SEMESTER I

Discipline: ELECTRONICS AND COMMUNICATION
Stream : EC7

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TEC100	ADVANCED ENGINEERING MATHEMATICS	DISCIPLINE CORE	3	0	0	3

Preamble: The purpose of this course is to expose students to the basic theory of linear algebra and probability.

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs. After the completion of the course the student will be able to

CO 1	To analyze distributions of random variables and make computations based on that
CO 2	evaluate average behaviour of random variables, and analyze their converging behviours
CO 3	To analyze behaviour of random processes and explain basis of vector spaces.
CO 4	To evaluate properties of linear transformations
CO 5	To evaluate if a linear tranformaion is diagonalizable and decompose it using spectral decomposition theorem.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO4	PO5	PO6	PO7
CO 1	3		3		3	3	
CO 2	3		3		3	3	
CO 3	3		3		3	3	
CO 4	3		3		3	3	
CO 5	3		3		3	3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	20
Evaluate	20
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Evaluation shall only be based on application, analysis or design-based questions.
Micro project/Course based project: 20 marks
Course based task/Seminar/Quiz: 10 marks
Test paper, 1 no.: 10 marks
The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

End Semester Examination: 60 marks

There will be two parts; Part A and Part B

- Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions.
- Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question Paper

A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY
M.TECH DEGREE EXAMINATION
SEMESTER:
Branch:
ADVANCED ENGINEERING MATHEMATICS

Time: 2.5 Hours **Marks: 60**

Part A

Answer ALL Questions. Each question carries 5 marks

1. Given that $ff(x) = \frac{k}{2^x}$ is a probability distribution of a random variable that can take on the values $x = 0,1,2,3,\text{A}\ 4$. Find k. Find the cumulative distribution function.
2. State and prove weak law of large numbers.
3. Show that $(1,3,2,-2), (4,1,-1,3), (1,1,2,0), (0,0,0,1)$ is a basis for R^4.
4. Let $T: V \rightarrow$ Wbe a linear transformation defined by $T(x,y,z) = (x+y, x-y, 2x+z)$. Find the range, null space, rank and nullity of T.
5. Describe an inner product space. If V is an inner product space, then for any vectors α, βin V prove that $\|\alpha+\beta\| \leq \|\alpha\| + \|\beta\|$.

Part B
Answer ANY FIVE Questions, one from each module
(5 x 7 marks = 35marks)

6. If the probability mass function of a RV X is given by $P(\text{X} = x) = kx^3, x = 1,2,3,4$. Find the value of k, $P\left(\frac{1}{2} < \text{X} < \frac{3}{2} / \text{X} > 1\right)$ mean and variance of X.
7. If the moment generating function of a uniform distribution for a random variable X is $\frac{1}{t}(e^{5t} - e^{4t})$.Find E(X).
8. Consider the Markov chain with three states, s={1,2,3} that has the following transition matrix $P = \begin{bmatrix} \frac{1}{2} & \frac{1}{4} & \frac{1}{4} \\ \frac{1}{3} & 0 & \frac{2}{3} \\ \frac{1}{2} & \frac{1}{2} & 0 \end{bmatrix}$ Draw the state diagram for the chain. If $P(\text{X}_1 = 1) = P(\text{X}_2 = 2) = \frac{1}{4}$, find $P(\text{X}_1 = 3, \text{X}_2 = 2, \text{X}_3 = 1)$.
9. Find the eigen values and eigen vectors of $A = \begin{matrix} 2 & 2 & 1 \\ 1 & 3 & 1 \\ 1 & 2 & 2 \end{matrix}$

10. Find the least square solution to the equation $Ax = b$, where $A = \begin{bmatrix} 1 & 2 \\ 1 & 3 \\ 0 & 0 \end{bmatrix}$ and $b = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix}$. Obtain the projection matrix P which projects b on to the column space of A.
11. Let T be the linear transformation from R^3 to R^2 defined by T(x,y,z) =(x+y, 2z-x). Let B_1, B_2 be standard ordered bases of R^3 and R^2 respectively. Compute the matrix of T relative to the pair B_1, B_2.
12. Let V be a finite-dimensional complex inner product space, and let T be any linear operator on V. Show that there is an orthonormal basis for V in which the matrix of T is upper triangular.

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Syllabus

Module 1 Axiomatic definition of probability. Independence. Bayes' theorem and applications. Random variables. Cumulative distribution function, Probability Mass Function, Probability Density function, Conditional and Joint Distributions and densities, Independence of random variables. Functions of Random Variables: Two functions of two random variables. Pdf of functions of random variables using Jacobian.

Module 2 Expectation, Fundamental theorem of expectation, Moment generating functions, Characteristic function. Conditional expectation. Covariance matrix. Uncorrelated random variables. Pdf of Jointly Gaussian random variables, Markov and Chebyshev inequalities, Chernoff bound. Central Limit theorem. Convergence of random variables. Weak law of large numbers, Strong law of large numbers.

Module 3 Random Processes. Poisson Process, Wiener Process, Markov Process, Birth-Death Markov Chains, Chapman- Kolmogorov Equations,

Groups, Rings, homomorphism of rings. Field. Vector Space. Subspaces. direct sum. Linear independence, span. Basis. Dimension. Finite dimensional vector spaces. Coordinate representation of vectors. Row spaces and column spaces of matrices.

Module 4 Linear Transformations. Four fundamental subspaces of a linear transformation. Rank and Rank-nullity theorem. Matrix representation of linear transformation. Change of basis transformation. System of linear equations. Existence and uniqueness of solutions. Linear functionals. Dual, double dual and transpose of a linear transformation.

Module 5 Eigen values, Eigen vectors, Diagonizability.

Inner product. Norm. Projection. Least-squares solution. Cauchy-Schwartz inequality. Orthonormal bases. Orthogonal complement. Spectral decomposition theorem.

Course Plan

No	Topic	No. of Lectures
	Module I	
1.1	Axiomatic definition of probability. Independence. Bayes' theorem and applications.	2
1.2	Random variables. Cumulative distribution function, Probability Mass Function,	1
1.3	Probability Density function, Conditional and Joint Distributions and densities, Independence of random variables.	2
1.4	Functions of Random Variables: Two functions of two random variables. Pdf of functions of random variables using jacobian.	2
	Module II	
2.1	Expectation, Fundamental theorem of expectation, Conditional expectation.	1
2.2	Moment generating functions, Charectristic function.	1
2.3	Covariance matrix. Uncorrelated random variables. Pdf of Jointly Guassian random variables,	2
2.4	Markov and Chebyshev inequalities, Chernoff bound. Central Limit theorem.	2
2.5	Convergence of random variables. Weak law of large numbers, Strong law of large numbers.	2
3	**Module III**	
3.1	Random Processes. Poisson Process, Wiener Process,	2
3.2	Markov Process, Birth-Death Markov Chains, Chapman-Kolmogorov Equations,	2
3.3	Groups, Rings, homomorphism of rings. Field. Vector Space. Subspaces. direct sum.	2
3.4	Linear independence, span. Basis. Dimension. Finite dimensional vector spaces.	2
3.5	Coordinate representation of vectors. Rowspaces and column spaces of matrices.	1
4	**Module IV**	
4.1	Linear Transformations. Four fundamental subspaces of a linear transformation. Rank and Rank-nullity theorem.	2
4.2	Matrix representation of linear transformation. Change of basis transformation.	1
4.3	System of linear equations. Existence and uniqueness of solutions.	2
4.4	Linear functionals. Dual, double dual and transpose of a linear transformation.	2

5	**Module V**	
5.1	Eigen values, Eigen vectors, Diagonizability.	2
5.2	Inner product. Norm. Projection. Least-squares solution. Cauchy-Schwartz inequality.	2
5.3	Orthonormal bases. Orthogonal complement. Spectral decomposition theorem.	2

Reference Books

1. Hoffman Kenneth and Kunze Ray, Linear Algebra, Prentice Hall of India.

2. Jimmie Gilbert and Linda Gilbert, Linear Algebra and Matrix Theory, Elsevier

3. Henry Stark and John W. Woods "Probability and Random Processes withApplications to Signal Processing", Pearson Education, Third edition.

