. Creativity Aptitude. **Group Discussion-** Theory &Evaluation : Understanding why and how is the group discussion conducted, The techniques of group discussion, Discuss the FAQs of group discussion, body language during GD.	**06 Hrs**
UNIT-III.A	
Resume Writing- Writing Resume, how to write effective resume, Understanding the basic essentials for a resume, Resume writing tips Guidelines for better presentation of facts.	**06 Hrs**
VI Semester	
UNIT-III.B	
Technical Documentation - Introduction to technical writing- Emphasis on language difference between general and technical writing, Contents in a technical document, Report design overview & format Headings, list & special notes, Writing processes, Translating technical information, Power revision techniques, Patterns & elements of sentences, Common grammar, usage & punctuation problems.	**06 Hrs**
UNIT-IV	
Interview Skills -a) Personal Interviews , b) Group Interviews , c) Mock Interviews - Questions asked & how to handle them, Body language in interview, Etiquette, Dress code in interview, Behavioral and technical interviews, Mock interviews - Mock interviews with different Panels. Practice on stress interviews, technical interviews, General HR interviews etc.	**06 Hrs**
UNIT-V	
Interpersonal Relations - Optimal Co-existence, Cultural Sensitivity, Gender sensitivity Adapting to the Corporate Culture- Capability & Maturity Model, Decision Making Analysis, Brain Storm. Adapting to the Corporate Culture.	**06 Hrs**

Course Outcomes: After completing the course, the students will be able to	
CO1:	Inculcate employability skill to suit the industry requirement.
CO2:	Analyze problems using quantitative and reasoning skills
CO3:	Exhibit verbal aptitude skills with appropriate comprehension and application.
CO4:	Focus on Personal Strengths and Competent to face interviews and answer
Reference Books	
1.	The 7 Habits of Highly Effective People, Stephen R Covey Free Press, 2004 Edition, ISBN: 0743272455
2.	How to win friends and influence people, Dale Carnegie General Press, 1st Edition, 2016, ISBN: 9789380914787
3.	Crucial Conversation: Tools for Talking When Stakes are High, Kerry Patterson, Joseph Grenny, Ron Mcmillan 2012 Edition, McGraw-Hill Publication ISBN: 9780071772204
4.	Aptimithra: Best Aptitude Book ,Ethnus,2014 Edition, Tata McGraw Hill ISBN: 9781259058738

Scheme of Continuous Internal Examination (CIE)
Evaluation of CIE will be carried out in TWO Phases.

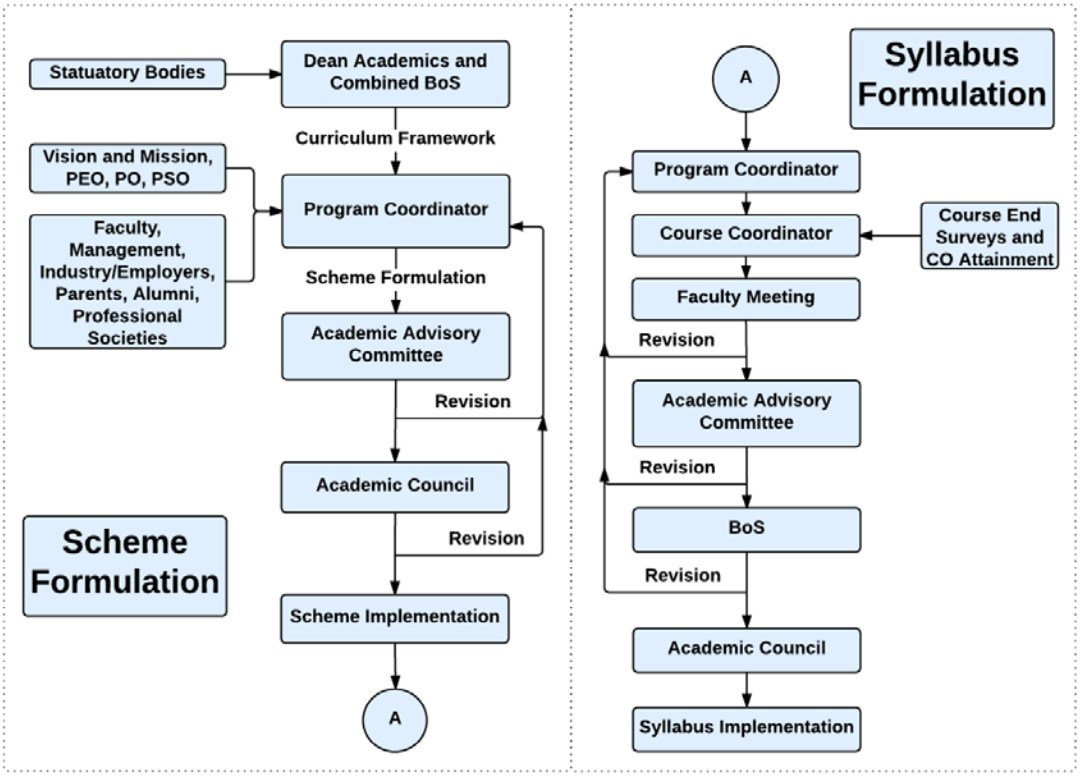
Phase	Activity	Weightage
I	Test 1 is conducted in V Sem for 50 marks (15 Marks Quiz and 35 Marks Descriptive answers) after completion of Unit-1, Unit-2 and Unit -3.A for 18 hours of training sessions.	50%
II	Test 2 is conducted in VI Sem for 50 marks ((15 Marks Quiz and 35 Marks Descriptive answers) after completion of Unit -3B, Unit - 4 and Unit-5 for 18 hours of training sessions.	50%
	At the end of the VI sem Marks of Test 1 and Test 2 is consolidated for 50 marks (Average of Test1 and Test 2 (T1+T2/2). The grading is provided by the Coe. The final CIE marks is scrutinized by the committee comprising of HSS- Chairman, Training Co-ordinator, respective department Staff Placement co-ordinator before submitting to CoE.	

