RV 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 of VII &VIII Semesters

2016 SCHEME

BIOTECHNOLOGY

VISION

Leadership in Quality Technical Education, Interdisciplinary Research & Innovation, with a Focus on Sustainable and Inclusive Technology

MISSION

1. To deliver outcome based Quality education, emphasizing on experiential learning with the state of the art infrastructure.
2. To create a conducive environment for interdisciplinary research and innovation.
3. To develop professionals through holistic education focusing on individual growth, discipline, integrity, ethics and social sensitivity.
4. To nurture industry-institution collaboration leading to competency enhancement and entrepreneurship.
5. To focus on technologies that are sustainable and inclusive, benefiting all sections of the society.

QUALITY POLICY

Achieving Excellence in Technical Education, Research and Consulting through an Outcome Based Curriculum focusing on Continuous Improvement and Innovation by Benchmarking against the global Best Practices.

CORE VALUES

Professionalism, Commitment, Integrity, Team Work, Innovation

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2016 SCHEME

DEPARTMENT OF
BIOTECHNOLOGY

DEPARTMENT VISION

A Premier Department in Biotechnology Education, Research and Innovation with a Focus on Sustainable Technologies for the Benefit of Society and Environment.

DEPARTMENT MISSION

- Create state-of-the-art infrastructure for research and training in Biotechnology
- Develop graduates who are ethically and socially concerned
- Promoting collaboration with academia, industries and research organizations at national and international level
- Contribute to socioeconomic development through sustainable and inclusive technologies

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Have a strong foundation in scientific and engineering principles, develop oral and written communication skills and team work that prepare them for a successful career in Biotechnology and allied industries.

PEO2: Function at a technically competent level in formulating and solving problems in Biotechnology and to develop an outlook for higher education and lifelong learning.

PEO3: Organize and utilize the knowledge to develop biological processes and products, exhibit professionalism, ethical attitude to become an entrepreneur.

PROGRAM SPECIFIC OUTCOMES (PSOS)

PSO	Description
PSO1	Gain knowledge in Basic sciences, Mathematics and Biology to understand the Engineering problems related to Biotechnology and Bioinformatics.
PSO2	Develop the skills in the area of Biotechnology, Chemical Engineering and Informatics to solve complex Biological problems.
PSO3	Acquire technical knowledge to design, analyse, optimize and scale up Bio processes to develop value added products.
PSO4	Develop intellectual, personal and professional abilities through experiential learning and interdisciplinary projects.

Lead Society: American Society of Agricultural and Biological Engineers

ABBREVIATIONS

Sl. No.	Abbreviation	Meaning
1.	VTU	Visvesvaraya Technological University
2.	BS	Basic Sciences
3.	CIE	Continuous Internal Evaluation
4.	SEE	Semester End Examination
5.	PE	Professional Core Elective
6.	GE	Global Elective
7.	HSS	Humanities and Social Sciences
8.	CV	Civil Engineering
9.	ME	Mechanical Engineering
10.	EE	Electrical & Electronics Engineering
11.	EC	Electronics & Communication Engineering
12.	IM	Industrial Engineering & Management
13.	EI	Electronics & Instrumentation Engineering
14.	CH	Chemical Engineering
15.	CS	Computer Science & Engineering
16.	TE	Telecommunication Engineering
17.	IS	Information Science & Engineering
18.	BT	Biotechnology
19.	AS	Aerospace Engineering
20.	PY	Physics
21.	CY	Chemistry
22.	MA	Mathematics

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RV COLLEGE OF ENGINEERING®

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BIOTECHNOLOGY

SEVENTH SEMESTER CREDIT SCHEME								
Sl. No.	**Course Code**	**Course Title**	**BOS**	**Credit Allocation**				**Total Credits**
				L	**T**	**P**	**S**	
1.	16BT71	Plant Biotechnology	BT	4	0	1	0	5
2.	16BT72	Downstream Processing	BT	4	0	1	0	5
3.	16BT73	Animal Biotechnology	BT	3	0	0	0	3
4.	16XX7FX	Elective F (PE)	BT	4	0	0	0	4
5.	16XX7GX	Elective G (PE)	BT	4	0	0	0	4
6.	16G7HXX	Elective H (GE)Nanotechnology	BT	3	0	0	0	3
Total Number of Credits				**22**	**00**	**02**	**00**	**24**
Total number of Hours/Week				**22**	**00**	**04**	**00**	**26**

EIGHTH SEMESTER CREDIT SCHEME								
Sl. No	**Course Code**	**Course Title**	**BOS**	**Credit Allocation**				**Total Credits**
				L	**T**	**P**	**S**	
1.	16BT81	Major Project	BT	0	0	16	0	**16**
2.	16BT82	Technical Seminar	BT	0	0	2	0	**2**
3.	16HS83	Innovation and Social Skills	HSS	0	0	2	0	**2**
Total Number of Credits				**0**	**0**	**20**	**0**	**20**
Total number of Hours/Week				**0**	**0**	**40**	**0**	**40**

*Mandatory Audit course for lateral entry diploma students

** Non-contact hours

VII Semester		
GROUP F: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16BT7F1	Nanotechnology
2.	16BT7F2	Plant based vaccines
3.	16BT7F3	Equipment Design & Drawing
4.	16BT7F4	MAT LAB

VII Semester		
GROUP G: PROFESSIONAL ELECTIVES		
Sl. No.	**Course Code**	**Course Title**
1.	16BT7G1	Vaccine Technology
2.	16BT7G2	Nutraceuticals
3.	16BT7G3	GMP, GLP, Biosafety and Bio business
4.	16BT7G4	HPC and Big data analysis

Sl. No.	Course Code	Host Dept	Course Title
1.	16G7H01	BT	Nanotechnology
2.	16G7H02	CH	Industrial safety and risk management
3.	16G7H03	CV	Intelligent transport systems
4.	16G7H04	CS	Intelligent systems
5.	16G7H05	EC	Image processing and machine learning
6.	16G7H06	EE	Design of renewable energy systems
7.	16G7H07	IE	Systems engineering
8.	16G7H08	EI	Mems and applications
9.	16G7H09	IS	Introduction to internet of things
10.	16G7H10	ME	Industry 4.0– smart manufacturing for the future
11.	16G7H11	TE	Space technology and applications
12.	16G7H12	MA	Advanced linear algebra
13.	16G7H13	AE	Thin film nanotechnology
14.	16G7H14	HS	Engineering materials for advanced technology
15.	16G7H15	HS	Applied psychology for engineers
16.	16G7H16	HS	Foundational course on entrepreneurship
17.	16G7H17	AS	Unmanned aerial vehicles

Semester: VII						
PLANT BIOTECHNOLOGY (Theory and Practice)						
Course Code	**:**	16BT71		**CIE**	**:**	**100+50Marks**
Credits: L:T:P:S	**:**	4:0:1:0		**SEE**	**:**	**100+50Marks**
Total Hours	**:**	44L+24P		**SEE Duration**	**:**	**3.00 + 3.00 Hours**

Course Learning Objectives: The students will be able to

1	Understand tissue culture techniques and its application for enhanced production of various bioactive compounds
2	Analyse and comprehend the various molecular and genetic transformation mechanisms in generating transgenic plants
3	Interpret the modern mechanisms and strategies for the production of various resistant/tolerant plants for the crop improvement
4	Apply the omics and edge cutting transgenic strategies for crop improvement adhering to environmental and ethical standards for societal betterment.
5	Understand tissue culture techniques and its application for enhanced production of various bioactive compounds

	Unit-I	**09 Hrs**

Introduction: Plant tissue culture; Plasticity and Totipotency**,** culture media, growth regulators. Culture types; callus, cell suspension culture. Micropropgation; Regeneration Methods of plants in Culture Organogenesis-direct and Indirect Organogenesis. Organ culture: root cultures, Shoot, meristem culture, embryo culture and endosperm culture. Molecular basis of Organogenesis protoplast culture and somatic hybridization and cybridization. Haploid plants; Microspore culture, somatic embryogenesis. Gene regulation during somatic embryogenesis. Artificial seeds. Soma clonal variation for crop improvement, Cryopreservation. Advantages of tissue culture as source of secondary metabolites**,** Growth and production kinetics of cell cultures, scale-up procedures in bioreactors, types of bio--reactors for plant cell cultures. Biotic and abiotic elicitation, biotransformation.

Unit – II	**09 Hrs**

Techniques for plant transformation. Modes of gene delivery in plants; physical, chemical and Biological methods. Ti and Ri plasmids, Plant expression vectors; co-integrative and binary vectors. Promoters and terminators, selectable markers, reporter genes,. Methods of transformation; tissue culture based, *in planta* and floral dip. Transplastomic transformation. Transformation systems: transposon tagging, enhancer/promoter/gene trap, transactivation, over expression and under expression, gene silencing, virus induced gene silencing, gene replacement, gene targeting. Screening and selection of transformants; Histochemical, PCR and hybridization methods. Generation and maintenance of transgenic plants, Transgene silencing. Clean gene technology. Molecular breeding.

Unit –III	**09 Hrs**

Stress tolerant/resistant plants: Plant defence system Genetic basis of plant pathogen interaction, R genes and R gene mediated resistance, Biochemistry and Molecular biology of defence reactions, Systemic acquired resistance, ABA in stress tolerance, Role of Salicylic, Jasmonic acid and ethylene in plant defence. Plant Stress Response. Biotic stress resistance plants- Disease resistance plants; Insect resistant plants (Case study: BT Cotton).Viral resistant plants, Bacterial resistance plants and Fungal resistant plants. Nematode resistance Herbicide resistance plants. Abiotic stress tolerant plants; Drought and Salt tolerance plants (Case study- rice). *Arabidopsis* as a model for molecular genetic studies in plant biology, an introduction to systems approaches.

Unit –IV	**09 Hrs**

Application of transgenic plants: Molecular farming/pharming Improvement of Products and Food Quality; Nutritional Improvements- Golden rice. Modified Plant lipids, carbohydrates and proteins. Pharmaceutical Products; genetic manipulations involved in the production of commercially important enzymes, therapeutic proteins, edible vaccines, bio plastics, and other novel compounds. Biofuels, Bio plastics. Genetic manipulation of fruit ripening; Delay of fruit ripening; polygalacturanase, ACC synthase, ACC oxidase (Case study –tomato), flower colour (Case study- Anthurium, rose and Gerbera). Genetic manipulation of crop yield by enhancement of photosynthesis.

Unit –V	**09 Hrs**
The Omics in Plant world: Interrelationships of omic disciplines. Identifying genes of interest through genomic studies. Plant Cyc databases. RNAi for Crop Improvement. Advanced genetic tools for plant biotechnology; plant genome editing- (CRISPR)/CRISPR-associated protein 9 (Cas9) system, Zinc finger nucleases (ZFNs), mega nucleases and transcription activator-like effector nucleases (TALENs). Recent advances of Epigenetics in Crop Biotechnology**.** **Plant transgenics- Science and society:** The public acceptance of GM crops; issues and concerns, biosafety, societal and ethical aspects of genetically modified foods and crops.	

LAB EXPERIMENTS

1. Callus induction from various explants
2. Cell suspension culture and elicitation studies
3. Extraction and estimation of total phenolics from callus cultures
4. Extraction and estimation of lycopene from tomato.
5. Protoplast isolation and culture. Anther and microspore culture technique for the production of haploids.
6. Isolation of genomic DNA from plant tissue.
7. Competent cell preparation of Agrobacterium tumefaciens and transformation of plant expression vector
8. Genetic transformation in plants (in planta and tissue culture based).
9. Screening and selection of transformants (GUS Assay and PCR using GUS specific primers).
10. PAL enzyme assay in Cell cultures
11. Antioxidant assay in cultures
12. Functional annotation using plant cyc databases
13. Pathway using Gen map
14. Mapping QTLs using Join map.

Note: Each student has to perform all the 12 experiments in a semester.

Reference Books

1	Plant Biotechnology and Genetics: Principles, Techniques, and Applications.Jr. C. Neal Stewart,Wiley publishers. 2nd Edition. 2016.ISBN: 9781118820124.
2	Plant Biotechnology and Agriculture. Arie Altman, Paul HasegawaAcademic Press 2012. 1st Edition. ISBN: 9780123814661.
3	Plant Biotechnology: Mark R. Fowler,AdrianSlater,Nigel W. Scott.The genetic manipulation of plants : Oxford University Press. 2nd Edition. ISBN: 9780199560875.
4	.PlantOmics: The Omics of Plant Science. Springer India.DebmalyaBarh,MuhammadSarwar Khan, Eric Davies 1st Edition, 2015. ISBN: 9788132221715.

Course Outcomes: After completing the course, the students will be able to	
CO1:	Conceptualize the fundamentals of plant biotechnology from tissue culture intricacies to modern transgenics using omic strategies for crop improvement.
CO2:	Apply and execute the mechanism of plant transformation to generate functionally designer transgenic plants for better outreach.
CO3:	Analyze and evaluate the wide array application considering the ethical issues of plant biotechnology for crop improvement.
CO4:	Design and formulate genetically modified plant for a desired trait complying to biosafety, societal and ethical aspects.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.

Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Scheme of Continuous Internal Evaluation (CIE); Practical Test for 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 marks (AM) over number of weeks is considered for 30 marks. At the end of the semester a test (T) is conducted for 10 marks. The students are encouraged to implement additional innovative experiments (IE) in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.
Total CIE is 30(AM) +10 (T) +10 (IE) =50 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the 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.

Scheme of Semester End Examination (SEE); Practical Exam for 50 Marks
SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

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

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

High-3: Medium-2 : Low-1

Semester: VII						
DOWNSTREAM PROCESSING (Theory and Practice)						
Course Code	**:**	16BT72		**CIE**	**:**	**100+50Marks**
Credits: L:T:P:S	**:**	4:0:1:0		**SEE**	**:**	**100+50Marks**
Total Hours	**:**	45L+24P		**SEE Duration**	**:**	**3.00 + 3.00 Hours**

Course Learning Objectives: The students will be able to

1	Understand the importance of purification technology of biological products at industrial scale.
2	Comprehends various primary purification techniques for bio products.
3	Learn Purification techniques for isolation of products from complex biological mixtures
4	Impart membrane technology application to lab scale and process scale techniques for handling crude broth and purification techniques.
5	Apply the knowledge towards secondary and advanced separation techniques for lab and process scale purification of biological products

Unit-I	**09 Hrs**
Introduction: Overview of a bioprocess including upstream and downstream processing, Basic concepts of bio separation technology, Economic importance of downstream processing in biotechnology, nature and basis of bio separation, properties of biological materials. Characteristics of biological molecules, New Separation process in modern biotechnology; Separation characteristics of recombinant proteins, enzymes and monoclonal antibodies. Numerical on properties of biological materials and purification efficiency	
Unit – II	**09 Hrs**
Biomass removal and disruption: Cell disruption by Mechanical and non- mechanical methods, Chemical lysis, Enzymatic lysis, physical methods, Sonication, High pressure Homogenizer, Flocculation methods and its applications. Centrifugation and ultracentrifugation. Simple Numerical on cell disruption and centrifugation	
Unit –III	**09 Hrs**
Product Isolation: Separation of particulate by filtration: dead end filtration, depth filtration, concept of filter medium resistance, Rotary Vacuum Filtration, scale up of filtration systems, different modes of operation. **Extraction:** principles of solid-liquid extraction and Liquid - liquid extractions, material balance for single, concurrent multistage and counter current multistage extraction. Simple problems, Selection of solvent, extraction equipment: working of Bollman, Mixer-settler and York-Scheibel extractors. Precipitation (salt, pH, organic solvent, high molecular weight polymer).Numerical problems on filtration and extraction	
Unit –IV	**09 Hrs**
Diffusion: Types of diffusion, measurement and calculation of diffusivities, theoretical estimation of diffusivities, mass transfer co-efficients and their correlations. Theory of mass transfer. **Membrane Based Separation:** Structure and characteristics of membranes, types of membranes, membrane equipment, Phenomenon of concentration polarization, membrane fouling and its consequences. Membrane based purification: Microfiltration, Ultrafiltration, Nano filtration and Diafiltration. Biotechnological applications of membrane based separations. Numerical on membrane based bioseperation.	
Unit –V	**09 Hrs**
Advanced Separation Techniques: Chromatography:- general theory; separation based on Size, Charge, Hydrophobicity and Affinity: Gel filtration, Ion exchange chromatography, Affinity chromatography, and hydrophobic interaction chromatography (HIC). Polishing of Bio products by Crystallization, Drying- definition of Bound, Unbound, Critical Moisture Content, Wet and dry moisture content, Drying Curve, Drying equipment- Tray Drier, Rotary Drier and Freeze Drier. Case study: Large scale separation and purification of Recombinant products Insulin, Interferon, Streptokinase and Monoclonal Antibodies	

LAB EXPERIMENTS
1. Cell disruption techniques- physical method. 2. Solid-liquid separation methods: sedimentation by flocculating agents. 3. Solid-liquid separation methods: Membrane filtration. 4. Solid-liquid separation methods: Centrifugation. 5. Product enrichment operation: ammonium sulphate precipitation of proteins. 6. Product enrichment operation: aqueous two phase extraction (single stage). 7. Separation of amino acids/carbohydrates/pigments by Thin Layer Chromatography. 8. Estimation of citric acid from Fermentation Broth. 9. Product drying technique-vacuum tray drier. 10. Crystallization Technique for bioactive compound.
Note: Each student has to perform 10 experiments in a semester. 10 Experiments are guided experiments

Course Outcomes: After completing the course, the students will be able to	
CO1:	Highlight the importance of downstream processing of biological products.
CO2:	Interpret the techniques for various intracellular and extracellular products from complex biological mixtures.
CO3:	Apply techniques to concentrate and purify biological products
CO4:	Develop different processes for separation and purification of biological products

Reference Books	
1	Principles of Bio separation Engineering R.Ghosh,. World Scientific Publishing, 1st Edition, 2006. ISBN: 9812568921.
2	Protein Purification: Principles, High Resolution Methods, and Applications. J.C Janson and L. Rayden., John Wiley and sons. 2012. ISBN: 1118002199.
3	Downstream Process Technology: A New Horizon In Biotechnology, PHI Learning India ltd, N. Krishnaprasad Eastern Economy Edition, 2010. ISBN: 9788120340404.
4	Principles Of Downstream Techniques In Biological And Chemical Processes, Mukesh Doble, Apple Academic Press And CRC Press, 2015, ISBN: 9781771881401

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Scheme of Continuous Internal Evaluation (CIE); Practical Test for 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 marks (AM) over number of weeks is considered for 30 marks. At the end of the semester a test (T) is conducted for 10 marks. The students are encouraged to implement additional innovative experiments (IE) in the lab and are rewarded for 10 marks. Total marks for the laboratory is 50.
Total CIE is 30(AM) +10 (T) +10 (IE) =50 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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.