4. Athanasios Papoulis and S. Unnikrishna Pillai. Probability, Random Variables and Stochastic Processes, TMH

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TEC010	LOW DIMENSIONAL DEVICE PHYSICS AND DEVICES	PROGRAM CORE 1	3	0	0	3

Preamble: To inspire the students with interest, excitement, and urge to learn the subject of nanodevices. To understand the fundamental concepts, theories and methods in nanodevices physics.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Familiarize the concepts of nano scale device Physics
CO 2	Investigate the use of quantum effect in nanodevices
CO 3	Investigate the use of nanodevices

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern

Micro project/Course based project : 20 marks Course based task/Seminar/Quiz : 10 marks Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**MOS Capacitor and MOSFET(8 hours)**	
1.1	Surface Potential: Accumulation, Depletion, and Inversion Electrostatic Potential and Charge Distribution	3
1.2	MOSFET- Threshold Voltage, body bias effect on Vt, drain current and transconductance	2
1.3	Short-Channel MOSFETs-Short Channel Effect, Velocity Saturation and High-Field Transport, Channel Length Modulation	3
2	**Quantum wells and low dimensional systems (8 hours)**	
2.1	Statistical interpretation of wave function – Normalization of wave function, Schrödinger's time dependent and time independent wave equations	3
2.2	Effect of 2-, 1- and zero-dimensional quantisation on properties of electrons and holes. Wavefunctions, density y of states.	3
2.3	One-dimensional potential: Free electron in vacuum, electron in a potential well with infinite barriers, finite barriers and propagation of an electron above the potential well	2
3	**Hetero structures (8 hours)**	
3.1	Hetero structure concepts and low dimensional systems such as quantum wells, nano wires and quantum dots. Quantum physics applied to such systems.	4
3.2	direct source drain tunneling, Quantum effects and influences in nanodevices. Resonant Tunneling, quatum tunneling	4
4	**Quantum dots and single electron devices (8 hours)**	
4.1	Quantum dots and single electron devices. Coulomb blockade, and the single electron transistor.	4

4.2	quantum dot single electron devices, Resonant Tunneling Transistors	4
5	**Quantum capacitance (8 hours)**	
5.1	Quantum capacitance, Metal-contacted MOSFETs – SWNT MOSFETs - SWNT band-to-band tunneling FETs	4
5.2	Single- Electron Memory. Single Electron Transistor (SET), Logic Circuit Applications of SETs	4
		40 hours

Reference Books

1. Fundamentals of VLSI devices, Taur and Ning., Cambridge University Pres
2. WaserRanier, Nanoelectronics and Information Technology (Advanced Electronic Materials and NovelDevices), Wiley-VCH (2003).
3. Silicon nano electronics Edited by ShunriOda, David Ferry Taylor & Francis Group, LLC
4. R. Saito and M. S. Drbselmus, Physical properties of Carbon Nanotubes, Imperial College Press.
5. Francois Leonard, The Physics of Carbon Nanotube Devices, William Andrew Inc.
6.Griffiths, Introduction to Quantum Mechanics, Prentice Hall 1995.
7. David A. B. Miller Quantum Mechanics for Scientists and Engineers, Cambridge University Press
8. John H. Davies ,'The Physics of Low-Dimensional Semiconductors An Introduction, Glasgow University, Cambridge University Pres

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221TEC011	RTL DESIGN	PROGRAM CORE 2	3	0	0	3

Preamble: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Model RTL design
CO 2	Analysis timing and functional verification
CO 3	Synthesis digital system

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examinatio
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks
Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Verlog HDL**	
1.1	Introduction to Linux-Components of UNIX system, Directory Structure, Utilities and Commands, Vi Editor. Verilog HDL - RTL Coding and Synthesis	2
1.2	Applications of Verilog HDL,Verilog HDL language concept, Verilog language basics and constructs, Abstraction levels	3
1.3	Data Types-Type Concept, Nets and registers, Non hardware equivalent variables, Arrays	3
2	**Operators**	
2.1	Verilog Operators- Logical operators, Bitwise and Reduction operators, Concatenation and conditional, Relational and arithmetic, Shift and Equality operators, Operators precedence	4
3	**modeling**	
3.1	Assignments- Type of assignments, Continuous assignments, Timing references, Procedures, Blocking and Non-Blocking assignments, Execution branching, Tasks and Functions	3
3.2	Modeling using basic Verilog gate primitives, description of and/or and buf/not type gates, rise, fall and turn-off delays, min, max, and typical delays	3
3.3	Structured procedures, initial and always, blocking and non-blocking statements, delay control, generate statement, event control, conditional statements, Multiway branching, loops, sequential and parallel blocks.	2

4	**Dataflow Modeling**	
4.1	Continuous assignments, delay specification, expressions, operators, operands, operator types.	2
4.2	Arithmetic Circuits: Adder/Subtractor Circuits, Ripple Carry Adder, Universal Ripple carry Adder, BCD Adder, MultipliersComparators, Multiplexer, Demultiplexer, Decoder, Encoder and Priority Encoder, Code Converters: Binary to Gray, Binary to BCD.	3
4.3	Latch, Flip-Flop: S-R,D,J-K,T, Flip-Flop Conversion and Excitations Counter: Asynchronous and Synchronous counter Design, Register: SISO, SIPO,PISO and PIPO, Universal Shift Register, Johnson Counter and Ring Counter.	3
5	**verification**	
5.1	Finite State Machine- Basic FSM structure, Moore Vs Mealy,Common FSM coding styles, Registered outputs	3
5.2	Verification-System Tasks, Internal variable monitoring, Compiler directives, File input and output	3
5.3	Synthesis Coding Style-Registers in Verilog, Unwanted latches, Operator synthesis, RTL Coding style	2

Reference Books

1. Fundamentals of Digital Logic with Verilog Design - Stephen Brown,Zvonkoc Vranesic, TMH, 2nd Edition.
2. Zainalabdien Navabi, Verliog Digital System Design, TMH, 2nd Edition.
3. Advanced Digital Logic Design using Verilog, State Machines & Synthesis for FPGA - Sunggu Lee, Cengage Learning, 2012.
4. Advanced Digital Design with Verilog HDL - Michel D. Ciletti, PHI, 200

SEMESTER I

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC053	MEMS AND NEMS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: This course aims to impart knowledge in design and fabrication of microsystems

Prerequisite: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the Laws of scaling, multidisciplinary nature of MEMS and various Engineering disciplines in MEMS.
CO 2	Describe the various actuation mechanisms employed in MEMS devices and the geometry of typical sensors and actuators
CO 3	Discuss the various process steps in microfabrication
CO4	Explain the various micromachining techniques and packaging techniques employed in MEMS

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			
CO 4			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**MEMS –Introduction**	
1.1	Overview of microelectronics manufacture and Microsystem technology	1
1.2	Quasi-fundamental scaling laws applicable to MEMS	2
1.3	Multi-disciplinary nature of MEMS and Microsystem	1
1.4	Survey of materials central to micro engineering	1
1.5	Application of MEMS in various industries	1
2	**Microsensors and Actuators**	
2.1	Overview of various micro sensing and actuation techniques	1
2.2	Parallel plate electrostatic sensing - analysis	2
2.3	Interdigitated finger capacitors or comb drive sensors and micro accelerometers	2
2.4	Microactuators – various types - micropump – micromotors	2
2.5	Microvalves – microgrippers	1