SEE: NA

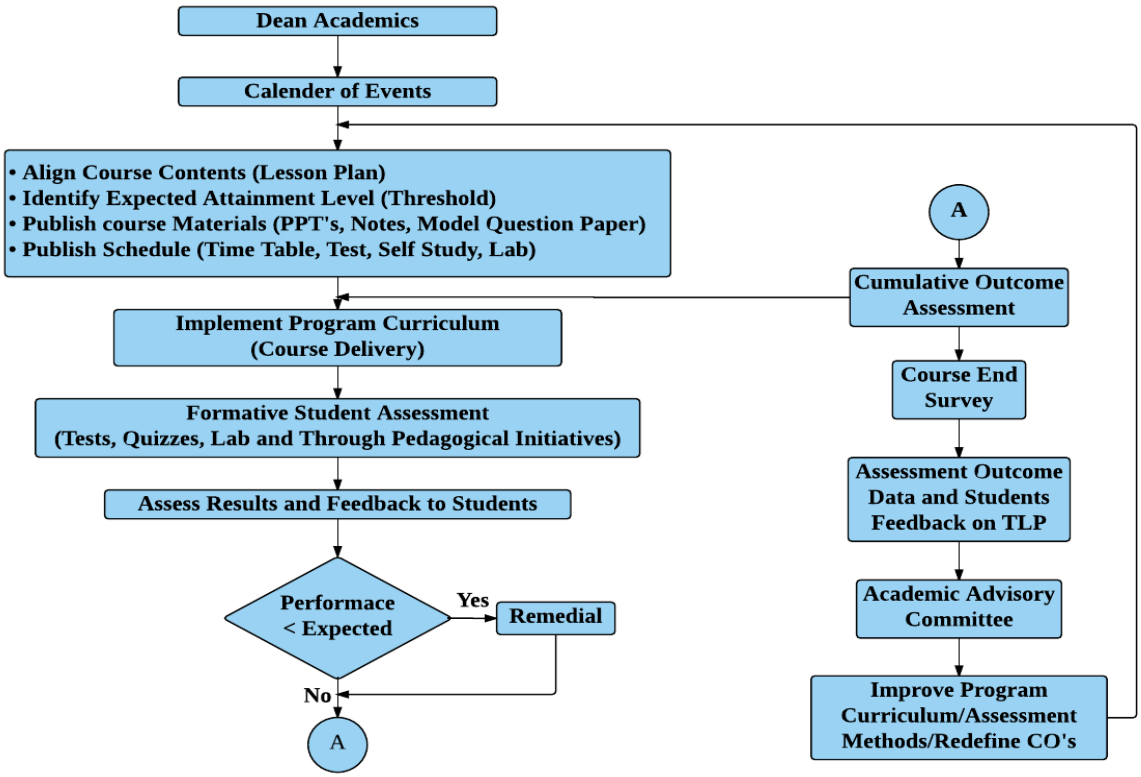
CO-PO Mapping												
CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	1	---	___	---	----	1	----	1	1	1	2	1
CO2	1	2	2	---	---	---	----	1	2	1	2	1
CO3	---	---	3	---	---	1	---	2	1	2	1	---
CO4	---	---	___	---	----	1	3	1	1	1	1	---