Scheme of Semester End Examination (SEE); Practical Exam for 50 Marks

SEE for the practical courses will be based on experiment conduction with proper results, is evaluated for 40 marks and Viva is for 10 marks. Total SEE for laboratory is 50 marks.

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

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

High-3 : Medium-2 : Low-1

Semester: VII						
ANIMAL BIOTECHNOLOGY (Theory)						
Course Code	**:**	16BT73		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	3:0:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	33L		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Understand principles of animal cell culture techniques, properties and applications of specialized cells.
2	Demonstrate the properties of specialized cells, monolayer culture and bioreactor design of scaling up of cells.
3	Explore the knowledge of health care products vaccine, toxoids and Hybridoma technology.
4	Evaluate on ethical dimensions, laboratory safety and validation of tissue products.
5	Understand principles of animal cell culture techniques, properties and applications of specialized cells.

Unit-I	**07 Hrs**
Animal Cell Culture Technology: Principles of animal and cell culture, origin of concept, types of cells, Culturing of cells, primary and secondary cell lines, kinetics of cell growth, Cell lines and their applications. Sources of cells, Techniques of cell culture, Equipment's, substrate for cell growth, Media handling equipment's, Types of culture media, Primary culture, somatic cell fusion. Specialized techniques animal cell cultures	
Unit – II	**06 Hrs**
Specialized cells and Scaling up of animal cells: stem cells, epithelial cells, Hemopoitic cells and cryopreservation, Amniocentesis, Oncofetal antigens, 3D culture, cell immobilization, application of molecular genetics, storage of DNA and handling of enzymes, Cytotoxicity. Mono layer culture, types of bio-reactors used for animal cell cultures.	
Unit –III	**07 Hrs**
Hybridoma Technology and Healthcare: Production of Hybridomas- Antibodies, Immunotoxins, Vaccines, Toxoids, Interferons and Antiviral substances, and organ culture, Tumour immunology, Immune diagnosis and therapy monoclonal antibodies. DNA finger printing in forensic medicine. Gene Therapy- Prospects and problems; Knockout mice and mice model for human genetic disorder	
Unit –IV	**06 Hrs**
Transgenic Animal Technology and applications: Strategies for gene transfer in animal cells; mechanisms of transfection, vectors used in transfection. Methods of production of transgenic animals, recent advances in gene targeting technology. Characterization and screening of transgenic animals. Applications of genetically modified animals and molecular bio pharming. Stem cell research - Hematopoietic and embryonic stems cells.	
Unit –V	**07 Hrs**
Animal Breeding, Ethical Issues and Safety: Artificial insemination and storage; In vitro fertilization and embryo transfer micro manipulation of embryos, advantages of cell manipulation techniques, Ethical issues in animal biotechnological products and techniques. Ethical issues related to transgenic animals, Human tissue cell and products. Laboratory safety, Risk assessment, Standard operating systems, Biohazards, Bioethics and Validation.	

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

CO1:	Comprehend the principles of animal cell biotechnology and techniques
CO2:	Analyze the environmental, societal, ethical, health and safety issues of anthropogenic activities.
CO3:	Appraise the elements of environmental designs and models and examine their significance in sustainable development.
CO4:	Animal improvement and vaccine technology and other industrial applications.

Reference Books	
1	Textbook of animal biotechnology - B Singh, S K Gautam and M S Chauhan, The Energy and Resource Institute 1st Edition, ISBN No: 9788180301032, 2015.
2	Textbook of Animal Biotechnology - P. R. Yadav, Discovery Publishing House, 1st Edition, ISBN No: 9788183564953, 2016.
3	Animal cell biotechnology – R.E. Spier and J.B. Griffiths, Academic Press, 5th Edition, 2012.
4	Culture of Animal cells A manual of basic techniques – R. Ian Freshney, John Wally and Sons Publishers, 7th Edition, 2015.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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	2	1	1	-	-	2
CO2	2	2	-	-	-	1	-	-	1	-	-	1
CO3	2	2	1	-	-	2	2	-	1	-	-	2
CO4	2	2	1	-	-	2	-	-	-	-	-	1

High-3: Medium-2: Low-1

Semester: VII						
NANOBIOTECHNOLOGY (Group F: Professional Elective)						
Course Code	**:**	**16BT7F1**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**44L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Describe methods by which nanoscale manufacturing can be enabled.
2	To design a concept for a nanoscale product and their applications in mechanical, electrical, electronic, Magnetic, Chemical field and in Medical field.
3	To design a concept for a nanoscale product and their applications in medical field.
4	To learn about Nano sensors and Nano biosensors and products available in the market.
5	To study about the Nano sensors used in diagnostic and therapeutics.

Unit-I	**08 Hrs**
Introduction to nanomaterials: Types of nanomaterials, Top-Down and Bottom-up methods of nanofabrication and Nanosynthesis. Nanolithography: soft- and hard-lithography. Characterization of nanomaterials: Atomic Force Microscopy, Scanning &Tunnelling Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy.	
Unit – II	**08 Hrs**
Micro & Nano Electromechanical systems and Microfluidics: MEMS/NEMS: Nanotransducers: Nano- mechanical, electrical, electronic, Magnetic and Chemical Transducers. Nano sensors and Nano Actuators. Microfludics: Laminar flow, Hagen-Peouiselle equation, basic fluid ideas, Special considerations of flow in small channels, mixing, microvalves & micropumps. Approaches toward combining living cells, Microfluidics and 'the body' on a chip, Chemotaxis, cell mobility.	
Unit –III	**08 Hrs**
Medical Nano biotechnology: Diagnostics: Resonance Light Scattering (RLS) Technology, Nano chips, gene and protein chips. Therapeutic: Drug delivery: Bioavailability, Sustained and targeted release. Benefits of Nano drug delivery system. Use of Microneedles and nanoparticles for targeted and highly controlled drug delivery. Drug delivery applications, Nano robots in drug delivery system. Tissue Engineering: Nanostructuring, nano implants, nanocoating.	
Unit –IV	**10 Hrs**
Nanosensors: Overview of nanosensors, prospects and market. Types of Nanosensors and their applications. Electromagnetic nanosensors: Electronic nose and electronic tongue, Magnetic nanosensors. Mechanical nanosensors: Cantilever Nanosensors, Mechanics of CNTs, Biosensors in modern medicine.	
Unit –V	**10 Hrs**
Nanobiosensors: Types of nanobiosensors: Cantilever, nanotube, nanowire and nanoparticle based sensor., Nanofabricated devices to separate and interrogate DNA, Interrogation of immune and neuronal cell activities through micro- and nanotechnology based tools and devices. Benefits of Nano-imaging agents, Nanosensors in Drug Discovery, Drug Delivery. Nanotoxicity studies	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember, understand and apply knowledge about nanomaterials and their uses
CO2:	Interpret and applythe techniques of manufacturing and characterization processes.
CO3:	Apply knowledge of Nano sensors,in applications like electronics, mechanical, chemical, and biological systems
CO4:	Create and evaluate nano design, devices and systems applicabletovarious disciplines.

Reference Books	
1	L. H, Gabor. J, Dutta. H. F.,Tibbals., A. Rao., Introduction to Nanosciences, CRC press, 1st Edition,2008, ISBN- 1420048058.
2	B.S., Murty, P.Shankar, B.Raj, B.B. Rath and J. Murday, Textbook of Nanosciences and Nanotechnology, Springer, Co-publication with University Press (India) Pvt. Ltd. VCH, XII. 2013,ISBN- 978-3-642-28030-6.
3	Niemeyer and C.A. Mirkin, Nanobiotechnology: Concepts, Applications and perspectives, Wiley –VCH, 2nd Edition, 2013.ISBN -978-3-527-30658-9.
4	V.K. Khanna, Nanosensors:, Physical, Chemical and Biological, CRC press,1st Edition 2013, ISBN 9781439827123.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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	-	-	2	2	1	1	-	-	2
CO2	2	2	3	-	-	1	-	-	1	-	-	1
CO3	2	2	2	-	-	2	2	-	1	-	-	2
CO4	2	2	2	-	-	2	-	-	-	-	-	1

High-3: Medium-2: Low-1

Semester: VII						
PLANT BASED VACCINES **(Group F: Professional Elective)**						
Course Code	**:**	**16BT7F2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**45L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Know the principle and applications of Plant-based vaccines.
2	Outline the various techniques involved in Plant-based vaccine production.
3	Acquire knowledge on mechanism of action of various kinds of Plant-based vaccines.
4	Present the scientific importance, advantages and disadvantages of Plant-based vaccine technology.

Unit-I	**08 Hrs**
Principles of plant-based vaccines, Production of Plant-Based Vaccines: Direct Gene Delivery Method, Indirect Gene Delivery Methods (*Agrobacterium*-Mediated Gene Transfer), Mechanism of action, Plant-based vaccines as a global vaccination approach current perspectives.	
Unit – II	**09 Hrs**
Viral vector-based expression strategy (Tobacco mosaic virus, Cowpea mosaic virus, Gemini viruses).Plastid-based expression strategy (Technology, engineering of plastid transgenes for high level protein expression).Seed-based expression strategy (Rice seed for delivery of vaccines to gut mucosal immune tissues, Production of Biologically Active Cecropin A Peptide in Rice Seed Oil Bodies).	
Unit –III	**09 Hrs**
Plant cell culture types: Plant Cell Suspension Culture, Culture of hairy roots, Factors affecting biomass production, Bioreactor: design and types, choice of different bioreactor systems for plant cell culture, Scale-up, Bioprocess optimization and control. Commercial production of recombinant proteins from plant cell culture. Monoclonal antibodies production against cancer.	
Unit –IV	**10 Hrs**
Plant-based vaccines against influenza: Transient plant expression systems, production of virus-like particles (VLPs), characterization, assessment of immune response. HIV: strategies targeting structural (Env, Gag) and early non-structural HIV-1 proteins (Rev, Tat, and Nef),expression in plants. Hepatitis-B: Production of HBV Antigens in Plant Systems, characterization of the major surface antigen in plant tissues, efficacy of plant-based hepatitis B vaccines. Vaccines against HPV and Ebola viruses..	
Unit –V	**09 Hrs**
Mucosal Immunology and oral vaccination: Mucosal immune system, oral vaccination, immunogenicity, immunoprotection. Plant-based vaccines against Toxoplasmosis: Expression of GRA4 and SAG1 in plants. Plant-based vaccines against pollen-allergy: Development of Seed-based pollen allergy vaccines. Plant-based vaccines against some neglected tropical diseases: developing low-cost vaccination, vaccines against rabies, cysticercosis, dengue, and helminthiasis.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain the principle, applications and mechanism of action of Plant-based vaccines.
CO2:	Apply the techniques for production and characterization of Plant-based vaccines.
CO3:	Differentiate between production processes and various kinds of Plant-based vaccines.
CO4:	Assess the quality of synthesized Plant-derived vaccines, and effect of Plant-based vaccines in the target cell.

Reference Books	
1	Genetically Engineered Plants as a Source of Vaccines against Wide Spread Diseases-An Integrated View. Rosales-Mendoza S,Springer, 2014, ISBN: 9781493908493
2	Medical Biotechnology, GlickBR, DelovitchTL, and Patten CL, ASM Press, 2013, ISBN : 9781555817053
3	Plant-derived Vaccines: Technologies & Applications, Buonaguro FM (Edi)Future Medicine Ltd, 2012, ISBN-10: 1780841469
4	Biopharmaceuticals in Plants: Toward the Next Century of Medicine, Hefferon KL, CRC Press, 2009, ISBN-10:1780841469

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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	1	1	1	-	1	-	-	2	2	-
CO2	2	3	2	3	3	-	2	-	-	2	2	-
CO3	2	3	2	3	3	-	2	2	-	2	2	-
CO4	2	3	2	3	3	1	2	2	-	2	2	-

High-3: Medium-2 : Low-1

Semester: VII						
EQUIPMENT DESIGN AND DRAWING (Elective - F) (Theory and practice) (Group F: Professional Elective)						
Course Code	**:**	**16BT7F3**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**2:0:2:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**42L**		**SEE Duration**	**:**	**4.00 Hours**

Course Learning Objectives: The students will be able to

1	Learn the basics of design using Code book and Perry Hand book
2	Explore the abilities of sectional front view and top view of the biochemical equipment accessories.
3	Study mechanical design of equipment's involved in biological reactions as per IS2825 unfired pressured vessels code book.
4	Study the process design of equipment involved in biological reactions as per Perry Hand book.

Unit-I	**42 Hrs**
Detailed Process Design and mechanical design of the following equipment's using standard code books. The detailed dimensional drawings shall include sectional front view, Full Top/Side view depending on equipment and Major component drawing with dimensioning and Part Template. 1. Shell and tube heat exchanger 2. Packed bed Distillation Column 3. Batch continuous bio reactors 4. Jacketed vessel 5. Adsorption column	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember and understand the concepts of design and use of the IS 2825 code book and J H Perry hand book
CO2:	Integrate the standard design parameters to design of bio equipment.
CO3:	Evaluate the various parameters of distillation column, heat exchangers
CO4:	Generate drawings of distillation column, heat exchanger and bioreactors.

Reference Books	
1	R.H. Perry & D.W. Green, Chemical Engineers Handbook, 7th Edition, McGraw Hill 2008;ISBN: 9780071422949
2	IS 2825 Code: Unfired pressure vessels, BIS New Delhi.
3	M.V. Joshi and V.V. Mahajan, Design of Process Equipment Design, 4th Edition , McMillan India 2009; ISBA: 978-0230638105
4	J.M. Coulson & J.F. Richardson, Chemical Engineering Vol. 6, Pregman Press, 1993; ISBN 07506 65386

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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 10 marks component is for Equipment drawing/Assignment/Presentation/Project.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks executed by means of an examination. The Question paper for the course contains two main questions with internal choice; each main question carries 100 marks (60 Marks for design and 40 Marks for drawing). Each main question may have sub questions covering 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	-	-	-	2	2	1	1	-	-	2
CO2	2	2	-	3	3	1	-	-	1	-	-	1
CO3	3	2	1	-	-	2	2	-	1	-	-	2
CO4	2	3	2	2	2	2	-	-	-	-	-	1

High-3: Medium-2: Low-1

Semester: VII						
MATLAB **(Group F: Professional Elective)**						
Course Code	**:**	16BT7F4		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	4:0:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Explore conceptually MATLAB applications in the domains of Life sciences and in general study the role of computer science in life sciences
2	Acquire knowledge of the Programming and Advanced programming skills in MATLAB
3	Study MATLAB Tool Boxes that are used for Graphics analysis, Next Generation Sequence Analysis, Spectral Analysis, Sequence and Structure analysis.
4	Understand the importance of MATLAB Tool Boxes to solve the problems related to High throughput Data analysis, Biophysical Data, Microarray data analysis, Modelling and Simulation.
5	Explore practically the applications of various MATLAB Tool Boxes along with programming capability of MATLAB.