3	**Microfabrication**	
3.1	Single crystal silicon wafer formation – Czochralski crystal growth process	1
3.2	Photolithography	1
3.3	Ion Implantation – Diffusion – Oxidation	1
3.3	Chemical Vapour Deposition – LPCVD – PECVD – Physical Vapour Deposition – Sputtering process	3
3.4	Deposition Epitaxy – Etching process – various types – Photo resists	3
4	**Microsystem Manufacturing**	
4.1	MEMS Process – Bulk Micromachining – Surface Micromachining	2
4.2	-Sacrificial etching process – Micromachined cantilevers	2
4.3	LIGA Process – process steps , example , SLIGA	2
4.4	Microsystem packaging materials – die level – device level – System level	2
4.5	MEMS packaging techniques – die preparation - surface bonding – wire bonding - sealing	2
5	**MEMS Applications**	
5.1	Bio-MEMS - Medical pressure sensors	2
5.2	Optical MEMS - Digital Mirror Devices (DMDs),	2
5.3	Microfluidics – InkJet Print head technology,	1
5.4	MEMS inertial sensors – Gyroscopes	2
5.5	MEMS microphones and RF MEMS switches	2

Reference Books

1. Tai-Ran- Hsu, MEMS and Microsystems – Design and Manufacture, Tata McGraw-Hill Publishing Company Limited, 2010
2. Chang Liu, Foundation of MEMS, Pearson Educati
3. Mohamed Gad – el - Hak, “MEMS Handbook”, CRC Press, 2002
4. Rai - Choudhury P, “MEMS and MOEMS – Technology and Applications”, PHI Learning Private Limited, 2009
5. M. H. Bao, “Micromechanical Transducers: Pressure sensors, accelerometers and gyroscopes”, Elsevier Pvt. Ltd., NewYork, 1st Edition, 2000
6. Marc Madou, “Fundamentals of Microfabrication”, CRC Press, 1st Ed., 1997
7. Edited by D.Uttamchandani, “Handbook of MEMS for wireless and mobile applications”, Woodhead Publishing Limited, 2013
8. Stephen D. Senturia, “Microsystem Design”, Kluwer Academic Publishers, 1st Ed. 200

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC054	NANOMATERIALS AND CHARACTERIZATION	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: To impart a knowledge about the features of nanomaterials. To understand the processing and characterization techniques of nanomaterials.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Demonstrate the synthesis, characterization, properties and applications of nanomaterials
CO 2	Understand the manufacturing and testing of nanomaterials
CO 3	Summarize the various characterization studies pertaining to nanomaterials

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2	1		3			
CO 3	1		3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Nanoclusters (8 hours)**	
1.1	Nanoclusters, nanoclusters on polymers, Inorganic nanotubes and nanowires: properties and applications, Metallic nanorods, Nanostructured ordered/disordered materials, organic nano crystals, nanofibers: biomedical applications	4
1.2	Synthesis of metal colloids, Synthesis of nanoclusters: Laser induced evaporation, Laser methods, Polymer nanoparticle synthesis, Synthesis of nanotubes and nanowires:	2
1.3	Synthesis of nanorods. Template based synthesis, Solvo thermal synthesis, Synthesis of nanocrystalline materials: synthesis of silver nanocrystals and semiconductor nanaoparticles,	2
2	**Nano technology (8 hours)**	
2.1	Deposition techniques of Nanomaterials: Thermal PVD, Molecular Beam epitaxy (MBE), Pulsed Laser deposition (PLD), Plasma /Arc Physical Vapour deposition	2
2.2	Physics of Sputtering, Ion Beam Deposition (IBD), CVD, PECVD, Laser induced CVD, Activated Reactive evaporation, Sol-Gel Process, Electrophoretic Deposition	2
2.3	ALD Etching of Nanostructures, Progressive etching techniques, Lithographic procedures: Optical lithography- contact and non-contact exposure, XRL, Scanning probe based lithography: AFM lithography, Laser lithography, Ion beam lithography, Nanoimprint lithography (NIL)	4
3	Characterization tools of Nanomaterials	

3.1	Scanning Probe Microscopy: Scanning Tunneling Microscope(STM), Atomic force microscopy(AFM)	4
3.2	Electron spectroscopy: Scanning Electron Microscopy, Transmission Electron Microscopy(TEM), Optical Microscopy: Confocal Microscopy, SNOM	4
4	**Characterization (8 hours)**	
4.1	Characterization of nanomaterials, structure of nanomaterials, X-Ray Diffraction (XRD): Powder method and Rotating crystal method, Xray absorption method, Infrared and Raman Spectroscopy	4
4.2	X-Ray Photoelectron spectroscopy (XPS), Ultraviolet Photoelectron Spectroscopy(UPS), NMR and EPR spectroscopy, Secondary Ion Mass Spectrometry (SIMS), Auger electron spectroscopy(AES)	4
5	**Hybrid Nanocomposite Materials (8 hours)**	
5.1	Application for corrosion protection	2
5.2	Nanoparticulate systems with organic matrices – Applications	3
5.3	Nanocomposites – Optical, Structural applications	3
		40 hours

Reference Books

1. W. R. Fahrner, Nanotechnology and Nanoelectronics, Springer International Edition, 2004.
2. V.S. Muralidharan, A.Subramania, Nanoscience &Technology, Ane Books Pvt Ltd., 2009
3. T. Pradeep, NANO: The Essentials,Tata McGraw Hill Education Private Limited, 2007
4. Hans H. Gatzen, Volker Saile, Micro & Nano Fabrication, Springer-Verlag, Heidelberg, 2015
5. D. K. Schroder, Semiconductor Material and Device Characterization, Wiley-Interscience, New York, 1990.
6. Sami. Fransilla, Introduction to Micro fabrication, John Wiley & Sons Limited,2004
7. Charles P. Poole Jr., Frank J. Owens, Introduction to Nanotechnology, John Wiley& Sons Pvt. Ltd., 2007

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC055	RF MEMS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: Study the central concepts of Molecular biology. Decipher the knowledge on nanoparticle inaction with cell membrane. Know how to probe the nanoparticles inside the cell with developed techniques

Course Outcomes: After the completion of the course the student will be able to

CO 1	To explain the fundamental principles of bionanotechnology
CO 2	To introduce the concepts of bionanomachines
CO 3	To illustrate various self-assembled nano structures
CO 4	To reveal various applications of bionanotechnology
CO 5	To understand the impact of bionanotechnology in a biomedical context

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1		1	2		
CO 2	1		1	2		
CO 3	1		1	2		
CO 4	1		1	2		
CO 5	1		1	2		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction to MEMS (8 hours)**	
1.1	Review of basic mechanics and elements of strength of materials Stress and strain Stresses of beams Deflection of beams and spring constants	3
1.2	Mechanical modeling of MEMS switches Static analysis Dynamic analysis	2
1.3	Review of Electromagnetic analysis and modeling Transmission lines & high-frequency effects Scattering parameters Review of numerical techniques	3
2	**RF switches (8 hours)**	
2.1	Electromagnetic modeling of RF MEMS switches distributed models lumped-element models-	4
2.2	Review of MEMS fabrication Bulk micromachining surface micromachining	4
3	**RF components (8 hours)**	
3.1	RF MEMS inductors	3
3.2	FR MEMS varactors	2
3.3	Switching networks series and shunt configurations capacitive vs. ohmic contact absorptive switches	2
4	**RF MEMS components case studies: (8 hours)**	