Low-1 Medium-2 High-3

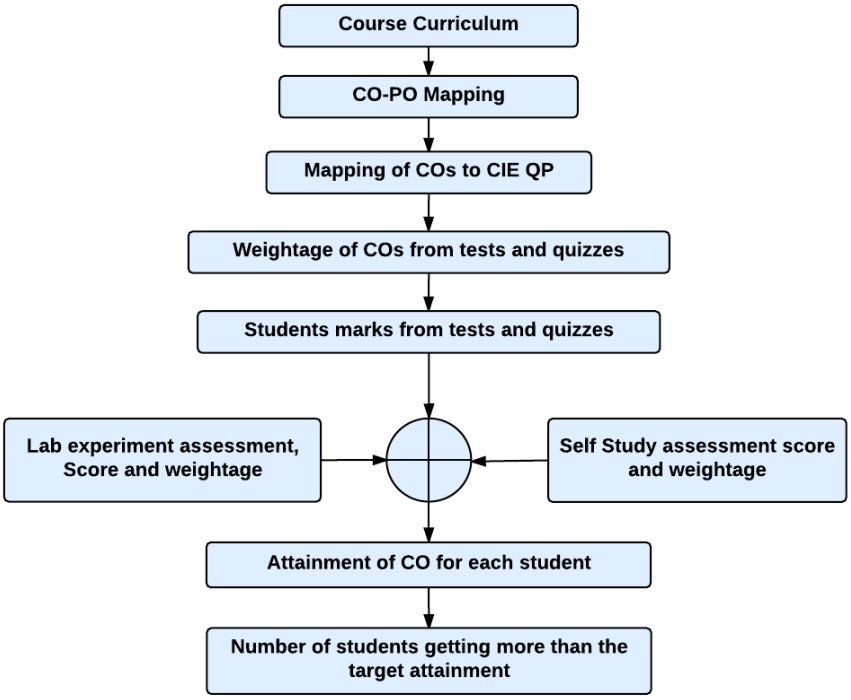
Curriculum Design Process



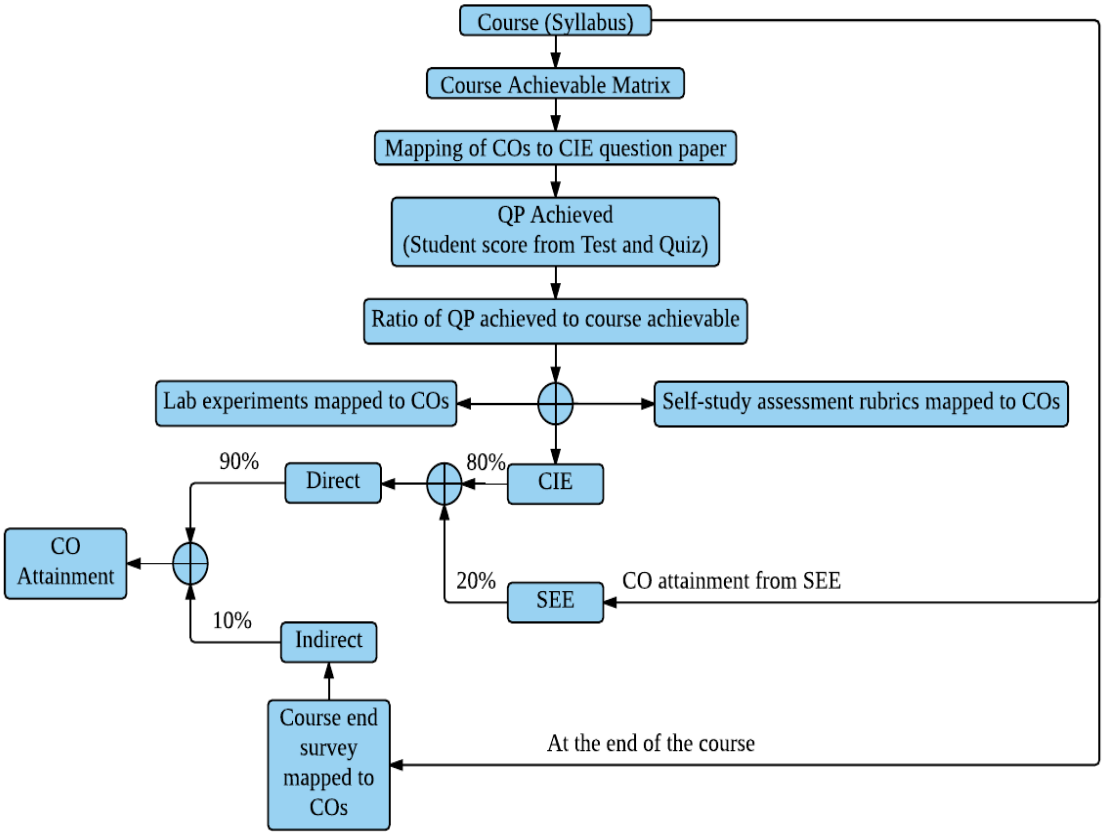
Academic Planning And Implementation



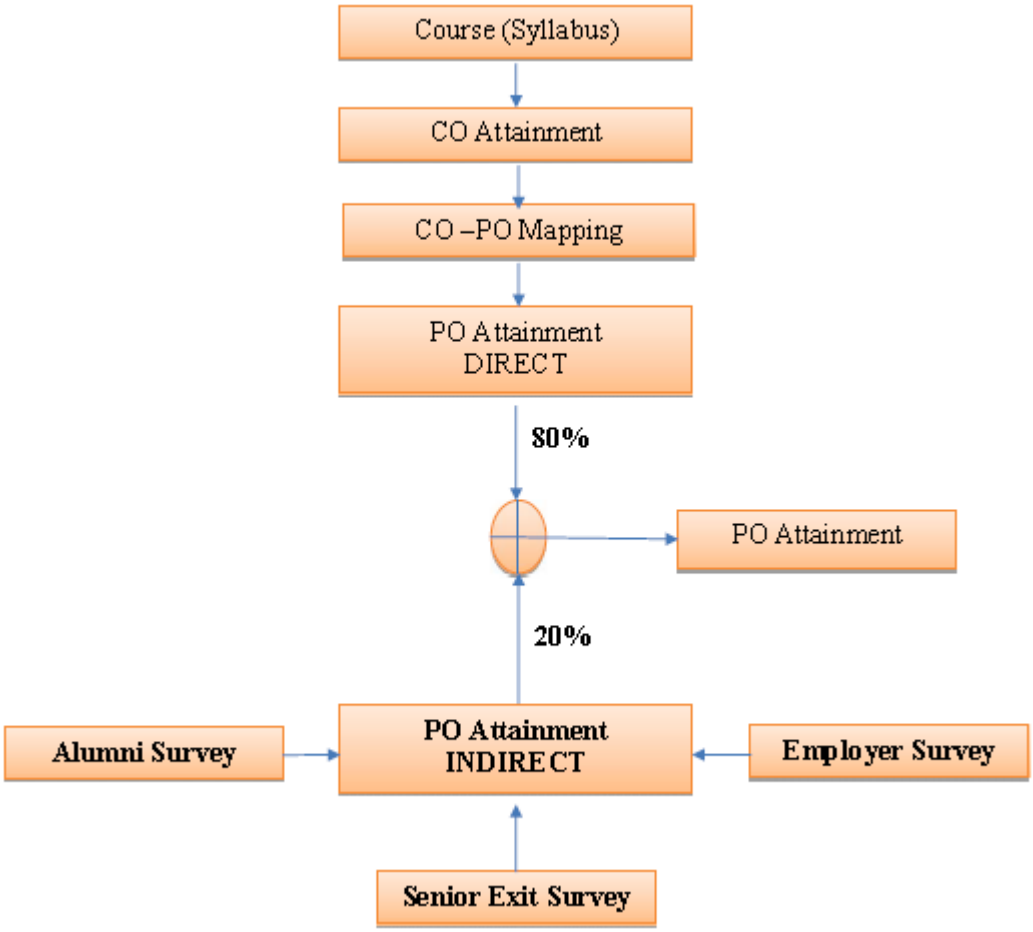
Process For Course Outcome Attainment



Final CO Attainment Process



Program Outcome Attainment Process



PROGRAM OUTCOMES (PO)

PO1: **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: **Modern tool usage** : Create, select, and apply appropriate techniques, resources, and modern Engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7**:** **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11**: Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.