Unit-I	**09 Hrs**
Introduction to Java: Introduction to MATLAB, Basic computer programming - Variables and constants, operators and simple calculations - Formulas and functions, Functions and Commands, Arrays - Vectors and matrices. Operators', expressions and Statements.	
Unit – II	**09 Hrs**
Matrix Graphics – Basic 2D Graphs, Subplot, logarithmic and polar plots. 3D plots – mesh and contour plots. Handle graphics, Editing plots, applying effects to plots. Algorithms and structures, MATLAB scripts and functions (m-files). Applications of MATLAB; Simulation - Rolling dice, Bacteria division, Normal Random Numbers. Numerical methods – Integration, Numerical differentiation, solving first order differential equations (Bacterial growth), Linear Ordinary Differential Equations, Runge-Kutta methods and Partial Differential equations(Heat conduction)	
Unit –III	**09 Hrs**
MATLAB Toolbox Overview of Matlab Toolbox, Introduction to Bioinformatics Toolbox. Applications of Bioinformatics Toolbox - Scanning of Genome wide differences, Identification of Differentially Expressed genes, Prediction of Protein-DNA binding sites, Mapping of sequence reads, Sequential clustering of sequences, Bootstrapping of Phylogenies, and metagenomic analysis.	
Unit –IV	**09 Hrs**
MATLAB and Microarray Data analysis –pre-processing Affymetrix® oligonucleotide microarray probe-level data, estimation of Gene expression pro, file, detect DNA copy number alterations, Visualizing Microarray data, Finding patterns in gene expression profiles, identification of differentially expressed genes. Performing pairwise and Multiple sequence alignment, Accessing local and remote databases, Working with Illumina®/Solexa Next-Generation Sequencing Data.	
Unit –V	**09 Hrs**
Spectral Analysis and Machine Learning: mass spectrometry data, manipulate, pre-process and visualize data from Liquid Chromatography, pre-process a large set of mass spectrometry signals, classification mass spectrometry data, Differential Analysis of Complex Protein and Metabolite Mixtures. Machine Learning in Bioinformatics - Identifying Biomolecular Subgroups, Prediction of protein secondary structure, enrich microarray gene expression data. Visualisation of molecules – creation and visualization of molecular graph, Finding the shortest path, Traversing a graph, Working with the Cluster gram Function, Navigation of 3D structure of macromolecules.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the MATLAB Tool Boxes that are used for Graphics analysis, Spectral Analysis, Sequence and Structure analysis.
CO2:	Explore the Mind crunching Algorithms in MATLAB, which are used to make predictions in Biology, Chemical Engineering, and Medicine.
CO3:	Apply the Programming and Analytical skills to solve the problems related to process simulation and process engineering in Biological system, analysis of High throughput Data, Biophysical Data, Microarray data as well as Modelling and Simulation..
CO4:	Use MATLAB Tool Boxes along with programming capability of MATLAB to model and simulate biological phenomenon.

Text Books	
1	MATLAB for Engineering and the Life Sciences. Joseph V. Tranquillo. Morgan & Claypool Publishers, 2011. ISBN: 9781608457106
2	Stormy Attaway. Matlab: A Practical Introduction to Programming and Problem Solving. Butterworth-Heinemann, 2016. ISBN: 9780128045411

Reference Books	
1	Applied Numerical Methods with MATLAB for Engineers and Scientists. Steven Chapra. McGraw-Hill Education, 2017, 4th Illustrated Edition ISBN: 9780073397962
2	eMATLAB Programming for Engineers. Stephen J. Chapman. Cengage Learning, 2015. 5th Edition. ISBN: 9781305445369

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

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Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
VACCINE TECHNOLOGY (Group G: Professional Elective)						
Course Code	**:**	16BT7G1		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	4:0:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	44L		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Explain role of immune cells and their mechanism in preventing the body from foreign attack and infectious disease, cancer and other disease development
2	Apply the knowledge of immune associated mechanisms in medical biotechnology research.
3	Design experiment to see effect of drug molecule on immune response
4	Carry out immunological techniques in industry.
5	Able to apply the concept of vaccine technology in new vaccines development.

Unit-I	**09 Hrs**
Immunopathology: Tolerance and Autoimmunity, Hypersensitive reactions, Primary and Secondary Immunodeficiency, Active and passive immunization, General immunization practices, , AIDS, Immune response to Infectious disease, Basic principles of vaccine development. Vaccination of immune-compromised hosts, Vaccination of human immunodeficiency virus- infected persons. Vaccines and its historical perspective.	
Unit – II	**09 Hrs**
Traditional and modern methods of vaccine production, Egg and cell based vaccine development, Current and future scenario of Vaccines, Edible Vaccines, Reverse vaccinology, Immunoinformatics approach to identify T and B cell epitopes, Bacterial and Viral vaccine. Passive immunization; antibody, transfusion of immune competent cells, cell based vaccines. Immunomodulators (cytokines) Innovative methods of delivery of immunogens through liposomes, microspheres, ISCOMS.	
Unit –III	**09 Hrs**
Vaccine Technology: Criteria for effective vaccine, Vaccines, Live, killed, attenuated, sub unit vaccines; Role and properties of adjuvants, recombinant DNA and protein based vaccines, Multivalent subunit vaccines, mini cell vaccines, conjugate vaccines plant-based vaccines, recombinant antigens as vaccines. Interferons, designing and screening for antivirals, mechanisms of action, antiviral libraries, antiretroviral—mechanism of action and drug resistance. Comparative Genomics as a tool for vaccine design	
Unit –IV	**09 Hrs**
Vaccines: Licensed vaccines, Viral Vaccine (Poliovirus vaccine-inactivated & Live, Rabies vaccines Hepatitis A & B vaccines), Bacterial Vaccine (Anthrax vaccines, Cholera vaccines, Diphtheria toxoid), Parasitic vaccine (Malaria Vaccine). Vaccines against Hepatitis A, Malaria, Typhoid (in clinical trials). Conventional vaccines, antiidiotype vaccine, naked DNA vaccine. Recombinant Vaccines - Definition, recombinant vector vaccines, DNA vaccines. Vaccine potency testing.	
Unit –V	**08 Hrs**
The vaccine industry, Vaccine manufacturing, Vaccine additives and manufacturing residuals, Regulation and testing of vaccines, Vaccine safety and Legal issues. Regulatory issues- Environmental concerns with the use of recombinant vaccines- Disease security and biosecurity principles and OIE guidelines Method of manufacture- in process control, batch control, test on final products. large scale manufacturing—QA/QC issues	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Apprehend the concepts of immunization and vaccination
CO2:	Analyze the various types of vaccines
CO3:	Apply the knowledge of vaccine technology to cure various health ailments and intricacies.
CO4:	Evaluate the biosafety, ethical and quality issues of various vaccine technologies.

Reference Books	
1	BMA Medical Book Awards Highly Commended in Public Health. Stanley A. Plotkin & Walter Orenstein & Paul A. Offit, Vaccines, 6th Edition 2013 Elsevier Publication. **ISBN:** 9781455700905
2	Clinical Immunology, 6th Edition, Brostoff J, Seaddin JK, Male D, Roitt IM., Gower Medical Publishing, 2002. *ISBN: 3527304401.*
3	Essential Immunology by Blackwell Scientific Publications, Roitt, I. Oxford. 2001, ISBN 0-63205902-8
4	New Vaccine Technologies, Ronald W. Ellis, Landes Bioscience, 2001.ISBN: 1587060507

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

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Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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	2	3	2	1	-	2	2	1	-	2
CO2	2	3	3	3	3	2	3	2	3	1	-	3
CO3	1	3	3	2	2	3	3	3	2	2	1	2
CO4	2	2	3	1	1	3	3	3	2	3	2	3

High-3: Medium-2: Low-1

Semester: VII						
NUTRACEUTICALS (Group G: Professional Elective)						
Course Code	**:**	**16BT7G2**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**4:0:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**43L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Obtain a solid foundation the nutraceutical constituents and health benefits of functional foods
2	Understand various food components and their broader array of interactions in lines of nutraceuticals
3	Emphasize on potential applications and health risk assessment through nutrigenomics
4	Get an overview of various modes and mechanism for nutigenomics and nutrigenetics

Unit-I	**08 Hrs**
Food Pyramid, Nutritional assessment of Carbohydrates, proteins and lipids. Dietary Fibre – Components, physiological Effects, potential health benefits, recommended Dietary Intake. Glycemic index. RDA, Protein Efficiency Ratio (PER). Basics of Energy Balance - Basal Metabolic Rate (BMR) and Factors Affecting BMR. Food Styles.	
Unit – II	**09 Hrs**
Nutrigenetics and Nutrigenomics: Organizational elements of nutraceuticals**,** classification of nutraceuticals, dietary supplements, fortified foods, functional foods and phytonutracuticals **Gene-Diet Interactions**: Functional Foods and Personalized Nutrition, Microbiome, Nutritional Epigenomics, Nutritional Signaling and Aging **Technologies in Nutrigenetics /Nutrigenomics:** Data Mining and Network Analysis, Metabolomics, Epigenetics and Personalized Nutrition. Food omics: Human Dietary Interventions Metabolomics**, Nutrigenomics to Industry, Health Professionals, and the Public:** Indian and global scenario.	
Unit –III	**09 Hrs**
Carbohydrates, Protein, Fat - Excess and deficiency, Metabolic disorders– types Nutritional Factors, prevention and treatment. Role of nutraceuticals in the prevention and treatment with special reference to diabetes mellitus, hypertension, hypercholesterolemia. Concept of antioxidants, minerals and enrichment - dietary supplements in prevention and treatment of cancer, obesity and stress. Role of nutraceuticals and functional foods in pediatrics, geriatrics, sports, pregnancy and lactation.	
Unit –IV	**09 Hrs**
Role of medicinal and aromatic plants in nutraceutical industry, Plant secondary metabolites, classification and sub-classification - Alkaloids, phenols, Terpenoids. Applications with reference to skin, hair, eye, bone, muscle, heart, brain, liver, kidney, general health and stimulants. Concept of cosmoceuticals and aquaceuticals. Animal metabolites- chitin, chitosan, glucosamine, chondroitin sulphate and other polysaccharides of animal origin, uses and applications in preventive medicine.	
Unit –V	**08 Hrs**
Concept of prebiotics and probiotics - principle, mechanism and applications of probiotics, prebiotics Synbiotics for maintaining good health. Source of omega - 3 fatty acids, formulations, toxicology, bioavailability, bioequivalence; use of animal models and pre-clinical and clinical trials involved. Hopes and Concerns about Nutrigenomics and Public Health, Commercialization and Potential of Nutrigenetics and Nutrigenomics, ethics and morals in nutrigenomics and its future.	

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

CO1:	Remember and explain various fundamentals of nutraceuticals, nutrigenomics and nutrigenetics.
CO2:	Apply the knowledge of modern tools of nutraceuticals to analyse human health and diagnostics.
CO3:	Comprehend better usage of food as nutraceuticals for societal, ethical and environmental sustainability.
CO4:	Evaluate and analyse latest research area on nutraceutical and functional food components.

Text Books	
1	Nutrigenomics and Nutrigenetics in Functional Foods and Personalized Nutrition, Lynnette R. Ferguson, 2013 CRC Press ISBN 9781439876800
2	Functional foods, Nutraceuticals and Natural Products- concepts and application, Dhiraj A Vattem and VatsalaMaitin, Destech Publication 2016, ISBN - 101-59506-1-879.
3	Nutrigenetics: Applying the Science of Personal Nutrition 1st Edition, Martin Kohlmeier, Academia Press 2012 ISBN: 9780123859013

Reference Books	
1	Handbook of Nutraceuticals and functional foods, 2nd Edition, E C Willdman, CRC Press 2006, ISBN: 978-0-8493-6409-9
2	Nutraceutical and Functional Food Processing Technology. Joyce I. Boye, Wiley-Blackwell 2014, ISBN: 978-1-118-50494-9
3	Functional foods and Nutraceuticals, Aluko R E, Springer 2012, ISBN: 978-1-4614-3479-5

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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	2	3	2	1	-	2	2	1	-	2
CO2	2	3	3	3	3	2	3	2	3	1	-	3
CO3	1	3	3	2	2	3	3	3	2	2	1	2
CO4	2	2	3	1	1	3	3	3	2	3	2	3

High-3: Medium-2: Low-1

Semester: VII						
GMP, GLP, BIOSAFETY AND BIOBUSINESS (Group G: Professional Elective)						
Course Code	**:**	16BT7G3		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	4:0:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	41L		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Promotes entrepreneurship in the field of engineering and acquire the awareness about the biosafety principles and their significance in engineering education.
2	Demonstrate the risks involved in various manufacturing activities, products and services
3	Conceptualizes safety measures in laboratory for handling and releasing of engineered products.
4	Evaluates the bio business dimensions of professional engineering and scientific practice and to develop an effective conceptual framework for addressing bio business related opportunities and challenges.

Unit-I	**07 Hrs**
GLP (Good Laboratory Practice): Principles; Commodities; Apparatus. General Precautions-Storage, Test Systems, Standard protocols, and Quality assurance. Laboratory signage- safety level and containment. Treatment and disposal. Stock & lab ware- toxin and waste.	
Unit – II	**08 Hrs**
GMP (Good Manufacture Practice): Basic components of GMP Facilities, Design, Materials, Flow, Environment Control, Prevention of Cross Contamination. Quality, concept of GMP, Quality Assurance & Quality control. Legal requirements pertaining to GMP.	
Unit –III	**08 Hrs**
Biosafety: Guidelines for biosafety in teaching laboratories. ASM guidelines, Biological Materials, containment levels and zones. Biosafety program management, Biosecurity, Large scale work, Biological safety cabinets, Decontamination, Waste management, Emergency response plan, Incident reporting and Investigation.	
Unit –IV	**09 Hrs**
Business models; meaning and functions of a business model, basic types of models: vertical, product, platform and hybrid models. Transition in business models, models for biotech business in India, Intellectual property – plant patents: characteristics, composition, subject matter on microbial processes and products, patents involving micro-organisms, protection of Plant Varieties, Geographical Indications, protection of Traditional Knowledge. Governance of biotechnology and multilevel regulatory framework for GMOs.	
Unit –V	**09 Hrs**
Bio business: Business plan – model vs plan, general considerations, proposal content, proposal preparation, risk analysis, case study. Funding: financial alternatives for start-ups and established firms, venture capital, exit strategy, valuation, funding for biotech in India, case study. Licensing: meaning, scope, types, terms and trends, accessing technology, technology transfer, collaborations, partnerships, alliances, mergers and acquisitions, licensing of biotechnological inventions, case study.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Describe in outline good laboratory practice and good manufacture practices respect to slander operating day to day in engineering practices.
CO2:	Instilling an appreciation of the impact of technology on society and develop a higher level of an understanding of safety of engineering technologies.
CO3:	Describe in outline of framework engineering concepts and bio business models.
CO4:	Select suitable product and/ process for commercialization and Develop business plans.

Text Books	
1	GMP for Equipment, Utilities and Facilities; Dr Jürgen Hofmann; ECA, Academy Publishers; Berlin Germany, 1st Edition; 2017
2	Canadian Biosafety Handbook, 24th Edition; Public Health Agency of Canada; 2016. ISBN : 978 -1-100-25773-0

Reference Books	
1	Handbook on Good Laboratory Practice, Dr. R. Ridley, World Health Organization,2nd Edition. 2010 WHO Library Catalogues for non-clinical research and development ISBN 978 9241547550
2	Good Clinical, Laboratory and Manufacturing Practices: Techniques for the QA Professionals Phillip A. Carson, N. Den, 1st Edition Royal Society of Chemistry 2007. ISBN 9780854048342
3	Marilyn Buchanan Industrial Safety and Risk Management Laird Wilson, Doug McCutcheon, 1st Edition University of Albarta Press 2003. ISBN 0888643942.
4	Bio business: A Strategic Perspective Global Bio Business, Gurinder Shahi, Books, 2005. ISBN: 978080126456.