4.1	Micro-switches	3
4.2	Planar, on-chip components, Transmission lines and other components	5
5	**Rf systems (8 hours)**	
5.1	RF MEMS Phase shifters	3
5.2	RF MEMS filters	2
5.3	RF MEMS antennas	3
		40 hours

Reference Books

1. RF MEMS - Theory, Design and Technology , 1st Edition , Gabriel M. Rebeiz , John Wiley & Sons , 2003
2. Schaum's Outline of Statics and Strength of Materials , 1st Edition , John J. Jackson, Harold G. Wirtz , McGraw-Hill , 1983
3. Microsensors MEMS and Smart Devices , 1st Edition , Julian W. Gardner, Vijay K. Varadan, Osama O. Awadelkarim , John Wiley & Sons , 2001
4. Microsystem Design , 1st Edition , Stephen D. Senturia , Kluwer Academic Publishers , 2000
5. RF MEMS & Their Applications , 1st Edition , Vijay K. Varadan, K.J. Vinoy, K.A. Jose , Johy Wiley & Sons , 2003

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC056	MICROSENSORS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: overview of microsensor technologies, including the basic principles of measurement systems and the scaling effects arising from system miniaturization

Course Outcomes: After the completion of the course the student will be able to

CO 1	Appreciate the scaling effects arising from miniaturizing systems.
CO 2	Construct an interface circuit and characterize the performance of a microsensor.
CO 3	Use industry-standard software to simulate sensor interfacing circuits.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2	3					
CO 3						3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Microfabrication (8 hours)**	
1.1	Microfabrication techniques for silicon, non-silicon and other emerging fabrication processes	4
1.2	bulk/surface micromachining, microlensing and micro actuation mechanisms	4
2	**Microsensors (8 hours)**	
2.1	Magnetic Sensors	2
2.2	Pressure Sensors	2
2.3	Resonant sensors, MEMS resonant sensors	4
3	**Nanoparticle based delivery through various routes (8 hours)**	
3.1	Inertial sensors, automotive applications	2
3.2	Microfluidics, flow sensors, flow control	3
3.3	Biotechnology and medical microsystems	3
4	**Micro sensors II (8 hours)**	
4.1	Physical sensors	3
4.2	Intelligent sensors	2
4.3	Thermal sensors	3
5	**Microsensor signal conditioning circuits (8 hours)**	
5.1	Charge amplifiers,	3
5.2	Interfacing with sensors and actuators (Bridge circuits, Amplifiers, Closed-loop control, Filtering and signal conditioning	5
		40 hours

Reference Books

1. Brignell JE and White NM (1996). Intelligent sensor systems revised edition. IOP Publishing.
2. Bentley JP (2005). Principles of measurement systems. Longman Scientific and Technical.
3. Maluf N and Williams K (2004). An Introduction to Microelectromechanical Systems Engineering. https://ebookcentral.proquest.com/lib/soton-ebooks/detail.action?docID=227665.
4. Beeby SP, Ensell GJ, Kraft M and White NM (2004). MEMS Mechanical Sensors. Artech House.
5. Kaajakari V (2009). Practical MEMS: Design of microsystems, accelerometers, gyroscopes, RF MEMS, optical MEMS, and microfluidic systems. Small Gear Publishing.
6. Gaura E and Newman R (2006). Smart MEMS and Sensor Systems, Imperial College Press. https://ebookcentral.proquest.com/lib/soton-ebooks/detail.action?docID=1681718.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC118	OPTIMIZATION TECHNIQUE	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: One dimensional- necessary and sufficient conditions, Search methods, Gradient methods, Multivariable- Search methods, Gradient based methods, Linear programming, Theory of Simplex method, Two phase method, Non Linear Programming, search method, Meta-heuristic optimization Techniques, Differential Evolution, Harmony Search Algorithm, Artificial Bee Colony Algorithm**.**

Course Outcomes: After the completion of the course the student will be able to

CO 1	To familiarize the students with the need of optimization in engineering
CO 2	To introduce the students with the different types of optimization algorithms
CO 3	To enable the students to select the suitable optimization technique for the particular problem

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred): 15 marks Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	Hrs
1	**Optimization Algorithms (8 hours)**	
1.1	One Dimensional Optimization Algorithms– necessary and sufficient conditions	3
1.2	Search methods- Fibonacci search, golden section search Gradient methods- Newton- Raphson method, cubic search	5
2	**Optimization Algorithms II (8 hours)**	
2.1	Multivariable Optimization Algorithms- necessary and sufficient conditions, Search methods- Evolutionary method, Hook-Jeevs pattern search	4
2.2	Gradient based methods- steepest descent, Newton's method, conjugate gradient method.	4
3	**Linear and nonlinear Programming (8 hours)**	
3.1	Systems of linear equations & inequalities, Formulation of linear programming problems, Theory of Simplex method, Simplex Algorithm, Two phase method- Duality, Dual Simplex method	4
3.2	Kuhn-Tucker conditions- Necessary and Sufficiency theorem – transformation method – penalty function method search method –random search method, linearized search - Frank-Wolf method.	4
4	**optimization Techniques (8 hours)**	
4.1	Meta-heuristic optimization Techniques- Principle and implementation steps for examples related to signal processing, communication, control system and process and device modeling. case studies.	8

5	**Algorithms (8 hours)**	
5.1	Differential Evolution (DE), Harmony Search Algorithm (HSA), Artificial, Bee Colony Algorithm (ABC).application case studies.	8
		40 hours

Reference Books

1. Kalyanmoy Deb, "Optimization for Engineering Design, Algorithms and Examples. -PHI, ISBN -978-81-203-0943-2", IIT Kanpur.
2. S.S Rao ,"Optimization theory and Applications", New Age International

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC058	BIO-MEMS AND BIO SENSORS	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: The purpose of this course is to evaluate the various aspects of nanomaterials used for nano remediation, nanomaterial safety for various applications, its impact on environment and also to determine the real or perceived risks of using nanomaterials.

Course Outcomes: After the completion of the course the student will be able to

CO 1	To aware the students about the fundamental principles of microsystems
CO 2	To provide the concepts essential for the designing of lab-on -a chip and Point -of-care devices for biomedical application.
CO 3	Design simple microfluidic device

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Sensing Technologies (8 hours)**	
1.1	Electrochemistry basics, Nersnt Equation, Referencing of electrodes, Nicolskii Eisenmann method of evaluation of electrode potential, Debye Huckel Theory, Zeta Potential on electrode surfaces, Cyclic Voltametry, Ion selectivity analysis	6
1.2	Impedometric sensing, Optical Sensing (Fluorescence, phosphorescence, FRET, Visible range and IR sensing), Mechanical sensing etc.	2
2	**microfluidics (8 hours)**	
2.1	Basic principles in microfluidics, design principles for microfluidic devices, device fabrication procedures, (such as optical lithography and soft lithography	3
2.2	components of microfluidic devices utility of microfluidic devices in various biological, chemical, and optical sensing applications	3
2.3	optofluidics, Inertial-microfluidics, droplet-microfluidics, microfluidics based-flow cytometry.	2
3	**Characteristics of microflow (8 hours)**	
3.1	Characteristics of microflow, Flow actuation: electrokinetic flow, pressure driven flow, surface energy driven flow centrifugal microflow.	5
3.2	Concept of bio-microfluidics, Design and function of H-filter and T-sensor, Peclet number.	3
4	**Microelectronic-fabrication processes (8 hours)**	