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

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Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the 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	2	1	-	-	-	2	2	1	1	-	-	2
CO2		2	-	2	-	1	-	-	1	-	-	1
CO3	2	2	1	-	-	2	2	-	1	-		2
CO4	3	2	1	-	2		-	-	-	-	-	1

High-3: Medium-2: Low-1

Semester: VII						
HPC AND BIG DATA ANALYSIS **(Group G: Professional Elective)**						
Course Code	**:**	16BT7G4		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	4:0:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	45L		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Impart the basic concepts of High performance computing(HPC) in applied bioinformatics.
2	Understand and explain the role of HPC in large data driven operations.
3	Compare the difference in normal computing and HPC processing speed.
4	Develop basic scripts to run the commands in HPC

Unit-I	**09 Hrs**
Introduction to HPC: Introduction to Linux operating system, Basic commands used in HPC cluster, Major components and its functions in HPC Cluster- head node, login node, interactive node, compute node, I/O node, Hardware architecture of HPC-processor design, cache architectures, design and evaluation techniques, operating systems and compilers, communications libraries, programming strategies for vector and parallel computers, optimization strategies, grid computing.	
Unit – II	**09 Hrs**
Introduction to shell scripting: Basics of shell scripting, invocation, variables, if-then-else. Loops, Workflows and nested workflows, How to submit and monitor workflow execution. HPC Data Storage, Serial and parallel batch jobs and scripting to run processes in parallel.	
Unit –III	**09 Hrs**
Big Data analytics: Introduction of Cloud computing, Hadoop architecture. MIKE2.0, Multiple layer architecture, Distributed Parallel architecture, NGS data analysis using Hadoop.	
Unit –IV	**09 Hrs**
Installation of Software Packages: Install R packages, Perl modules, Python modules and general software packages. Molecular dynamics and use of VMD Software's and tools used to access HPC cluster with examples. Applications of High performance Computing in the field of Bioinformatics	
Unit –V	**09 Hrs**
High throughput data analysis with HPC: Conversion of SRA files, FASTQC analysis using HPC – Command and tools required, interpretation of results. Adapter trimming, Alignment, Variant calling, Performing BLAST search, interpretation of results. Comparison of the results from various tools using HPC.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the basic knowledge of High Performance Computing
CO2:	Describe architectural hardware for high performance computing systems and installation of software packages
CO3:	Analyse and apply the appropriate tools and techniques to perform high throughput data analysis
CO4:	Develop parallel software tools using High Performance Computing

Reference Books	
1	Bioinformatics for High Throughput Sequencing. Naiara Rodríguez-Ezpeleta, Michael Hackenberg, Ana M. Aransay. Springer, 2012. ISBN-13: 9781461407812.
2	Review of Next-generation DNA sequencing informatics. Stuart M. Brown. Cold Spring Harbor Laboratory Press, Cold Spring Harbor: New York, 2013. ISBN-13: 978-1936113873.

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

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Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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	-	1	1	2	-
CO2	2	3	3	2	3	2	2	1	2	1	2	-
CO3	2	3	3	3	2	3	3	2	3	2	3	-
CO4	1	1	3	2	2	3	2	2	3	2	2	-

High-3: Medium-2: Low-1

Semester: IV						
NANOTECHNOLOGY (Group H: Global Elective)						
Course Code	**:**	**16G7H01**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**36L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	To have the basic knowledge of nanomaterials and the process.
2	Describe methods of nanoscale manufacturing and characterization can be enabled.
3	To learn about Nano sensors and their applications in mechanical, electrical, electronic, Magnetic, Chemical field.
4	To understand the concept for a nanoscale product based on sensing, transducing, and actuating mechanism.
5	To have awareness about the nanoscale products used in multidisciplinary fields.

Unit-I	**06 Hrs**
Introduction to Nanomaterials: History of Nanotechnology, structures and properties of carbon based: Fullerenes (Bucky Ball, Nanotubes), metal based: Nano Shells, Quantum Dots, Dendrimers, Diamond like carbon (DLC) Nano carriers, bionanomaterails: protein & DNA based nanostructures, Hybrids: hybrid biological/inorganic, Nano safety Issues: Toxicology health effects caused by nanoparticles.	
Unit – II	**08 Hrs**
Characterization of Nanostructures: Spectroscopy: UV-Visible spectroscopy, Fourier Transform infrared spectroscopy (FTIR), Raman Spectroscopy, X-ray spectroscopy. **Electron microscopy**: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM).**Scanning probe microscopy**: Atomic Force microscopy (AFM), Scanning tunnel microscopy (STM). **Nano Synthesis and Fabrication**: Introduction & overview of Nanofabrication: Bottom up and Top down approaches using processes like Ball milling, Sol-gel Process, Chemical Vapour deposition (CVD), plsma arching and various lithography techniques (Hard & Soft lithography).	
Unit –III	**09 Hrs**
Nano sensors: Overview of Nano sensors, prospects and market. Types of Nano sensors and their applications. Electromagnetic Nano sensors: Electronic nose and electronic tongue, Magnetic Nano sensors. Mechanical Nano sensors: Cantilever Nano sensors, Mechanics of CNTs, Biosensors: Biosensors in modern medicine.	
Unit –IV	**06 Hrs**
. **Micro & Nano-Electromechanical systems and Microfluidics**: MEMS/NEMS: Magnetic, Chemical and Mechanical Transducers –Sensing and Actuators. Microfluidics: Laminar flow, Hagen-Peouiselle equation, basic fluid ideas, Special considerations of flow in small channels, mixing, micro valves & micro pumps.	
Unit –V	**07 Hrs**
Applications of Nanotechnology: Molecular electronics, molecular switches, mechanical cutting tools, machine components, DLC coated grinding wheels. solar cells, Batteries, fuel cells, Nano filters. Medical nanotechnology: in Diagnostics, Therapeutics, Drug delivery and Nano surgery.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Remember, understand, and apply knowledge about of nanomaterials and their uses.
CO2:	Interpret and apply the techniques of manufacturing and characterization processes
CO3:	Apply the knowledge of Nano sensors, related to Nano sensors in electronics, mechanical, chemical, and biological systems.
CO4:	Create and evaluate Nano Design, Devices and Systems in various disciplines

Reference Books	
1	Textbook of Nanoscience and Nanotechnology, B.S. Murty., P. Shankar., B.Raj, B.B. Rath, and J. Murday, Springer, Co-publication with University Press (India) Pvt. Ltd. VCH, XII. 1st Edition, 2013, ISBN- 978-3-642-28030-6.
2	Nano sensors: Physical, Chemical and Biological, V. K. Khanna, CRC press, 1st Edition, 2013, ISBN 9781439827123 (Unit III).
3	Nanostructured materials, Nanostructured materials, C. C. Kock, William Andrew Publishing, 2nd Edition, 2007, ISBN 0-8155-1534-0.
4	Nanotechnology, M .Wilson., K. Kannangara., G.Smith., M.Simmons., B. Raguse overseas Press (India) Private Ltd.,1st Edition, 2005,ISBN 81-88689-20-3.

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

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Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
INDUSTRIAL SAFETY AND RISK MANAGEMENT (Group H: Global Elective)						
Course Code	**:**	**16G7H02**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**36L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Understand the basics of risk assessment methodologies
2	Select appropriate risk assessment techniques
3	Analyze public and individual perception of risk
4	Relate safety, ergonomics and human factors
5	Carry out risk assessment in process industries

Unit-I	**08 Hrs**
General Risk Identification Methods – I: Hazard identification methodologies, risk assessment methods-PHA, HAZOP, MCA, consequence analysis, hazards in workplaces-nature and type of work places, types of hazards, hazards due to improper housekeeping, hazards due to fire in multi floor industries and buildings.	
Unit – II	**07 Hrs**
Risk Assessment Methods – II: Risk adjusted discounted rate method, certainty equivalent coefficient method, quantitative analysis, probability distribution, coefficient of variation method, Simulation method, Shackle approach, Hiller‟s model, Hertz Model.	
Unit –III	**07 Hrs**
Risk Management – III: Emergency relief Systems, Diers program, bench scale experiments, design of emergency relief systems, risk management plan, mandatory technology option analysis, risk management alternatives, risk management tools, risk management plans, risk index method, Dowfire and explosion method, Mond index Method.	
Unit –IV	**07 Hrs**
Risk Assurance and Assessment – IV: Property insurance, transport insurance, liability insurance, risk Assessment, low Probability high consequence events. Fault tree analysis, Event tree analysis.	
Unit –V	**07Hrs**
Risk Analysis in Chemical Industries– V: Handling and storage of chemicals, process plants, personnel protection equipment's. International environmental management system.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Recall risk assessment techniques used in process industry
CO2:	Interpret the various risk assessment tools
CO3:	Use hazard identification tools for safety management
CO4:	Analyze tools and safety procedures for protection in process industries

Reference Books	
1	Kirkcaldy K.J.D Chauhan, Functional Safety in the Process Industry : A Handbook of practical Guidance in the application of IEC61511 and ANSI/ISA-84,North corolina, Lulu publication,2012,ISBN:1291187235
2	Goble and William M. Safety Instrumented Systems Verification Practical probabilistic calculations, Pensulvania ISA publication,2005, ISBN:155617909X
3	Laird Wilson and Doug Mc Cutcheon. Industrial safety and risk Management, The University of Alberta press, Canada, 1st Edition, 2003, ISBN: 0888643942.
4	Sincero A P and Sincero G A Environmental Engineering – A Design Approach, Prentice Hall of India, New Delhi,1996, ISBN: 0024105643
5	Pandya C G, Risks in Chemical units, Oxford and IBH publications, New Delhi,1992,ISBN: 8120406907

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

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Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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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Semester: VII						
INTELLIGENT TRANSPORT SYSTEMS (Group H: Global Elective)						
Course Code	**:**	**16G7H03**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**36L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Understand basic traffic flow and control for ITS
2	Understand user services for application in transportation system
3	Understand ITS architecture and its planning at various levels
4	Evaluate user services at various levels

Unit – I	**8 Hrs**
Introduction: –Historical Background, Definition, Future prospectus, ITS training and educational needs. **Fundamentals of Traffic Flow and Control**- Traffic flow elements, Traffic flow models, Shock waves in Traffic streams, Traffic signalization and control principles, Ramp metering, Traffic simulation	
Unit – II	**6 Hrs**
ITS User services-User services bundles, Travel and Traffic management, Public Transportation Operations, Electronic Payment, Commercial Vehicles Operations, Emergency Management, Advanced Vehicle Control and safety systems, Information Management, Maintenance and construction Management	
Unit –III	**7 Hrs**
ITS Applications and their benefits-Freeway and incident management systems-objectives, functions, traffic Surveillance and incident detection, Ramp control, incident management, Advanced arterial traffic control systems- historical development, Adaptive traffic control algorithms, Advanced Public Transportation Systems-Automatic vehicle location systems, Transit Operations software and information systems, Electronic fare payment systems, Multimodal Traveller Information systems	
Unit –IV	**7 Hrs**
ITS Architecture-Regional and Project ITS Architecture, Need of ITS architecture, concept of Operations, National ITS Architecture, Architecture development tool. **ITS Planning**-Transportation planning and ITS, Planning and the National ITS Architecture, Planning for ITS, Integrating ITS into Transportation Planning, relevant case studies.	
Unit –V	**8 Hrs**
ITS Standards-Standard development process, National ITS architecture and standards, ITS standards application areas, National Transportation Communications for ITS Protocol, Standards testing. **ITS Evaluation** – Project selection at the planning level, Deployment Tracking, Impact Assessment, Benefits by ITS components, Evaluation Guidelines, Challenges and Opportunities.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify various applications of ITS
CO2:	Apply ITS applications at different levels.
CO3:	Examine ITS architecture for planning process.
CO4:	Define the significance of ITS for various levels

Reference Books	
1	Choudury M A and Sadek A, Fundamentals of Intelligent Transportation Systems Planning Artech House publishers (31 March 2003); ISBN-10: 1580531601
2	Bob Williams, Intelligent transportation systems standards, Artech House, London, 2008. ISBN-13: 978-1-59693-291-3.
3	Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva, Ignacio Julio García Zuazola Intelligent Transport Systems Technologies and Applications Wiley Publishing ©2015, ISBN:1118894782 9781118894781
4	ITS Hand Book 2000 Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.
5	Dominique Luzeaux ,Jean-René Ruault, Michel Chavret Intelligent Transport Systems 7th MAR 2013 Copyright © 2010 by John Wiley & Sons, Inc DOI: 10.1002/9781118557495.ch6

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
INTELLIGENT SYSTEMS (Group H: Global Elective)						
Course Code	**:**	**16G7H04**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**36L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Understand fundamental AI concepts and current issues.
2	Understand and apply a range of AI techniques including search, logic-based reasoning, neural networks and reasoning with uncertain information.
3	Recognize computational problems suited to an intelligent system solution.
4	Identify and list the basic issues of knowledge representation, blind and heuristic search.

Unit-I	**07 Hrs**
Introduction: The Foundations of Artificial Intelligence, History of Artificial Intelligence, The State of the Art, **Intelligent Agent:** Introduction, How Agents Should Act, Structure of Intelligent Agents, **Problem-solving**: Solving Problems by Searching Search Strategies, Avoiding Repeated States Avoiding Repeated States	
Unit – II	**07 Hrs**
Informed Search Methods: Best-First Search, Heuristic Functions, Memory Bounded Search, Iterative Improvement Algorithms **Game Playing:** Introduction: Games as Search Problems, Perfect Decisions in Two-Person, Games Imperfect Decisions, Alpha-Beta Pruning, Games That Include an Element of Chance	
Unit –III	**07 Hrs**
Knowledge Inference Knowledge representation -Production based system, Frame based system. Inference - Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning - Certainty factors, Bayes Rule, Uncertainty Principles, Bayesian Theory-Bayesian Network-Dempster - Shafer theory.	
Unit –IV	**07 Hrs**
Learning from Observations: A General Model of Learning Agents, Inductive Learning, Learning Decision Trees, Using Information Theory, Learning General Logical Descriptions, Why Learning Works: Computational Learning Theory **Reinforcement Learning:** Passive Learning in a Known Environment, Passive Learning in an Unknown Environment, Active Learning in an Unknown Environment	
Unit –V	**07 Hrs**
Expert Systems, Components, Production rules, Statistical reasoning, certainty factors, measure of belief and disbelief, Meta level knowledge, Introspection. Expert systems - Architecture of expert systems, Roles of expert systems - Knowledge Acquisition –Meta knowledge, Heuristics. Typical expert systems - MYCIN, DART, XOON, Expert systems shells.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand and explore the basic concepts and challenges of Artificial Intelligence.
CO2:	Analyse and explain basic intelligent system algorithms to solve problems.
CO3:	Apply Artificial Intelligence and various logic-based techniques in real world problems.
CO4:	Assess their applicability by comparing different Intelligent System techniques

Reference Books	
1	AI – A Modern Approach , Stuart Russel, Peter Norvig , 2nd Edition, Pearson Education, 2010, ISBN-13: 978-0137903955.
2	Artificial Intelligence (SIE) ,Kevin Night, Elaine Rich, Nair B., ,McGraw Hill, 1st Edition, 2008, ISBN: 9780070087705
3	Introduction to AI and ES , Dan W. Patterson, Pearson Education, 1st Edition ,2007. ISBN: 0132097680
4	Introduction to Expert Systems ,Peter Jackson, 3rd Edition, Pearson Education, 2007, ISBN-978-0201876864

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

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Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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**	**2**	**1**	**2**	**-**	**2**	**2**
CO2	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**-**	**2**	**2**
CO3	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**-**	**2**	**2**
CO4	**3**	**3**	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**2**	**2**

High-3: Medium-2: Low-1

Semester: VII						
IMAGE PROCESSING AND MACHINE LEARNING (Group H: Global Elective)						
Course Code	**:**	**16G7H05**		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	**3:0:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**03 Hours**

Course Learning Objectives: The students will be able to	
1	Understand the major concepts and techniques in image processing and Machine Learning
2	To explore, manipulate and analyse image processing techniques
3	To become familiar with regression methods, classification methods, clustering methods.
4	Demonstrate image processing and Machine Learning knowledge by designing and implementing algorithms to solve practical problems

Unit-I	**08 Hrs**
Introduction to image processing: Images, Pixels, Image resolution, PPI and DPI, Bitmap images, Lossless and lossy compression, Image file formats, Color spaces, Bezier curve, Ellipsoid, Gamma correction, Advanced image concepts	
Unit – II	**08 Hrs**
Basics of Python & Scikit image: Basics of python, variables & data types, data structures, control flow & conditional statements, uploading & viewing an image, Image resolution, gamma correction, determining structural similarities.	
Unit –III	**08 Hrs**
Advanced Image processing using Open CV Blending Two Images, Changing Contrast and Brightness Adding Text to Images Smoothing Images , Median Filter ,Gaussian Filter ,Bilateral Filter ,Changing the Shape of Images ,Effecting Image Thresholding ,Calculating Gradients , Performing Histogram Equalization	
Unit –IV	**08 Hrs**
Machine Learning Techniques in Image Processing Bayesian Classification, Maximum Likelihood Methods, Neural Networks; Non-parametric models; Manifold estimation, Support Vector Machines, Logistic Regression	
Unit –V	**08 Hrs**
Introduction to object Tracking , modelling & Recognition Exhaustive vs. Stochastic Search, Shapes, Contours, and Appearance Models. Mean-shift tracking; Contour-based models, Adaboost approaches: Face Detection / Recognition, Tracking.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Gain knowledge about basic concepts of Image Processing
CO2:	Identify machine learning techniques suitable for a given problem
CO3:	Write programs for specific applications in image processing
CO4:	Apply different techniques for various applications using machine learning techniques.