4.1	Review of basic silicon processes , Introduction to micro electronic fabrication, Optical lithography, photo-resists, Non optical lithography techniques,	4
4.2	LIGA processes, Design Considerations, Vacuum science and plasmas, Etching techniques, Physical vapor deposition, Chemical vapor deposition.	4
4.3	Polymer materials for micro-systems, Polymeric micromachining technology like soft lithography, Bulk and surface micromachining, replication technologies, laser machining, micro-stereo lithography, micro-molding, Assembly and packaging of micro-systems, Biocompatibility of materials and processes.	4
5	**Lab on a chip (8 hours)**	
5.1	Concept of 'Lab on a chip', Components of lab-on-a chip: micropump, microvalve, micromixer, microsensor, lenses, heaters, sensors, etc.	3
5.2	Field flow fractionation (FFF), Microfluidic PCR, Microfluidic cell sorter, Lab-on-chip array for biomolecules, Minimally invasive biomedical microdevices, and Microfluidics Future prospects.	5
		40 hours

Reference Books

1. E. Meng, Biomedical Microsystems, CRC Press, 2010 , 1st Ed. ISBN-13: 978-1420051223,
2. P. Tabeling, S .Chen, Introduction to microfluidics, Oxford University Press, 2010 , 1st Ed. ISBN-13: 978-0199588169
3. Suman Chakraborty, Microfluidics and Microfabrication, Springer, 2014 , ISBN-10:9781489984609
4. Francesco Piraino and Šeila Selimovic, Diagnostic Devices with Microfluidics, CRC Press 1 edition, 2017 , ISBN-10: 1498772935

SEMESTER I

PROGRAM ELECTIVE II

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC059	ADVANCED ANALOG CIRCUIT DESIGN	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: To understand the fundamental concepts of Data converters and PLL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Ability to analyze and design data converters in CMOS technology.
CO 2	Ability to formulate a design procedure and target specifications for circuit and system applications
CO 3	Ability to analyze and design PLL circuits in CMOS technology

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3		3	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred): 15 marks Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction to data converters (8 hours)**	
1.1	Fundamentals and Characterization of Data Converters	4
1.2	Switched-Capacitor Circuits	4
2	**DAC (8 hours)**	
2.1	Nyquist-Rate D/A Converters	2
2.2	CMOS Comparators	3
2.3	Oversampling D/A Converters	3
3	**ADC (8 hours)**	
3.1	Nyquist-Rate A/D Converters	4
3.2	Oversampling A/D Converters	4
4	**Advanced circuit design (8 hours)**	
4.1	Low-Power and Low-Voltage Circuit Design	3
4.2	State-of-the-Art in Data-Converter Design	3
4.3	Recent Advances and Emerging Techniques in Data Converter Design	2
5	**PLL (8 hours)**	
5.1	Phase detectors, Loop filters, VCOs; Charge-pump PLLs	4
5.2	Phase noise, VCO implementations, Divider implementations, Noise in PLLs.	2
5.3	Frequency Synthesis, Fractional-N PLLs, ΣΔ modulators, PLLs for Clock and Data recovery, PLLs for direct modulation transmitters	3
		40 hours

Reference Books

1. F. Maloberti, Data Converters, Springer (2005)
2. A. Ali, High Speed Data Converters (Materials, Circuits and Devices)
3. David A. Johns, Kenneth W. Martin, Analog Integrated Circuit Design, 2nd Edition, 2012
4. A. V. Oppenheim and A. S. Willsky, Signals and Systems, 1983 or recent edition.
5. X. Gao, E. A. M. Klumperink, M. Bohsali and B. Nauta, "A Low Noise Sub-Sampling PLL in Which Divider Noise is Eliminated and PD/CP Noise is Not Multiplied by N ^{2}," in IEEE J. Solid State Circuits, vol. 44, no. 12, pp. 3253-3263, Dec. 2009.
6. X. Gao, E. A. M. Klumperink, G. Socci, M. Bohsali and B. Nauta, "Spur Reduction Techniques for Phase-Locked Loops Exploiting A Sub-Sampling Phase Detector," in IEEE J. Solid State Circuits, vol. 45, no. 9, pp. 1809-1821, Sep. 2010.
7. L. Kong and B. Razavi, "A 2.4GHz 4mW inductorless RF synthesizer," in ISSCC Dig. Tech. Papers, Feb. 2015, pp. 450-451.
8. Z. Huang, B. Jiang, L. Li and H. C. Luong, "A 4.2us-settling-time 3rd-order 2.1GHz phase-noise-rejection PLL using a cascaded time-amplified clock-skew sub-sampling DLL," in ISSCC Dig. Tech. Papers, Feb. 2016, pp. 40-41.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC060	LOW POWER CIRCUIT DESIGN	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: Introduction to the concepts of low power CMOS design

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyze low power CMOS systems
CO 2	Design low power CMOS systems
CO 3	Optimize low power CMOS systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred): 15 marks Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Basics of CMOS circuits, (8 hours)**	
1.1	Basics of CMOS circuits, Sources of Power dissipation Dynamic and Static Power Dissipation	2
1.2	Power estimation at different design levels ,Probabilistic power analysis Approaches for low power design-Supply Voltage Scaling Approaches Switched Capacitance Minimization Approaches Leakage Power minimization Approaches	5
2	**Basic low power design (8 hours)**	
2.1	Low power design at different design levels – Circuit level, logic level, system and architecture level,	4
2.2	Low power memory circuits Power optimization for combinational and sequential circuits.	4
3	**Low power design (8 hours)**	
3.1	Software design for low power, Co-design. Circuit techniques for reducing power in adders and multipliers, Case studies.	8

4	**Layout design (8 hours)**	
4.1	Low power interconnect and layout design, Powe dissipation in clock distribution, single driver Vs distributed buffers, Zero skew Vs tolerable skew	8
5	**Adiabatic circuits (8 hours)**	
5.1	Chip and package co-design of clock network Advanced techniques Adiabatic Switching Circuits Battery-aware Synthesis Variation tolerant design, CAD tools for low power synthesis.	8

Reference Books

1. Sung Mo Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits, Tata Mcgraw Hill.
2. Neil H. E. Weste and K. Eshraghian, Principles of CMOS VLSI Design, 2nd Edition, Addison Wesley (Indian reprint).
3. A. Bellamour, and M. I. Elmasri, Low Power VLSI CMOS Circuit Design, Kluwer Academic Press, 1995.
4. Anantha P. Chandrakasan and Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer Academic Publishers, 1995.
5. Gary Yeap "Practical Low Power Digital VLSI Design", 1997.
6. Kaushik Roy and Sharat C. Prasad, Low-Power CMOS VLSI Design, Wiley-Interscience, 2000.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC061	RF IC AND SYSTEM DESIGN	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: Introduction to RF system design

Course Outcomes: After the completion of the course the student will be able to

CO 1	Design and analyze RF circuits,
CO 2	Simulation with CAD tools
CO 3	Exposure to industry standard tools for RF circuit design

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred): 15 marks Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Transmission line Theory (8 hours)**	
1.1	Review of Transmission line Theory, terminated transmission lines, smith chart, impedance matching	4
1.2	Microstrip and Coplanar waveguide implementations, microwave network analysis, ABCD parameters, S parameters, X parameters.	4
2	**RF components (8 hours)**	
2.1	Behavior of passive components and networks, resonant structures using distributed transmission lines, power dividers, couplers and filters; CRLH transmission line based components	4
2.2	Introduction to planar microwave antennas, definitions and basic principles, Smart antennas; Link plan and propagation studies	4
3	**RF Amplifiers (8 hours)**	
3.1	Basics of high frequency amplifier design, biasing techniques, simultaneous tuning of 2 port circuits	4

3.2	noise and distortion, linearity, noise and large signal performance, Power amplifier design,	4
4	**RF circuits 1 (8 hours)**	
4.1	Low Noise Amplifiers- design, analysis	4
4.2	Mixers - design, analysis	4
5	**RF circuits 2 (8 hours)**	
5.1	Voltage-Controlled-Oscillators - design, analysis	4
5.2	Phase-Locked-Loop - design, analysis	4
		40 hours

Reference Books

1. DM Pozar Microwave and RF Wireless Systems
2. TH Lee The design of CMOS Radio Frequency Integrated Circuits
3. R.E. Collin Foundations for Microwave Engineering John Wiley
4. C.A. Balanis, Antenna Theory: Analysis and Design, John Wiley
5. K Chang Radio Frequency Circuit design

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC039	VLSI SIGNAL PROCESSING	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: To provide sound foundation of digital signal processing (DSP) architectures and designing efficient VLSI architectures for DSP systems..

Course Outcomes: After the completion of the course the student will be able to

CO 1	Design CMOS circuits for signal processing
CO 2	Analysis CMOS circuits for signal processing in frequency domain
CO 3	Simulate CMOS circuits for signal processing

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred): 15 marks Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Transformations for retiming (8 hours)**	
1.1	Folding and unfolding DSP programs. Bit level arithmetic structures- parallel multipliers, interleaved floor plan and bit plan based digital filters. Bit serial multipliers	5
1.2	Bit serial filter design and implementation, Canonic signed digit arithmetic, Distributed arithmetic	3
2	**Redundant arithmetic (8 hours)**	
2.1	redundant number representations, carry free radix 2 addition and subtraction, Hybrid radix 4 addition. Radix hybrid redundant multiplication architectures	5
2.2	Data format conversion. Redundant to nonredundant converter. Numerical strength reduction.	3
3	**Synchronous pipelining (8 hours)**	
3.1	clocking styles, clock skew and clock distribution in bit level pipelined VLSI designs. Wave pipelining, constraint space diagram and degree of wave pipelining.	5

3.2	Implementation of wave-pipelined systems. Asynchronous pipelining.	3
4	**Scaling versus power consumption (8 hours)**	
4.1	Power analysis, power reduction techniques, power estimation techniques.	3
4.2	Low power IIR filter design .Low power CMOS lattice IIR filter	5
5	**Filters (8 hours)**	
5.1	Parallel FIR filters. Pipelining of FIR filters. Parallel processing. Pipelining and parallel processing for low power FIR filters. Pipeline interleaving in digital filters.	4
5.2	Pipelining and parallel processing for IIR filters. Low power IIR filter design using pipelining and parallel processing, Pipelined adaptive digital filters.	4
		40 hours

Reference Books

1. Keshab K. Parhi, VLSI Digital Signal Processing Systems - Design and
2. Implementation, Wiely, 2010
3. K. J. Ray Liu, High-Performance VLSI Signal Processing – Innovative Architectures
4. and Algorithms, Systems Design and Applications, IEEE Press, 1998
5. Thorsten Grotker, et al, System Design with SystemC, Kluwer Academic Publishers,2002
6. U Meyer Baese Digital Signal Processing with Field Programmable Gate Arrays Springer 2009
7. Roger Woods …[et al]. FPGA-based Implementation of Signal Processing Systems / (2008)
8. Jose E. France, Yannis Tsividis,"Design of Analog-Digital VLSI Circuits for Telecommunication and Signal Processing", Prentice Hall, 1994

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC057	MEMS	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: To understand the advance MEMS technology

Course Outcomes: After the completion of the course the student will be able to

CO 1	Apply suitable strategies for micro optical systems
CO 2	Apply suitable strategies for synthesizing magnetic MEMS
CO 3	Apply suitable strategies micro fluid systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred): 15 marks
Course basedtask/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**MICRO-OPTO-ELECTRO MECHANICAL SYSTEMS (8 hours)**	
1.1	Principle of MOEMS technology, properties of light, light modulators	4
1.2	Beam splitter, micro lens, micro mirrors	2
1.3	Digital micro mirror device (DMD), case study of DMD	2
2	**MOEMS(8 hours)**	
2.1	Light detectors, grating light valve (GLV).	4
2.2	optical switch, wave guide and tuning, shear stress measurement	4
3	**MAGNETIC SENSORS AND ACTUATORS (8 hours)**	
3.1	Magnetic materials for MEMS and properties, magnetic sensing and detection, magneto resistive sensor, more on hall effect	2
3.2	Magneto diodes, magneto transistor, MEMS magnetic sensor, pressure sensor utilizing MOKE, mag MEMS actuators, by directional micro actuator.	3
3.3	feedback circuit integrated magnetic actuator, large force reluctance actuator, magnetic probe based storage device.	3
4	**MICRO FLUIDIC SYSTEMS (8 hours)**	

4.1	Fluid actuation methods, dielectro phoresis (DEP), electro wetting, electro thermal flow, thermo capillary effect, electro osmosis flow, opto electro wetting (OEW)	4
4.2	tuning using micro fluidics, typical micro fluidic channel, microfluid dispenser, micro needle, molecular gate, micro pumps.	4
5	**CHEMICAL AND BIO MEDICAL MICRO SYSTEMS (8 hours)**	
5.1	Sensing mechanism & principle, membrane-transducer materials, chem.-lab-on-a-chip (CLOC) chemoresistors	4
5.2	Chemocapacitors, chemotransistors, electronic nose (E-nose), mass sensitive chemosensors, fluroscence detection, calorimetric spectroscopy	4
		40 hours

Reference Books

1. MEMS and NEMS, Sergey Edwrd Lyshevski, CRC Press, Indian Edition.
2. MEMS and Micro Systems: Design and Manufacture, Tai-Ran Hsu, TMH Publishers.
3. Introductory MEMS, Thomas M Adams, Richard A Layton, Springer International Publishers.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221EEC062	EMBEDDED C AND LINUX	PROGRAM ELECTIVE 2	3	0	0	3

Preamble: To introduce embedded operating systems and programming

Course Outcomes: After the completion of the course the student will be able to

CO 1	Model embedded system
CO 2	Design linux based embedded systems
CO 3	Write embedded programming

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Linux (8 hours)**	
1.1	Linux shell scripting and System Programming concepts.	4
1.2	Basics of an Embedded Linux toolchain , cross-compiler design .	4
2	**Embedded Linux (8 hours)**	
2.1	basics of File IO for Linux, Process Management, process forking, and Linux daemons.	4
2.2	Linux kernel and root filesystem, boot and run on QEMU.	4
3	**Threads (8 hours)**	
3.1	Threading and Multi Thread Synchronization in Linux system programming using POSIX	4
3.2	signal handling and time management in Linux System Programming, components of Embedded Linux debugging	4
4	**Embedded C(8 hours)**	
4.1	Operators, Constructs, Switch, Nested Loops and infinite loops	2
4.2	Functions, Passing arguments to the function, Macro, Array , Passing Array to Function	2
4.3	Declaring and Initializing strings, string functions, Character Lib Functions, able of String Library Functions	2
4.4	Pointers, Advanced Pointers	2
5	**ARMS (8 hours)**	
5.1	Features of ARM architecture, STATES & MODES, ARM Programmers model, Introduction to the LPC2129 kit and schematics, µvision-4 Keil IDE,	2