Reference Books	
1	Practical Machine Learning and Image Processing: For Facial Recognition, Object Detection, and Pattern Recognition Using Python, by Himanshu Singh, A press publisher.
2	Pattern Recognition and Machine Learning, by Christopher Bishop, Springer, 2008
3	Computer Vision: A modern Approach by David Forsyth and Jean Ponce, Prentice Hall India 2004.
4	Machine Vision: Theory Algorithms Practicalities, by E.R. Davies Elsevier 2005.
5	Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods Pearson Education, Edition, 2001.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
DESIGN OF RENEWABLE ENERGY SYSTEMS (GROUP H: GLOBAL ELECTIVE)						
Course Code	**:**	**16G7H06**		**CIE Marks**	**:**	**100**
Credits: L:T:P:S	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Total Hours	**:**	**40L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives:	
1	To provide opportunity for students to work on multidisciplinary projects.
2	To familiarize the students with the basic concepts of nonconventional energy sources and allied technological systems for energy conversion
3	To impart skill to formulate, solve and analyze basic Non – conventional energy problems and prepare them for graduate studies.
4	To enable the student to design primarily solar and wind power systems.
5	To expose the students to various applications of solar, wind and tidal systems.

UNIT – I	**07 Hrs**
An introduction to energy sources: Industry overview, incentives for renewable, utility perspective, Relevant problems discussion, current positions of renewable energy conditions	
UNIT – II	**09 Hrs**
PV Technology: photovoltaic power, PV projects, Building-integrated PV system, PV cell technologies, solar energy maps, Technology trends, **Photovoltaic Power Systems**: PV cell, Module and Array, Equivalent electrical circuit, open-circuit voltage and short-circuit current, I-V and P-V curves, Array design (different methodologies), peak-power operation, system components.	
UNIT – III	**09 Hrs**
Wind Speed and Energy: Speed and power relations, power extracted from the wind, Air density, Global wind patterns, wind speed distribution (parameters calculations) , wind speed prediction, **Wind Power Systems :** system components , turbine rating , power vs. speed and TSR, maximum energy capture, maximum power operation, system-design trade-offs , system control requirements, environmental aspects.	
UNIT – IV	**07 Hrs**
Geothermal and ocean energy: Geothermal power, geo pressured sources, Geothermal well drilling, advantages and disadvantages, Comparison of flashed steam and total flow concept **Energy from ocean**: OTEC power generation, OPEN and CLOSED cycle OTEC. Estimate of Energy and power in simple single basin tidal and double basin tidal system	
UNIT – V	**08 Hrs**
Standalone system: PV stand-alone, Electric vehicle, wind standalone, hybrid systems (case study), system sizing, wind farm sizing. **Grid-Connected Systems: I**ntroduction**,** interface requirements, synchronizing with the grid, operating limit, Energy storage and load scheduling**,** Grid stability issues**,** distributed power generation.	

Course outcomes:

CO1: Demonstrate an understanding of the scientific principles of methodology of Non-conventional energy.

CO2: Acquire working knowledge of different Renewable energy science-related topics.

CO3: Ability to analyse the system related concepts effectively in the wind energy designing.

CO4: Students will be able to decide the appropriate procedures to ensure that the working model has developed properly.

Reference Books	
1.	Wind and Solar Power Systems Design, Analysis and operation, Mukund R Patel, 2nd Edition, 2006, Taylor and Francis publishers, ISBN 978-0-8493-1570-1.
2.	Non-Conventional sources of energy, G.D.Rai, 4th Edition, 2009, Khanna Publishers, ISBN 8174090738, 9788174090737,
3.	Solar Energy, Sukhatme, 4th Edition, 2017, McGraw Hill Education, **ISBN-13:** 978-9352607112
4.	Renewable energy sources, John Twidell, Tony Weir, 3rd Edition, 2015, Routledge Publisher, ISBN-13: 978-0415584388.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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.

VII Semester						
SYSTEMS ENGINEERING (Group H: Global Elective)						
Course Code	**:**	**16G7H07**		**CIE Marks**	**:**	**100**
Credits: L:T:P:S	**:**	**3:0:0**		**SEE Marks**	**:**	**100**
Total Hours	**:**	**33L**		**SEE Duration**	**:**	**03 Hours**

Course Learning Objectives:	
1	Develop an appreciation and understanding of the role of systems engineering processes and systems management in producing products and services.
2	Document systematic measurement approaches for generally cross disciplinary development effort.
3	Discuss capability assessment models to evaluate and improve organizational systems engineering capabilities.

Unit-I	**07 Hrs**
System Engineering and the World of Modem System: What is System Engineering?, Origins of System Engineering, Examples of Systems Requiring Systems Engineering, System Engineering viewpoint, Systems Engineering as a Profession, The power of Systems Engineering, problems. **Structure of Complex Systems:** System building blocks and interfaces, Hierarchy of Complex systems, System building blocks, The system environment, Interfaces and Interactions. **The System Development Process:** Systems Engineering through the system Life Cycle, Evolutionary Characteristics of the development process, The system engineering method, Testing throughout system development, problems.	
Unit – II	**07 Hrs**
Systems Engineering Management: Managing systems development and risks, Work breakdown structure (WBS), System Engineering Management Plan (SEMP), Risk Management, Organization of Systems Engineering, Systems Engineering Capability Maturity Assessment, Systems Engineering standards, Problem. **Needs Analysis:** Originating a new system, Operations analysis, Functional analysis, Feasibility analysis, Feasibility definition, Needs validation, System operational requirements, and problems. **Concept Exploration:** Developing the system requirements, Operational requirements analysis, Performance requirements formulation, Implementation concept exploration, Performance requirements validation, problems.	
Unit – III	**07 Hrs**
Concept Definition: Selecting the system concept, Performance requirements analysis, Functional analysis and formulation, Concept selection, Concept validation, System Development planning, System Functional Specifications, problems **Advanced Development:** Reducing program risks, Requirements analysis, Functional Analysis and Design, Prototype development, Development testing, Risk reduction, problems.	
Unit – IV	**06 Hrs**
Engineering Design: Implementing the System Building blocks, requirements analysis, Functional analysis and design, Component design, Design validation, Configuration Management, problems. **Integration and Evaluation:** Integrating, Testing and evaluating the total system, Test planning and preparation, System integration, Developmental system testing, Operational test and evaluation, problems.	
Unit – V	**06 Hrs**
Production: Systems Engineering in the factory, Engineering for production, Transition from development to production, Production operations, Acquiring a production knowledge base, problems. **Operations and support**: Installing, maintenance and upgrading the system, Installation and test, In-service support, Major system upgrades: Modernization, Operational factors in system development, problems.	

Reference Books	
1	Systems Engineering – Principles and Practice, Alexander Kossoakoff, William N Sweet, 2012, John Wiley & Sons, Inc, ISBN: 978-81-265-2453-2
2	Systems Engineering and Analysis, Blanchard, B., and Fabrycky W, 5th Edition, 2010, Saddle River, NJ, USA: Prentice Hall.
3	Handbook of Human Systems Integration, Booher, H. (Edition) 2003. Hoboken, NJ, USA: Wiley.
4	Systems Engineering: A 21st Century Methodology, Hitchins, D., 2007. Chichester, England: Wiley.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the Life Cycle of Systems.
CO2	Explain the role of Stake holders and their needs in organizational systems.
CO3	Develop and Document the knowledge base for effective systems engineering processes.
CO4	Apply available tools, methods and technologies to support complex high technology systems.
CO5	Create the frameworks for quality processes to ensure high reliability of systems.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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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Semester: VII						
MEMS AND APPLICATIONS (Group H: Global Elective)						
Course Code	**:**	16G7H08		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	3:0:0		**SEE**	**:**	**100 Marks**
Total Hours	**:**	35L		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Understand the rudiments of Micro fabrication techniques.
2	Identify and associate the various sensors and actuators to applications.
3	Analyse different materials used for MEMS.
4	Design applications of MEMS to disciplines.

Unit - I	**06 Hrs**
Overview of MEMS & Microsystems: MEMS and Microsystems, Typical MEMS and micro system products, Evolution of micro fabrication, Microsystems and microelectronics, Multidisciplinary nature of Microsystems, Design and manufacture, Applications of Microsystems in automotive, healthcare, aerospace and other industries. **Working Principle of Microsystems**: Biomedical and biosensors. Micro sensors: Acoustic, Chemical, Optical, Pressure, Thermal.	
Unit – II	**08 Hrs**
Micro actuation: Using thermal forces, shape memory alloys, Piezoelectric crystals and electrostatic forces. MEMS with micro actuators: Micro grippers, micro motors, micro valves and micro pumps, micro accelerometers, microfluidics**.** **Introduction to Scaling:** Scaling in Geometry, Scaling in Rigid body dynamics, Scaling in Electrostatic forces, scaling in electromagnetic forces and scaling in fluid mechanics.	
Unit – III	**08 Hrs**
Materials for MEMS and Microsystems: Substrates and wafers, Active substrate materials, Silicon as substrate material, Silicon Compounds, Si-Piezo resistors, GaAs, Quartz, Piezoelectric Crystals, Polymers and packaging materials. Three level of Microsystem packaging, Die level packaging, Device level packaging, System level packaging. Interfaces in microsystem packaging. Essential packaging technologies: die preparation, Surface bonding, Wire bonding, Sealing, 3D packaging.	
Unit – IV	**06 Hrs**
Microsystem Fabrication Process: Introduction to microsystems, Photolithography, Ion Implantation, Diffusion, Oxidation, CVD,PVD-Sputtering, Deposition of Epitaxy, Etching, LIGA process: General description, Materials for substrates and photoresists, Electroplating and SLIGA process.	
Unit – V	**07 Hrs**
Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia, Acoustic, Tactile and Flow sensors. **Overview, Application, Fabrication Process in Applications:** Silicon Capacitive Accelerometer, Piezo resistive Pressure sensor, Electrostatic Comb drive, Portable blood analyser, Piezo electric Inkjet Print head, Micro mirror array for Video projection.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the operation of micro devices, micro systems and their applications.
CO2:	Apply the principle of material science to sensor design.
CO3:	Analyse the materials used for sensor designs.
CO4:	Conceptualize and design micro devices, micro systems.

Reference Books	
1	MEMS & Microsystems Design and Manufacture, Tai-Ran Hsu, 2nd Edition, 2002, Tata McGraw Hill Education, New Delhi, ISBN-13:978-0-07-048709-3.
2	Foundations of MEMS, Chang Liu, 2012, Pearson Education Inc., ISBN-13:978-0-13-249736-7.
3	Smart Material Systems and MEMS, Vijay K Varadan, K. J. Vinoy, S. Gopalakrishnan, 2006, Wiley-INDIA, ISBN-978-81-265-3170-7.
4	Micro and Smart Systems, G.K. Ananthasuresh, K.J .Vinoy, K.N. Bhat, V.K. Aatre, 2015, Wiley Publications, ISBN-:978-81-265-2715-1.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
INTRODUCTION TO INTERNET OF THINGS (Group H: Global Elective)						
Course Code	**:**	**16G7H09**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Learn the fundamentals of IoT
2	Understands the hardware, networks & protocols used in IoT development
3	Illustrate smart applications using IoT devices and building applications
4	Know more advanced concepts like cloud connectivity in IoT
5	Learn the fundamentals of IoT

Unit-I	**06 Hrs**
Fundamentals Of IOT: Introduction, Physical design of IoT, Logical design of IoT, IoT Enabling technologies, IoT Levels and Deployment Templates, , IoTvs M2M	
Unit – II	**06 Hrs**
IOT Design Methodology: Need for IoT systems management, IoT Design Methodology **Internet of Things Strategic Research and Innovation Agenda:** Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Smart-X Applications, Internet of Things and Related Future Internet Technologies.	
Unit –III	**11 Hrs**
IOT Systems - Logical Design using Python: Provides an introduction to Python, installing Python, Python data types & data structures, control flow, functions, modules, packages, file input/output, data/time operations and classes.	
Unit –IV	**09 Hrs**
IOT Physical Devices & Endpoints: What is an IoT device, Raspberry Pi device, About the board, Linux on Raspberry Pi, Raspberry Pi interfaces, Programming Raspberry Pi with Python.	
Unit –V	**07 Hrs**
IOT Physical Servers & Cloud Offerings: Provides an introduction to the use of cloud platforms and frameworks such as Xively and AWS for developing IoT applications.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Understand the fundamentals of IoT.
CO2:	Analyse the IoT devices, programming, networking requirements and protocols for building IoT products.
CO3:	Apply the concepts to design and develop IoT applications
CO4:	Creating applications of IoT using physical devices and interfacing with cloud.

Reference Books	
1	Internet of Things (A Hands-on-Approach), Vijay Madisetti and ArshdeepBahga, 1st Edition, VPT, 2014, ISBN-13: 978-0996025515.
2	Internet of Things – From Research and Innovation to Market Deployment, OvidiuVermesan, Peter Friess, River Publishers Series in Communication, River Publishers, 2014, ISBN: ISBN: 978-87-93102-94-1 (Hard copy), 978-87-93102-95-8 (Ebook) (Units II 2nd part)
3	Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, Francis daCosta, 1st Edition, A press Publications, 2013, ISBN-13: 978-1430257400.
4	Meta products - Building the Internet of Things, Wimer Hazenberg, Menno Huisman, BIS Publishers, 2012, ISBN: 9789863692515.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
INDUSTRY 4.0– SMART MANUFACTURING FOR THE FUTURE (Group H: Global Elective)						
Course Code	**:**	**16G7H10**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Understand the importance and role of Smart Manufacturing Systems, IoT and IIoT
2	Explain importance of automation technologies, sensors, Robotics and Machine vision.
3	Understand application of artificial intelligence and the need for data transformation, handling, storing and security.
4	Understand simulation, predictive and knowledge modelling along with analysis
5	Learn networking, sustainable technology and factory networks.

Unit-I	**06 Hrs**
Smart Manufacturing and Industry 4.0 Need for Smart Manufacturing, Advantages, Emerging technologies in Smart manufacturing, CAD Architecture surrounding 3D Models (B-rep and CSG), MEMS, Industry 4.0–Interoperability, Information transparency, Technical assistance, Decentralized decision-making, Internet of Things(IoT), Industry Internet of Things (IIoT), Future of Manufacturing industries	
Unit – II	**09 Hrs**
Manufacturing Automation Technology intensive manufacturing and cyber-physical systems, Automation using Robotics, Data storage, retrieval, manipulation and presentation; Mechanisms for sensing state and modifying processes, Material handling systems, controlling material movement and machine flow, Mechatronics, Transducers and sensors, Proximity sensors, Biosensors, Acceleration Machine Vision–Flaw detection, Positioning, Identification, Verification and Measurement–Application of Machine Vision in industries	
Unit –III	**09 Hrs**
Data handling using Embedded Systems Data transformation–Mathematical functions, Regression, Need for different functions, Data merging–Discrete and Random variables, Transformation languages, Interfacing systems-Microprocessors, Direct memory access, Data transfer schemes and systems, Communication systems–Modulation, Time domain and frequency domain, Industrial Network Data Communications, Data Security Artificial Intelligence – Intelligent systems, Fuzzy logics, Neural networks – Supervised, Unsupervised and Reinforced learning	
Unit –IV	**06 Hrs**
Simulation, Modeling and Analysis Simulation - system entities, input variables, performance measures, and Functional relationships, types of simulation. Predictive modeling and simulation tools, Knowledge Modeling –types and technology options, Functional analysis of control systems – Linear and Non-linear, Functional decomposition, Functional sequencing, Information / dataflow, Interface	
Unit –V	**09 Hrs**
Performance Measures of Smart Manufacturing Systems- Smart manufacturing- Sensing and Perception, Manipulation, Mobility and Autonomy, Factory Networks, Information Modeling and Testing, Performance Measurement and Optimization, Engineering System integration, Production Network integration, Production network data quality, Sustainable Processes and Resources, Integration Infrastructure for Sustainable Manufacturing	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Explain role and importance of Smart Manufacturing Systems, IoT and IIoT
CO2:	Explain importance of automation technologies, sensors, robotics and machine vision
CO3:	Illustrate the application of artificial intelligence and need for data transformation, handling
CO4:	Explain analytical and simulation for performance study of smart technologies and networks

Reference Books	
1	Zongwei Luo, Smart Manufacturing Innovation and Transformation: Interconnection And Intelligence, 1st Edition, IGI Global Publications, 2014,ISBN-13: 978-1466658363 ISBN-10: 1466658363
2	Yan Lu. KC Morris, Simon Frechette, Smart Manufacturing Standards, NIST, 1st Edition, 2016, Project report.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
SPACE TECHNOLOGY AND APPLICATIONS (Group H: Global Elective)						
Course Code	**:**	**16G7H11**		**CIE**	**:**	**100 Marks**
Credits: L:T:P :S	**:**	**3 : 0 : 0 : 0**		**SEE**	**:**	**100 Marks**
Hrs /Week	**:**	**35L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Define the earth environment and its behavior, launching vehicles for satellites and its associated concepts.
2	Analyse satellites in terms of technology, structure and communications.
3	Use satellites for space applications, remote sensing and metrology.
4	Apply the space technology, technology mission and advanced space systems to nation's growth.

UNIT-I	**07 Hrs**
Earth's environment: Atmosphere, ionosphere, Magnetosphere, Van Allen Radiation belts, Interplanetary medium, Solar wind, Solar- Earth Weather Relations. **Launch Vehicles:** Rocketry, Propellants, Propulsion, Combustion, Solid, Liquid and Cryogenic engines, Control and Guidance system, Ion propulsion and Nuclear Propulsion.	
UNIT-II	**07 Hrs**
Satellite Technology: Structural, Mechanical, Thermal, Power control, Telemetry, Telecomm and Quality and Reliability, Payloads, Space simulation. **Satellite structure:** Satellite Communications, Transponders, Satellite antennas.	
UNIT-III	**07 Hrs**
Satellite Communications: LEO, MEO and GEO orbits, Altitude and orbit controls, Multiple Access Techniques. **Space applications:** Telephony, V-SAT, DBS system, Satellite Radio and TV, Tele-Education, Tele-medicine, Satellite navigation, GPS.	
UNIT-IV	**07 Hrs**
Remote Sensing: Visual bands, Agricultural, Crop vegetation, Forestry, water Resources, Land use, Land mapping, geology, Urban development resource Management, and image processing techniques. **Metrology:** Weather forecast (Long term and Short term), weather modelling, Cyclone predictions, Disaster and flood warning, rainfall predictions using satellites.	
UNIT-V	**07Hrs**
Satellite payloads: Technology missions, deep space planetary missions, Lunar missions, zero gravity experiments, space biology and International space Missions. **Advanced space systems:** Remote sensing cameras, planetary payloads, space shuttle, space station, Inter-space communication systems.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Explain different types of satellites, orbit and associated subsystems.
CO2	Apply the basics of launching vehicles, satellites and sub systems for space applications.
CO3	Analyse the applications of satellite in the area of communication, remote sensing, metrology etc.,
CO4	Study technology trends, satellite missions and advanced space systems.

Reference Books	
1	Atmosphere, weather and climate, R G Barry, Routledge publications, 2009, ISBN- 10:0415465702.
2	Fundamentals of Satellite Communication, K N Raja Rao, PHI, 2012, ISBN: 9788120324015.
3	Satellite Communication, Timothy pratt, John Wiley, 1986 ISBN: 978-0- 471- 37007 -9, ISBN 10: 047137007X.
4	Remote sensing and applications, B C Panda, VIVA books Pvt. Ltd., 2009, ISBN: 108176496308.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
ADVANCED LINEAR ALGEBRA (Group H: Global Elective)						
Course Code	**:**	**16G7H12**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Adequate exposure to learn the fundamental concepts to model a system of linear equations and to obtain the solution of system of linear equations.
2	Analyse and extend the structure of vector spaces, linear transformations, Symmetric matrices, quadratic forms required in applications of Business, Science and Engineering.
3	Apply the concept of Eigenvalues to study differential equations and dynamical systems. Apply the concept of Orthogonality to examine some of the least-squares problems.
4	Apply Linear Programming to Network problems and Game theory.

Unit-I	**07 Hrs**
System of linear equations Matrices and system of linear equations, Geometry of linear equations, Linear models in Business, Science and Engineering-Input-Output model in Economics, Balancing chemical equations and Electrical networks.	
Unit – II	**09 Hrs**
Vector spaces and linear transformations Revision of Vector Spaces, Subspaces, Linear independence, Basis, Dimension and Change of basis. Applications to Difference equations, Markov chains. Intersection, Sum, Product of spaces and Tensor product of two vector spaces. Introduction to Linear transformations, Geometrical interpretations in 2-dimensions and 3-dimensions.	
Unit –III	**09 Hrs**
Orthogonality, Eigen values and Eigen vectors Orthogonality, Inner product spaces, Applications to Weighted least-squares and Fourier series, Fast Fourier transform. Eigen values and Eigen vectors, Applications to Differential equations, Discrete dynamical systems.	
Unit –IV	**07 Hrs**
Symmetric matrices and quadratic forms Introduction to symmetric matrices, Quadratic forms, Test for Positive definiteness, Constrained Optimization, Singular Value Decomposition. Applications to image processing.	
Unit –V	**07 Hrs**
Linear programming and game theory A Geometrical introduction to Linear programming, Simplex method and its geometrical meaning, Network models-Max flow-min cut theorem, Payoff matrix and Matrix games.	

Course Outcomes: After completing the course, the students will be able to	
CO1:	Identify and interpret the fundamental concepts of linear equations, vector spaces, linear transformations, Orthogonality, Eigen values, symmetric matrices, quadratic forms, linear programming and game theory.
CO2:	Apply the knowledge and skills of Linear algebra to solve linear equations, difference and differential equations, constrained optimization problems, linear programming problems and related problems.
CO3:	Analyse the input-output models, Markov chains, discrete dynamical systems, singular value decomposition, network models and related problems.
CO4:	Using the overall mathematical knowledge of Linear Algebra to solve problems arising in practical situations.

Reference Books	
1	David C Lay; Linear Algebra and Its Applications; Pearson Education; 3rd Edition; 2003; ISBN: 978-81-775-8333-5.
2	Gareth Williams; Linear Algebra with Applications; 6th edition; 2008; Narosa publications; ISBN: 978-81-7319-981-3.
3	Gilbert Strang; Linear Algebra and Its Applications; 4th Edition; Cengage Learning India Edition; 2006; ISBN: 81-315-0172-8.
4	Howard Anton and Chris Rorres; Elementary Linear Algebra Applications Version; Wiley Global Education; 11th Edition; 2013; ISBN: 9781118879160.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
THIN FILM NANOTECHNOLOGY (Group H: Global Elective)						
Course Code	**:**	**16G7H13**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**36L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Understand the importance of vacuum in thin film fabrication
2	Acquire the knowledge of thin film preparation by various techniques
3	Analyse the properties of thin films using different characterization methods
4	Optimize the process parameter and property dependence
5	Apply the knowledge for developing thin film devices.

Unit-I	**08 Hrs**
Vacuum Technology: Basics of Vacuum - Principles of different vacuum pumps: Rotary, Roots, Diffusion, Turbo molecular and Cryogenic pumps; Measurement of vacuum - Concept of Capacitance Manometer, Pirani and Penning gauges - Vacuum Systems & Applications.	
Unit – II	**08 Hrs**
Methods of thin film preparation Physical Vapour Deposition (PVD) Techniques**:** *Evaporation*: Thermal evaporation, Electron beam evaporation, Laser ablation, and Cathode arc deposition. *Sputtering*: DC sputtering, RF Sputtering, Magnetron sputtering, Reactive Sputtering, and Ion beam sputtering. Chemical Vapor Deposition (CVD) Techniques**:** Conventional CVD, Plasma Enhance CVD (PECVD) and Atomic layer deposition (ALD). Other Methods: Spin coating and Spray Pyrolysis.	
Unit –III	**07 Hrs**
Surface Modification and Growth of Thin Films: Surface preparation & Engineering for Thin film growth: Cleaning, Modification, Masking & Patterning, Base Coats and Top Coats. Thin Film growth: Sequence of thin film growth, Defects and impurities, Effect of Deposition Parameters on film growth.	
Unit –IV	**08 Hrs**
Properties and Characterization of Thin Films Film thickness (Quartz crystal thickness monitor and Stylus Profiler); Film Adhesion (Tape, Cross-hatch test, and Humidity methods); Surface morphology and topography (SEM and AFM); Film composition (X-ray Photoelectron Spectroscopy); Film structure (X-ray diffraction and Raman studies); Electrical characterization (Four Probe and Semiconductor Analyser); and Optical characterization (Spectrophotometer).	
Unit –V	**08 Hrs**
Thin Film Applications: • Electrodes: Deposition of a Metal film, Ex: Aluminium. • Transparent conducting oxides (TCO) – Preparation and Optimization of a semiconducting film, Ex: ZnO. • Optimization of a dielectric film, Ex: Al_2O_3 or Si_3N_4. **Thin Film Devices**: • Thin Film Transistors (TFT), • Thin Film Sensors • Thin Film Capacitors • Thin film Solar Cells,	

- Thin film Solar Absorbers
- Diamond-like carbon (DLC) coating
- EMI Shielding coatings
- Hard coatings
- Coatings on Plastics/Polymers.

Course Outcomes: After completing the course, the students will be able to	
CO1	Understand the importance of vacuum technology for thin film growth
CO2	Prepare various kinds of thin films using different deposition techniques
CO3	Characterize the deposited films for various properties
CO4	Fabricate thin film based devices.

Reference Books	
1.	Vacuum Technology by A. Roth, Elsevier, 3rd Edition, 1976, ISBN: 9780444880109, 9780444598745,
2.	Thin Film Phenomenon by K.L. Chopra, McGraw-Hill, 1st Edition, 1969, ISBN: 0070107998, 978-0070107991
3.	Materials Science of Thin Films by Milton Ohring, Elsevier, 2nd Edition, 2001, **ISBN:** 9780125249751
4.	Thin-Film Deposition: Principles and Practice by Donald Smith, McGraw-Hill, 1st Edition, 1995, ISBN: 0070585024, 9780070585027

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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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Semester: VII						
ENGINEERING MATERIALS FOR ADVANCED TECHNOLOGY (Group H: Global Elective)						
Course Code:	**:**	**16G7H14**		**CIE**	**:**	**100 Marks**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100 Marks**
Total Hours	**:**	**39L**		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to

1	Apply the basic concepts of Chemistry to develop futuristic materials for high-tech applications in the area of Engineering.
2	Impart sound knowledge in the different fields of material chemistry so as to apply it to the problems in engineering field.
3	Develop analytical capabilities of students so that they can characterize, transform and use materials in engineering and apply knowledge gained in solving related engineering problems.

UNIT-I	**08 Hrs**

Coating and packaging materials

Surface Coating materials:

Synthesis and applications of Polymer coating materials: Teflon, Silicone films Polyvinyl chloride & its copolymers, Poly vinyl acetate, Poly ethylene-HDPE, LDPE, Polyurethane.

Properties required in a pigment and extenders.

Inorganic pigments-titanium dioxide, zinc oxide, carbon black, chromate pigments, chrome green, ultramarine blue, iron blue, cadmium red.

Corrosion inhibiting pigments- zinc phosphate, zinc and barium chromate pigments, ceramic pigments, metal flake pigments, extenders.

Developments in new polymers such as dendrimers, biopolymers & biodegradable polymers.

Packaging materials:

Food products: Cellulosic and Polymeric packaging materials and their properties – including barrier properties, strength properties, optical properties. Glass, aluminium, tin, paper, plastics, composites.

Pharmaceutical products: Injectable and tablet packaging materials.

UNIT-II	**07 Hrs**

Adhesives

Introduction-Classification of Adhesives-Natural adhesives, synthetic adhesives-drying adhesives, pressure sensitive adhesives, contact adhesives, hot adhesives. One part adhesives, multi part adhesives. Adhesive Action. Development of Adhesive strength- Physical factors influencing Adhesive Action-surface tension, surface smoothness, thickness of adhesive film, elasticity and tensile strength. Chemical Factors Influencing Adhesive action - presence of polar groups, degree of polymerization, complexity of the adhesive molecules, effect of pH. Adhesive action- specific adhesive action, mechanical adhesive action, fusion adhesion. Development of adhesive strength- adsorption theory and diffusion theory. Preparation, curing and bonding Processes by adhesives-with reference to Epoxy, phenolics, Silicone, Polyurethane, Acrylic adhesives, Poly vinyl alcohol, Polyvinyl acetate.

UNIT-III	**08 Hrs**

Optical fibre materials

Fiber Optics, Advantages of optical fiber communication over analog communication, Classification based on refractive index of the core- step index and graded index optical fibres, Classification based on core radius-single mode and multimode optical fibres, Fibre fabrication.-Methods to manufacture optical glass fibres. Double crucible method and preform methods. Manufacture of perform- Chemical Vapour Deposition (CVD), Modified vapour deposition (MCVD) Plasma activated vapour deposition (PCVD), Outside vapour deposition (OVD)-Vapour-phase axial deposition (VAD). Drawing the fibres from perform, coating and jacketing process.

Ion exchange resins and membranes

Ion exchange resins-Introduction, Types, physical properties, chemical properties-capacity, swelling, kinetics, stability, ion exchange equilibrium, regeneration. Applications of ion exchange resins-softening of water, demineralization of water, advantages and disadvantages of ion exchange resins-calcium sulphate fouling, iron fouling, adsorption of organic matter, bacterial contamination. Ion exchange membranes, Types, Classification, Fabrication of ion exchange cottons- anion exchange cotton and cation exchange cotton. Application of ion exchange membranes in purification of water by electro dialysis method.

UNIT-IV	08 Hrs
Spectroscopic Characterization of materials: Electromagnetic radiation, interaction of materials with electromagnetic radiation. UV- visible spectrophotometry :Introduction-Electronic transitions- factors influencing position and intensity of absorption bands-absorption spectra of dienes, polyene and α,β-unsaturated carbonyl compounds, Working of UV-Vis spectrophotometer, Theoretical calculation of λ_{max} by using Woodward-Fieser rules- for cyclic and α,β-unsaturated carbonyl compounds. IR Spectroscopy: Introduction, principle, molecular vibrations, vibrational frequency, number of fundamental vibrations, factors influencing fundamental vibrations, instrumentation of IR spectrophotometer, sampling techniques and application of IR spectroscopy in characterization of functional groups.	
UNIT-V	**08 Hrs**
NMR spectroscopy: H^1 NMR Spectroscopy: Basic concepts- relaxation process. NMR spectrometer-FT NMR-Solvents used in NMR, internal standards-Chemical equivalence -Integrals and Integrations- chemical shift-Factors affecting chemical shifts- shielding and deshielding effects – chemical and magnetic equivalent –magnetic anisotropy-spin-spin splitting rules- Application of NMR on various compounds such as alkanes, alkenes, alkynes, alkyl halides, alcohols, ethers, amines, aldehydes, ketones, carboxylic acids, esters, amides & mono substituted aromatic compounds. Problems on prediction of structure of compounds.	

Course Outcomes: After completing the course, the students will be able to	
CO1	Identify sustainable engineering materials and understand their properties.
CO2	Apply the basic concepts of chemistry to develop futuristic materials for high-tech applications in different areas of engineering.
CO3	Analyse and evaluate the specific application of materials.
CO4	Design the route for synthesis of material and its characterization.
Reference Books	
1.	Materials Science, G.K.Narula, K.S.Narula & V.K.Gupta. 38th Edtion, 2015, Tata McGraw-Hill Publishing Company Limited ISBN: 978-0-07-451796-3.
2.	Solar Lighting, Ramachandra Pode and Boucar Diouf, Springer e-book, 2011, ISBN: 978-1-44-712133-6 (Print) 978-1-44-712134-3 (Online),
3.	Spectroscopy of organic compounds, P.S.Kalsi, 6th Edition, 2013, New Age International (P) Ltd, publisher, ISBN: 978-1-22-415438-6.
4.	Food Packaging Materials, Mahadeviah M & Gowramma RV, 6th Edition, 1996, Tata McGraw Hill Publishing Company Ltd, ISBN :746-2-23-82 9780-0.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
APPLIED PSYCHOLOGY FOR ENGINEERS **(Group H: Global Elective)**						
Course Code	**:**	**16HG7H15**		**CIE**	**:**	**100**
Credits: L:T:P	**:**	**3:0:0**		**SEE**	**:**	**100**
Total Hours	**:**	**35L**		**SEE Duration**	**:**	**3 Hours**

Course Learning Objectives: The students will be able to

1	To appreciate human behavior and human mind in the context of learner's immediate society and environment.
2	To understand the importance of lifelong learning and personal flexibility to sustain personal and Professional development as the nature of work evolves.
3	To provide students with knowledge and skills for building firm foundation for the suitable engineering professions.
4	To prepare students to function as effective Engineering Psychologists in an Industrial, Governmental or consulting organization.
5	To enable students to use psychological knowledge, skills, and values in occupational pursuits in a variety of settings that meet personal goals and societal needs.