5.2	Application of Timer, Programming Timer block, Interrupt, Vectored IRQ and Non-Vectored IRQ, UART	3

5.3	SPI Protocol, Registers used in SPI, Exceptions in SPI, I2C Protocol, Registers used in I2C Protocol, Handling of Multi-master using arbitration technique, Interfacing of EEPROM using I2C Protocol.	3
		40 hours

Reference Books

1. Nanomaterials- Synthesis, Properties and Applications, Edited by A.S. Edelstein and R.C. Cammarata, Institute of Physics Publishing, London, 1998 (paperback edition)
2. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al
3. Processing & properties of structural nanomaterials - Leon L. Shaw, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.
4. Michael Niaounakis, "Biopolymers: Applications and Trends", 1st Edition, Elsevier, 2015.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
221LEC005	SYSTEM DESIGN WITH FPGA	LABORATORY 1	0	0	2	1

Preamble: To introduce system design with FPGA

Course Outcomes: After the completion of the course the student will be able to

CO 1	Simulate digital systems
CO 2	Synthesis digital systems
CO 3	FPGA implementations

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1		2				3
CO 2		2				3
CO 3		2				3

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	100		

Continuous Internal Evaluation: 100 marks

Continues evaluation

Syllabus and Course Plan

1. Experiments with RTL Design,
2. Experiments on FSM Design and Verification,
3. Basic Verification using Simulation
4. Experiments on Coverage Analysis in Verification
5. Logic Design Synthesis
6. Gate Level Simulation
7. DFT Insertion and Test Pattern Generation
8. Power Analysis using Synopsys Power Compiler
9. Basic Static Timing Analysis using Primetime
10. Basic Placement and Routing using Cadence SoC Encounter

SEMESTER II

Discipline : Electronics and Communication Engineering
Stream : EC7

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TEC100	FOUNDATIONS OF DATA SCIENCE	DISCIPLINE CORE 2	3	0	0	3

Preamble: Nil

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the basics of machine learning and different types.
CO 2	Differentiate regression and classification, Understand the basics of unsupervised learning and non-metric methods
CO 3	Apply statistical methods in non-linear classification and neural networks
CO 4	Understand the basics of deep learning networks, convolutional neural networks

Mapping of course outcomes with program outcomes (1-3)

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2	1	2	3	3	2	2
CO 2	2	2	2	2	2	2	2
CO 3	2	1	2	3	3	1	1
CO 4	2	1	2	3	3	1	1

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation : 40 marks
Micro project/Course based project : 20 marks
Course based task/Seminar/Quiz : 10 marks
Test paper, 1 no. : 10 marks

End Semester Examination Pattern:
Total : 60 marks
Part A: Answer all – 5 questions x 5 marks : 25 marks
Part B: Answer 5 of 7: 5 questions x 7 marks : 35 marks

The end semester examination will be conducted by the University . There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Model Question paper

Total: 60 marks

Part A (Answer all) 25 marks

1. Discuss different types of machine learning with examples. (5)
2. Differentiate regression and classification with examples (5)
3. How SVM is used for multiclass problem? (5)
4. Explain clustering with examples. (5)
5. Discuss different activation functions used in deep neural networks (5)

Part B (Answer any 5) 35 marks

6. Explain the terms features, training set, target vector, test set, and curse of dimensionality in machine learning. (7)
7. Show that the Bayesian classifier is optimal with respect to minimizing the classification error probability. (7)
8. Give a step by step description of the perceptron algorithm in classification. (7)
9. Obtain the cost function for optimization in SVM for separable classes. (7)
10. Describe convolutional neural networks with detailed description of each layers (7)
11. Obtain the decision surface for an equi-probable two class system, where the probability density functions of n-dimensional feature vectors in both classes are normally distributed. (7)
12. Explain the principle of back propagation neural networks with neat architecture diagram (7)

Syllabus and Course Plan (total hours: 37)

No	Topic	hours
1	**8 hours**	
1.1	Basics of machine learning, supervised and unsupervised learning,examples,	2
1.2	features, feature vector, training set, target vector, test set	1
1.3	over-fitting, curse of dimensionality.	1
1.4	Evaluation and model selection: ROC curves, evaluation measures,	2
1.5	validation set, bias-variance trade-off.	1
1.6	confusion matrix, recall, precision, accuracy.	1
2	**7 hours**	
2.1	Regression: linear regression, error functions in regression	1
2.2	multivariate regression, regression applications, bias and variance.	1
2.3	Classification : Bayes' decision theory,	2
2.4	discriminant functions and decision surfaces,	1
2.5	Bayesian classification for normal distributions, classification applications.	2
3	**7 hours**	
3.1	Linear discriminant based algorithm: perceptron, perceptron algorithm,	1
3.2	support vector machines.	2
3.3	Nonlinear classifiers, the XOR problem,	2
3.4	multilayer perceptrons,	1
3.5	backpropagation algorithm.	1
4	**8 hours**	
4.1	Unsupervised learning:	1
4.2	Clustering, examples, criterion functions for clustering,	2
4.3	proximity measures, algorithms for clustering.	1
4.4	Ensemble methods: boosting, bagging.	2
4.5	Basics of decision trees, random forest, examples.	2
5	**7 hours**	
5.1	Introduction to deep learning networks,	1
5.2	deep feedforward networks,	2
5.3	basics of convolutional neural networks (CNN)	2
5.4	CNN basic structure, Hyper-parameter tuning, Regularization - Dropouts,	1
5.5	Initialization, CNN examples	1

Reference Books

1. Bishop, C. M. "Pattern Recognition and Machine Learning" Springer, New York, 2006.
2. Theodoridis, S. and Koutroumbas, K. "Pattern Recognition". Academic Press, San Diego, 2003.
3. Hastie, T., Tibshirani, R. and Friedman, J. "The Elements of Statistical Learning". Springer.

4. Duda, R.O., Hart, P.E., and Stork, D.G. “Pattern Classification”. Wiley, New York,

5. Ian Goodfellow, Yoshua Bengio, Aaron Courville. “Deep Learning” MIT Press, 2016

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222TEC006	MIXED SIGNAL CIRCUIT DESIGN	PROGRAM CORE 3	3	0	0	3

Preamble: To provide knowledge on circuit design in digital and analog domine

Course Outcomes:

CO 1	Design Digital CMOS systems
CO 2	Analysis cmos circuits in time and frequency domine
CO 3	Design CMOS analog circuits

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Micro project/Course based project: 20 marks Course based task/Seminar/Quiz: 10 marks Test paper, 1 no. : 10 marks
The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**CMOS LOGICS (8 hours)**	
1.1	CMOS Inverter-Static Characteristics, Derivation for VTH, V IL and VIH Switching Characteristics and Calculation of delay times Sequential Logic Circuits. switching and static power estimation.	5
1.2	Theory of operation and Circuits of static CMOS, Pass transistor Logic and transmission gate, Design of combinational circuits.	3
2	**Clocked CMOS (8 hours)**	
2.1	Clocked CMOS circuits, Domino Logic, NP Domino Logic, Pipelined NORA CMOS,	3
2.2	Design of Flip-Flops in CMOS - D Flip-Flops: General , The D-Latch, The RET D Flip-Flop , The Master-Slave D Flip-Flop , T, JK Flip-Flops.	4
3	**CMOS Amplifiers (8 hours)**	
3.1	Small signal analysis of Amplifiers- Common source, Common gate, Source follower. Cascode Current Mirror-Cascode Current Mirror, Wilson Current Mirror, Regulated Cascode BandgapVoltage Reference	4
3.2	Differential Amplifier, Gilbert Cell, Design of 2 stage CMOS OPAMP Differential to Single ended conversion, DC and AC response Frequency Compensation, Pole Splitting, Zero Cancellation	4