Unit – I	**7 Hrs**
Introduction to Psychology: Definition and goals of Psychology: Role of a Psychologist in the Society: Today's Perspectives (Branches of psychology). Psychodynamic, Behavioristic, Cognitive, Humanistic, Psychological Research and Methods to study Human Behavior: Experimental, Observation, Questionnaire and Clinical Method.	
Unit - II	**7 Hrs**
Intelligence and Aptitude: Concept and definition of Intelligence and Aptitude, Nature of Intelligence. Theories of Intelligence – Spearman, Thurston, Guilford Vernon. Characteristics of Intelligence tests, Types of tests. Measurement of Intelligence and Aptitude, Concept of IQ, Measurement of Multiple Intelligence – Fluid and Crystallized Intelligence.	
Unit – III	**7 Hrs**
Personality: Concept and definition of personality, Approaches of personality- psychoanalytical, Socio- Cultural, Interpersonal and developmental, Humanistic, Behaviorist, Trait and type approaches. Assessment of Personality: Self- report measures of Personality, Questionnaires, Rating Scales and Projective techniques, its Characteristics, advantages & limitations, examples. Behavioral Assessment. Psychological Stress: a. Stress- Definition, Symptoms of Stress, Extreme products of stress v s Burnout, Work Place Trauma. Causes of Stress – Job related causes of stress. Sources of Frustration, Stress and Job Performance, Stress Vulnerability-Stress threshold, perceived control.	
Unit – IV	**7 Hrs**
Application of Psychology in Working Environment: The present scenario of information technology, the role of psychologist in the organization, Selection and Training of Psychology Professionals to work in the field of Information Technology. Distance learning, Psychological consequences of recent developments in Information Technology. Type A and Type B Psychological Counseling - Need for Counseling, Types – Directed, Non- Directed, Participative Counseling.	
Unit – V	**7 Hrs**
Learning: Definition, Conditioning – Classical Conditioning, Basics of Classical Conditioning (Pavlov), the process of Extinction, Discrimination and Generalization. Operant Conditioning (Skinner expt). The basics of operant conditioning, Schedules of reinforcement. Cognitive – Social approaches to learning – Latent Learning, Observational Learning, Trial and Error Method, Insightful Learning.	

Experimental Psychology (Practicals)- Self Study 2 Hrs /Week	
1.Bhatia's Battery of Performance and intelligence test 2.Multidimensional Assessment of Personality 3.David's Battery of Differential Abilities (Aptitude test) 4.Bilateral Transfer of Training Mirror drawing apparatus with Electronic Digital Reset Error Counter (Performance) 5. Student Stress Scale.	
Course Outcomes: After completing the course, the students will be able to	
CO1	Describe the basic theories, principles, and concepts of applied psychology as they relate to behaviors and mental processes.
CO2	Define learning and compare and contrast the factors that cognitive, behavioural, and Humanistic theorists believe influence the learning process.
CO3	Develop understanding of psychological attributes such as intelligence, aptitude, creativity, resulting in their enhancement and apply effective strategies for self-management and self-improvement.
CO4	Apply the theories into their own and others' lives in order to better understand their personalities and experiences.
CO5	Understand the application of psychology in engineering and technology and develop a route to accomplish goals in their work environment.
Reference Books:	
1. . Understanding Psychology Feldman R. S, 4th Edition, (1996) McGraw Hill India	
2. Psychology Robert A. Baron, 3rd Edition (1995) Prentice Hall India.	
3. Organizational Behaviour , Stephen P Robbins Pearson Education Publications, 13th Edition, ISBN – 81-317 – 1132 – 3	
4. Organisational Behaviour: Human Behaviour at Work , John W.Newstrem and Keith Davis. Tata McGraw Hill India, 10th Edition, ISBN 0-07-046504-5	
5. Psychology-themes and variations , Wayne Weiten, 4th Edition, Brooks / Cole Publishing Co.	
Scheme of Continuous Internal Evaluation (CIE):	
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.	
Scheme of Semester End Examination (SEE):	
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.	

VII Semester						
FOUNDATIONAL COURSE ON ENTREPRENEURSHIP (Group H: Global Elective)						
Course Code	**:**	**16G7H16**		**CIE Marks**	**:**	**100**
Credits: L:T:P:S	**:**	**3:0:0:0**		**SEE Marks**	**:**	**100**
Total Hours	**:**	**36L**		**SEE Duration**	**:**	**03 Hours**

Course Learning Objectives:	
1	To make participants self-discover their innate flow, entrepreneurial style, and identify problems worth solving thereby becoming entrepreneurs
2	To handhold participants on lean methodology to craft value proposition and get ready with lean canvas
3	To create solution demo by conducting customer interviews and finding problem-solution fit for building Minimum Viable Product (MVP)
4	To make participants understand cost structure, pricing, revenue types and importance of adopting shared leadership to build good team
5	To help participants build a strong brand and identify various sales channels for their products and services
6	To take participants through basics of business regulations and other legal terms along-with understanding of Intellectual Property Rights

Unit-I	**07 Hrs**
Self-Discovery and Opportunity Discovery Finding the Flow; Effectuation; Identifying the Effectuation principles used in activities; Identifying Problem Worth Solving; Design Thinking; Brainstorming; Presenting the Identified problems; Identifying the Entrepreneurial Style.	
Unit – II	**07 Hrs**
Customer, Solution and Lean Methodology Customers and Markets; Segmentation and Targeting; Identifying Jobs, Pains, and Gains and Early Adopters; Crafting Value Proposition Canvas (VPC); Presenting VPC; Basics of Business Model and Lean Approach; Sketching the Lean Canvas; Risks and Assumptions; Presenting Lean Canvas.	
Unit – III	**07 Hrs**
Problem-Solution Fit and Building MVP Blue Ocean Strategy - Plotting the Strategy Canvas; Four Action Framework: Eliminate-Reduce-Raise-Create Grid of Blue Ocean Strategy; Building Solution Demo and Conducting Solution Interviews; Problem-Solution Fit; Building MVP; Product-Market Fit; Presenting MVP.	
Unit – IV	**06 Hrs**
Financial Planning & Team Building Cost Structure - Estimating Costs; Revenues and Pricing: Revenue Streams, Revenue Types, Identifying Secondary Revenue Streams, Estimating Revenue and Price; Profitability Checks; Bootstrapping and Initial Financing; Practising Pitch; Shared Leadership; Hiring and Fitment, Team Role and Responsibilities.	
Unit – V	**09 Hrs**
Marketing, Sales, Regulations and Intellectual Property Positioning and Branding; Channels; Sales Planning; Project Management; Basics of Business Regulations; How to Get Help to Get Started; Patents, Trademark, Licensing, Contracts; Common Legal mistakes, Types of Permits, Tax Registration Documents, Compliance; Infringement and Remedies, Ownership and Transfer.	

Course Outcomes: After completing the course, the students will be able to	
CO1	showcase the ability to discern distinct entrepreneurial traits
CO2	Know the parameters to assess opportunities and constraints for new business ideas
CO3	Understand the systematic process to select and screen a business idea
CO4	design strategies for successful implementation of ideas
CO5	Create Business Model and develop Minimum Viable Product

Reference Books	
1	Running Lean: Iterate from Plan A to a Plan That Works. O'Reilly Media, Maurya, A., 2012.
2	Entrepreneurship. Roy, R., 2012. Oxford University Press
3	Intellectual Property Law in India. Gupta, T. S., 2011. Kluwer Law International
4	Flow: The Psychology of Optimal Experience. Czikszentmihalyi, M., 2008. Harper Perennial Modern Classics
5	Effectuation: Elements of Entrepreneurial Expertise. Sarasvathy, S. D., 2009. Edward Elgar Publishing Ltd.

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

Semester End Evaluation (SEE); Theory (100 Marks)
SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VII						
UNMANNED AERIAL VEHICLES (Group H: Global Elective)						
Course Code	**:**	16G7H17		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	3:0:0:0		**SEE**	**:**	**100 Marks**
Hours	**:**	36L		**SEE Duration:**	**:**	**3Hrs**

Course Learning Objectives: The students will be able to	
1	Get an overview of the history of UAV systems
2	Understand the importance of aerodynamics, propulsion, structures and avionics in the design of UAV
3	Demonstrate ability to address the various mission payloads - on-board & off-board, propulsion systems, integration with manned systems
4	Assess the performance and airworthiness of the designed UAV

Unit-I	**06 Hrs**
Introduction to Flight Vehicles: History of Flight Vehicles and UAVs, Classifications, Woking principles of flight vehicle. **Introduction to Unmanned Aircraft Systems** Types of UAVs, configurations and their advantages disadvantages, System Composition, Applications of UAVs, Characteristics of Aircraft	
Unit – II	**07 Hrs**
Design of UAV Systems: Governing aspects: **a. Aerodynamics, b. Propulsion, C. structure, d. Controls** **Aerodynamics:** Introduction basic Aerodynamics, lift, drag, Aerofoils, wing area optimization. **Propulsion:** Introduction to propulsion system in UAV, Propulsion system for fixed wing UAV and VTOL (Vertical take-off and landing) UAV, Advanced propulsion systems, fuel cells, generators based systems.	
Unit -III	**07Hrs**
Structures of UAV: Mechanic loading, basics of types of load calculation and structural engineering, Material used for UAV (general introduction), FRP and methods of usage in UAV, Testing of FRP specimens for UAV, selection criteria for structure, Types of structural elements used in UAV their significance and characteristics, Methods of manufacturing UAV structure.	
Unit -IV	**07 Hrs**
Controls, Avionics, Hardware, Communication, Payloads: Basics of control system and Systems for control system in UAV, PID control, simulation introduction to Hardware in loop system (HILS), Avionics: Autopilot (AP) – architecture of AP, sensors, actuators, power supply, integration, installation, configuration, and testing. **Hardware, Communication** Electronics Hardware in UAV, Communication methods, communication antenna and their significance. **Payloads:** Payload types and their applications	
Unit -V	**09 Hrs**
Design of UAV Systems: Fixed wing UAV and Rotary wing UAV (VTOL) Task specific, activity based exercise	

Course Outcomes: At the end of this course the student will be able to :	
CO1	Appraise the evolution of UAVs and understand the current potential benefits of UAVs
CO2	Apply the principles of Aerospace Engineering in design and development of UAVs
CO3	Determine and evaluate the performance of UAV designed for various Missions and applications
CO4	Assess the performance and airworthiness of the designed UAV

Reference Books	
1	Unmanned Aircraft Systems UAV design, development and deployment, Reg Austin, 1st Edition, 2010, Wiley, ISBN 9780470058190.
2	Flight Stability and Automatic Control, Robert C. Nelson, 2nd Edition, October 1, 1997, McGraw-Hill, Inc, ISBN 978-0070462731.
3	Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy, Kimon P. Valavanis, 1st Edition,2007, Springer ISBN 9781402061141
4	Introduction to UAV Systems, Paul G Fahlstrom, Thomas J Gleason, 4th Edition, 2012, Wiley, ISBN: 978-1-119-97866-4
5	Design of Unmanned Air Vehicle Systems, Dr. Armand J. Chaput, 3rd Edition, 2001, Lockheed Martin Aeronautics Company, ISBN: 978-1-60086-843-6

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

CIE is executed by way of quizzes (Q), tests (T) and Assignment/Presentation/Project (A). 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/Presentation/Project is 10.
Total CIE is 30(Q) +60(T) +10(A) =100 Marks.

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

SEE for 100 marks is executed by means of an examination. The Question paper for the 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: VIII						
MAJOR PROJECT (Common to all Programs)						
Course Code	**:**	16BT81		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	0:0:16:0		**SEE**	**:**	**100 Marks**
Hours / Week	**:**	32		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Acquire the ability to make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
2	Acquire the skills to communicate effectively and to present ideas clearly and coherently to a specific audience in both written and oral forms.
3	Acquire collaborative skills through working in a team to achieve common goals.
4	Self-learn, reflect on their learning and take appropriate action to improve it.
5	Prepare schedules and budgets and keep track of the progress and expenditure.

Major Project Guidelines:

1. The project topic, title and synopsis have to be finalized and submitted to their respective internal guide(s) before the beginning of the 8th semester.
2. The detailed Synopsis ***(approved by the department Project Review Committee***) has to be submitted during the 1st week after the commencement of 8th semester.

Batch Formation:

- Students are free to choose their project partners from within the program or any other program;
- Each student in the team must contribute towards the successful completion of the project. The project may be carried out In-house / Industry / R & D Institution;
- ***The project work is to be carried out by a team of two to four students , in exceptional cases where a student is placed in a company and offered an internship through the competitive process or student is selected for internship at national or international level through competitive process*****,** the student can work independently.
- ***The students are allowed to do either a project for full 5 days in the industry or full 5 days in the college.***
- ***In case the project work is carried out outside Bengaluru, such students must be available during Project Evaluation process scheduled by the respective departments and they must also interact with their guide regularly through Email / Webinar / Skype etc.***

Project Topic Selection:

The topics of the project work must be in the *field of respective program areas or in line with CoE's (Centre of Excellence) identified by the college* or List of project areas as given by industry/Faculty. The projects as far as possible should have societal relevance with focus on sustainability.

Project Evaluation:

- Continuous monitoring of project work will be carried out and cumulative evaluation will be done.
- The students are required to meet their internal guides once in a week to report their progress in project work.
- **Weekly Activity Report** (WAR) has to be maintained in the form of a diary by the project batch and the same has to be discussed with the Internal Guide regularly.
- In case of ***Industry project***, during the course of project work, the internal guides will have continuous interaction with external guides and will visit the industry at least twice during the project period.
- For CIE assessment the project groups must give a final seminar with the draft copy of the project report.
- The presentation by each group will be for 20-30 minutes and every member of the team needs to justify the contributions to the project.

- The project team is required to submit Hard copies of the detailed Project Report in the prescribed format to the department.
- For CIE 50% weightage should be given to the project guide and 50% weightage to the project evaluation committee.
- Before the final evaluations the project group is required to produce a No dues certificate from Industry, Central Library and Department.

Course Outcomes of Major Project:	
1	Apply knowledge of mathematics, science and engineering to solve respective engineering domain problems.
2	Design, develop, present and document innovative/multidisciplinary modules for a complete engineering system.
3	Use modern engineering tools, software and equipment to solve problem and engage in life-long learning to follow technological developments.
4	Function effectively as an individual, or leader in diverse teams, with the understanding of professional ethics and responsibilities.

CIE Assessment:

The following are the weightings given for the various stages of the project.

1. Selection of the topic and formulation of objectives 10%
2. Design and Development of Project methodology 25%
3. Execution of Project 25%
4. Presentation, Demonstration and Results Discussion 30%
5. Report Writing & Publication 10%

SEE Assessment:

The following are the weightages given during Viva Examination.

1. Written presentation of synopsis 10%
2. Presentation/Demonstration of the project 30%
3. Methodology and Experimental Results & Discussion 30%
4. Report 10%
5. Viva Voce 20%

Calendar of Events for the Project Work:

Week	Event
Beginning of 7th Semester	Formation of group and approval by the department committee.
7th Semester	Problem selection and literature survey
Last two weeks of 7th Semester	Finalization of project and guide allotment
II Week of 8th Semester	Synopsis submission and preliminary seminar
III Week	First visit of the internal guides to industry (In case of project being carried out in industry)
III to VI Week	Design and development of project methodology
VII to IX Week	Implementation of the project
X Week	Submission of draft copy of the project report
XI and XII Week	Second visit by guide to industry for demonstration. Final seminar by Department project Committee and guide for internal assessment. Finalization of CIE.

Evaluation Scheme for CIE and SEE

Scheme of Evaluation for CIE		**Scheme of Evaluation for SEE**	
Particulars	**%Marks**	**Particulars**	**%Marks**
Project Evaluation I	10%	Project Synopsis (Initial Write up)	10%
Project Evaluation II	25%	Project Demo / Presentation	30%
Project Evaluation III	25%	Methodology and Results Discussion	30%
Project Evaluation Phase-IV (Submission of Draft Project Report for Verification**)**	30%	Project Work Report	10%
Project Evaluation Phase-V (Project Final Internal Evaluation**)**	10%	Viva-voce	20%
Total	100	Total	100

Semester: VIII						
TECHNICAL SEMINAR (Common to all Programs)						
Course Code	**:**	16BT82		**CIE**	**:**	**100 Marks**
Credits: L:T:P:S	**:**	0:0:2:0		**SEE**	**:**	**100 Marks**
Hours / Week	**:**	04		**SEE Duration**	**:**	**3.00 Hours**

Course Learning Objectives: The students will be able to	
1	Recognize recent developments in specific program and in multidisciplinary fields.
2	Summarize the recent technologies and inculcate the skills for literature survey.
3	Demonstrate good presentation skills.
4	Plan and improve the Technical Report writing skills.
5	Support Group discussion and Team work.

General Guidelines for the Seminar

1. The seminar has to be presented by individual student.
2. The topic of the seminar should be from current thrust area along with consultation with the guide.
3. The topic can be based on standard papers (like IEEE/ACM/CSI etc.) in the thrust area for the selected topic.
4. Presenting/publishing this paper in conference/ Journal will be given weightage in CIE.
5. The student needs to submit both hard & soft copy of the seminar report.
6. **As Outcome of Technical Seminar, each student has to prepare a technical paper out of seminar topic.**

Course Outcomes of Technical Seminar:	
1	Communicate effectively on complex engineering problems and demonstrate contextual knowledge to assess societal and environmental contexts.
2	Identify, formulate, review research literature, analyse and Design solutions for complex engineering problems using appropriate techniques with effective documentation.
3	Analyse, interpret and synthesize the information to provide valid conclusions with innovative ideas and ethical principles.
4	Apply the knowledge of engineering specialization to suggest solutions to complex engineering problems and recognize the need for technological changes.

Evaluation of CIE Marks:

1. Relevance of the topic 10%
2. Literature Survey 10%
3. Presentation 40%
4. Report 20%
5. Paper Publication 20%

Semester: VIII						
INNOVATION & SOCIAL SKILLS (Common to all Programs)						
Course Code	**:**	16HS83		**CIE**	**:**	**NA**
Credits: L:T:P:S	**:**	0:0:1:0		**SEE**	**:**	**NA**
Hours / Week	**:**	02		**SEE Duration**	**:**	**NA**

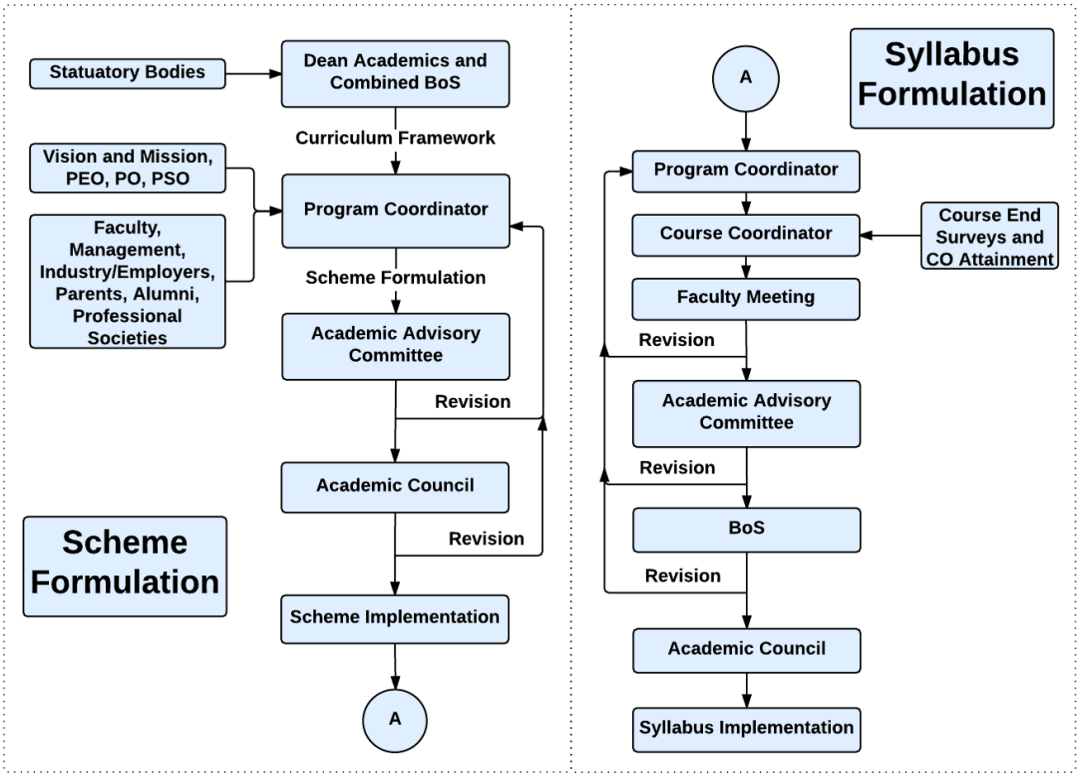
Course Learning Objectives: The students will be able to	
1	To provide a platform for the students to exhibit their organizational capabilities, team building, ethical values and extra mural abilities.
2	To encourage to carryout innovative ideas and projects.
3	Take part in societal and community building activities.
4	Make self-learning, ethics and lifelong learning a motto.

Guidelines

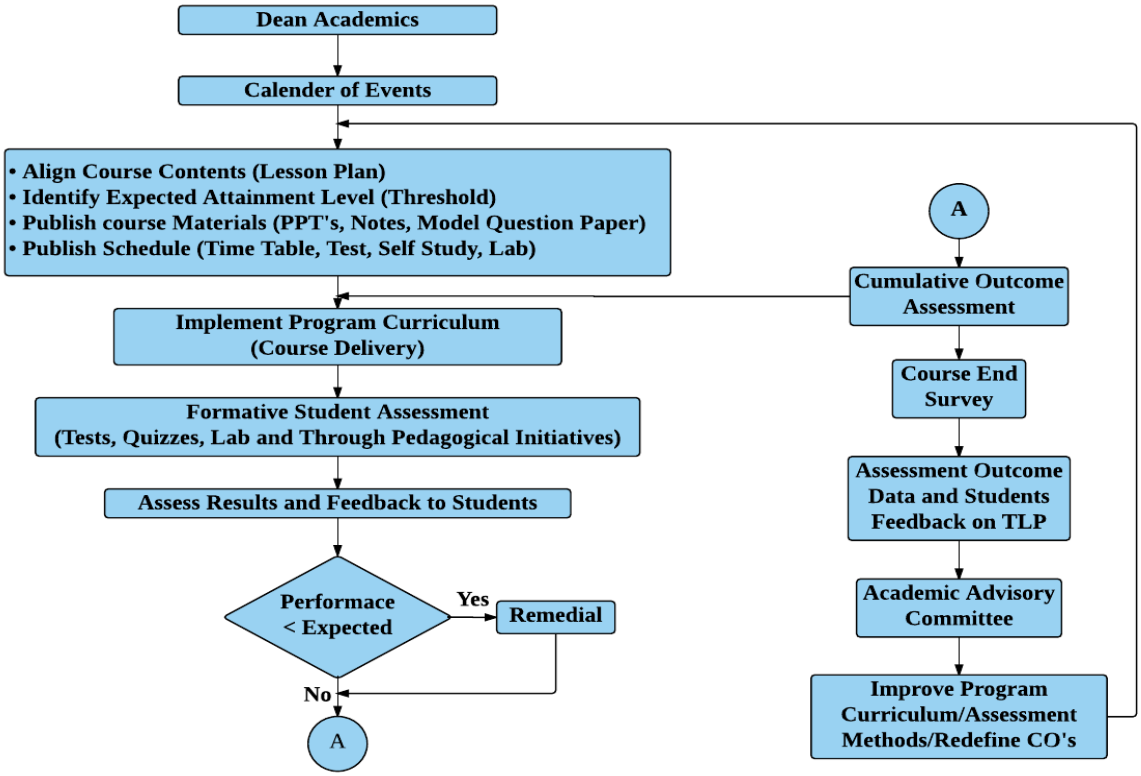
1. The HSS will be evaluated individually based on the broad parameters which include the progress made by student during 3rd& 4th year in innovative projects, Seminar, Paper Presentation, Field activity & other Co-curricular activities.
2. Students shall submit a report and documents as a proof his/her achievements.

Course Outcomes of Innovation & Social Skills:	
1	Apply the knowledge and skills for solving societal issues
2	Plan to work in team in various areas with inclusive effort and sustainability
3	Organize various events and use managerial and budgeting abilities
4	Demonstrate leadership qualities and ethics

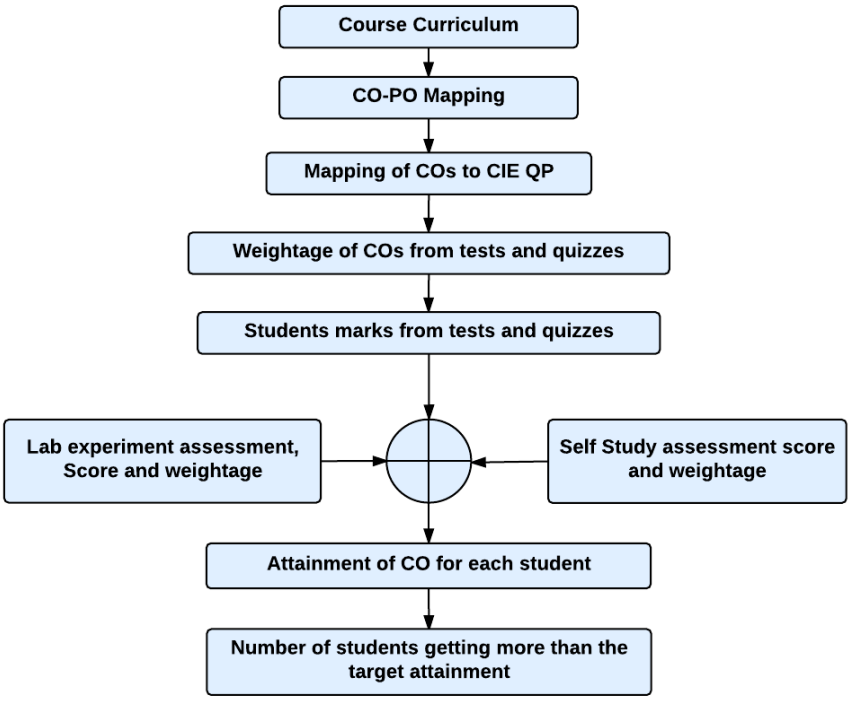
Curriculum Design Process



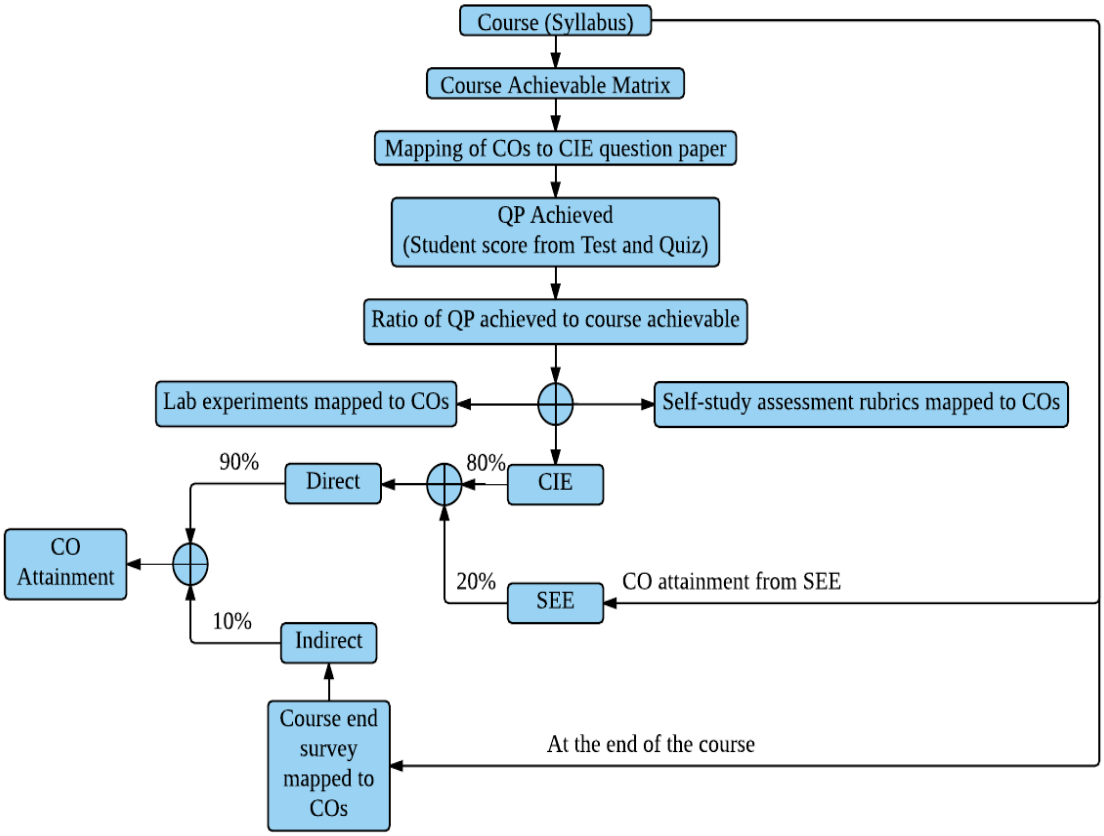
Academic Planning and Implementation



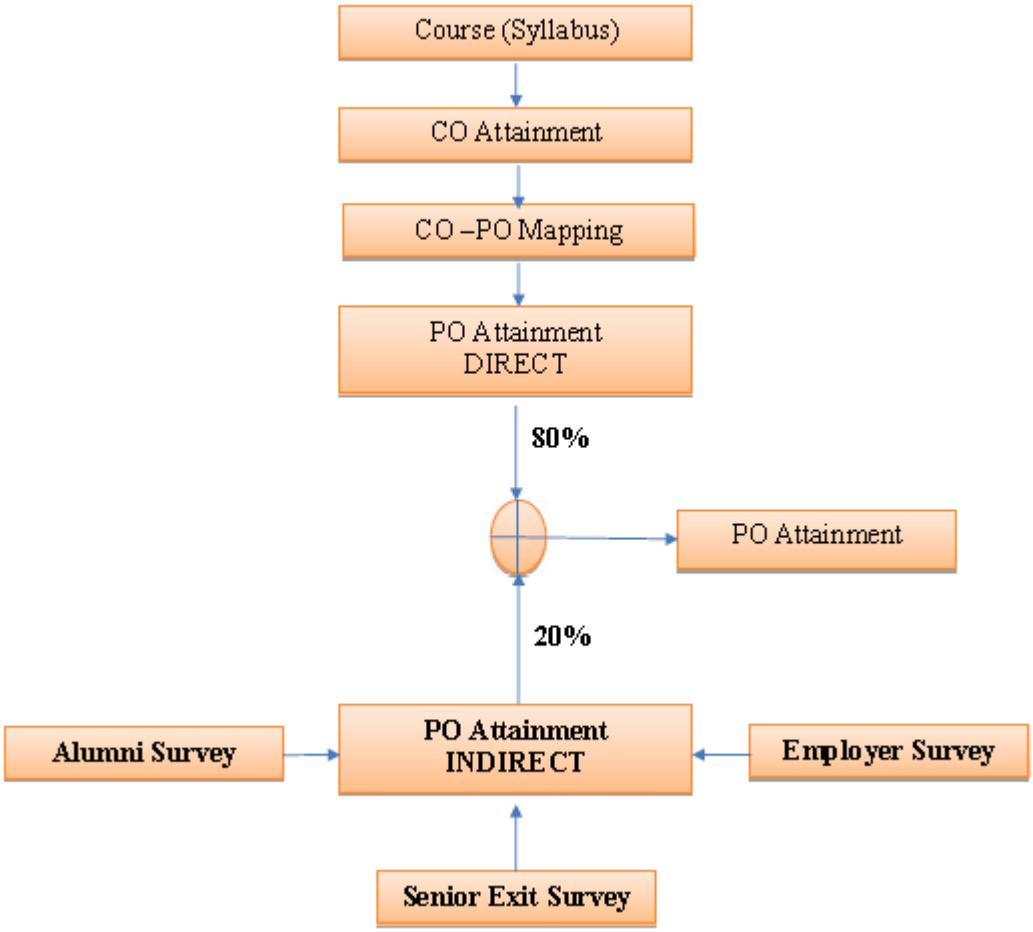
Process for Course Outcome Attainment



Final CO Attainment Process



Program Outcome Attainment Process



PROGRAM OUTCOMES (POs)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.

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

3. **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 public health and safety, and cultural, societal, and environmental considerations.

4. **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.

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

6. **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.

7. **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.

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

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

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with the 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.

11. **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.

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