4	**Switching circuits (8 hours)**	
4.1	sample-and-hold circuits – testing sample and holds, MOS sample-and-hold basics, examples of CMOS S/H Circuits, bipolar and BiCMOS Sample-and-Holds, Translinear gain Cell, trans-linear multiplier	4
4.2	capacitors, switches, non-overlapping clocks, Basic operation and analysis of switched capacitor circuits, resistor equivalence of a switched capacitor, parasitic-sensitive integrator, parasitic-insensitive integrators, signal-flow-graph analysis, noise in switched-capacitor circuits	4
5		
5.1	Switched-capacitor gain circuits, parallel resistor-capacitor circuit, resettable gain circuit, capacitive-reset gain circuit, correlated double-sampling techniques, other switched-capacitor circuits	5
5.2	Opamp as a comparator – input-offset voltage errors, charge-injection errors, making charge-injection signal independent, minimizing errors due to charge-injection, speed of multi-stage comparators	3
		40 hours

Reference Books

1. “Analog Integrated Circuit Design” by Tony Chan Carusone, David A. Johns, Kenneth W. Martin
2. “CMOS Analog Circuit Design” by Phillip Allen and Douglas R. Holberg.
3. “Analog Design Essentials” by Willy M. C. Sansen,
4.“Design of Analog CMOS Integrated Circuits” by Behzad Razavi.

SEMESTER II

PROGRAM ELECTIVE III

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC055	ALGORITHM FOR VLSI	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: As a graduate level course on VLSI Design Automation area, this course assures to deliver the students, a thorough understanding of the algorithms used in VLSI Physical Design Automation problems.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Learn the VLSI physical design automation problems and their mathematical formulation
CO 2	Learn efficient algorithms to solve the physical design automation problems.
CO 3	Adapts the students to inherit the methods learned, to analyse and solve the emerging physical design Automation problems in VLSI.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			2			
CO 2			2			
CO 3			2	2	2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction to VLSI Physical Design Automation (8 hours)**	
1.1	Introduction to graph theory-data structures for graphs. Backtracking, branch and bound algorithms.	4
1.2	Graph algorithms- depth first search, breadth first search, shortest path, critical path, strongly connected components, minimum spanning tree, min-cut max-cut algorithm, Steiner tree algorithm.	4
2	**IIP (8 hours)**	
2.1	Integer linear programming and simulated annealing. Graph algorithms for physical design problems. Algorithm for interval, permutation and circle graphs (MIS, Cliques).	4
2.2	Partitioning Algorithms- Kernighan and Lin Algorithm - Fiduccia and Mattheyses Algorithm.	4
3	Floor planning: Stockmayer algorithm, Normalized polish expression. Routing: Steiner routing.: L-shaped Steiner routing, 1-steiner routing, bounded radius and A-tree routing algorithms.	8

4	Clock routing schemes - design considerations and problem formulation. H-tree based, MMM, Geometric Matching based, Weighted center, Exact Zero Skew, DME Algorithms, Multiple clock routing.	8
5	Layout compaction- problem formulation, Longest path algorithm for DAG - Liao-Wong and Bellman-Ford algorithms 1-Dimensional Compaction - constraint graph based compaction. Virtual Grid based compaction.	8
		40 hours

Reference Books

1. Naveed A. Sherwaniz, ”Algorithms for VLSI Physical Design Automation”, Kluwer Academic Press,3e.
2. Sung Kyu Lim, " Practical Problems in VLSI Physical Design Automation”, Springer, 2008.
3. Sabih H Gerez, ”Algorithms for VLSI Design Automation”, Wiley, 1e, 1998.
4. M Sarafzadeh, CK Wong,”An Introduction to VLSI Physical Design”, McGrawHill, 1996.
5. Charles J Alpert,Dinesh P Mehta, Sachin S Sapatnekar, ”Handbook of Algorithms for Physical Design Automation”, CRC Press, 2009 6. Luis Scheffer,Luciano Lavango, Grant Martin, ”EDA for IC Implementation, Circuit Design and Process Technology”, CRC Taylor and Francis, 2006.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC056	PROCESS AND DEVICE MODELING	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: To introduce to the students about process and device modeling.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand MOSFET Process
CO 2	Understand MOSFET Process simulation
CO 3	MOSFET Device Modeling

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1		3	2	2	1
CO 2	1		3	2	2	1
CO 3	1		3	2	2	1

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1		
1.1	Diffusion in silicon : self diffusion , impurity diffusion modeling Thermal oxidation : oxidation kinetics, oxide charges, Ion implantation ,Implantation profiles, annealing types, Modelling of poly Si crystal structures	5
1.2	MOSFET Parasitic Elements ,MOSFET circuit models, Threshold Voltage Variations with Device Length and Width , Temperature Dependence of the Threshold voltage.	3
2		
2.1	MOSFET DC Model: Pao-Sah Model, Charge-Sheet Model ,	3
2.2	Piece-Wise Drain Current Model for Enhancement Devices, Drain Current Model for Depletion Devices, Short-Geometry Models	5
3		
3.1	Dynamic Model :Meyer Model Charge-Based Capacitance Model ,Long-Channel Charge Model	4
3.2	Short-Channel Charge Model , Small-Signal Model Parameters, Modeling Hot-Carrier Effects	3
4		

4.1	Model Parameter Extraction Using Optimization method- Model Parameter Extraction, Basics Definitions in Optimization, Optimization Methods, Constrained Optimization, Multiple Response Optimization,	4
4.2	Parameter Extraction Using Optimizer, Drain Current Model Parameter Extraction, MOSFET AC Model Parameter Extraction	4
5		
5.1	SPICE Diode and MOSFET Models- Diode Model MOSFET Level 1 Model, DC Model Capacitance Model, MOSFET Level 4 Model, DC Model, Capacitance Model	4
5.2	Statistical Modelling and Worst-Case Design Parameters - Methods of Generating Worst Case Parameters, Model Parameter Sensitivity, Principal Factor Method, Statistical Analysis with Parameter Correlation, Principal Component Analysis	4
		40 hours

Reference Books

1. N. Arora, MOSFET Models for VLSI Circuit Simulation Theory and Practice,
2. Paolo Antognetti, Dimitri A. Ajroniadis :Process and Device Simulation for MOS-VLSI Circuits
3. Mark S. Lundstrom: NanoscaleTransistors Device Physics, Modeling and Simulation

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC057	QUANTUM PRINCIPLES FOR NANOMATERIALS	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: To introduce the quantum mechanical aspects of nanotechnology and apply the knowledge on quantization effects in nanostructures.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand basics of nanoscience and technology through quantum mechanics
CO 2	Demonstrate the importance of Schrodinger wave equation & it's application
CO 3	Explain various approximation methods and gain knowledge on quantum computing
CO 4	Understand the wave function theory of atoms and molecules
CO 5	Comprehend the quantization effects in nanostructures

Mapping of course outcomes with program outcomes

	PO 1	PO2	PO 3	PO 4	PO 5	PO 6
CO 1	1		1	1		1
CO 2	1		1	1		1
CO 3	1		1	1		1
CO 4	2		1	1		1
CO 5	1		2	1		1

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Introduction to Quantum Mechanics (8 hours)**	
1.1	Introduction to quantum mechanics, Wave-particle duality, De-Broglie's hypothesis, uncertainty relations	1
1.2	Statistical interpretation of wave function – Normalization of wave function, Schrödinger's time dependent and time independent wave equations	3
1.3	Conservation of total probability, Dynamical variables and Hermitian operators, Position, Linear and angular momentum operators.	4
2	**Solutions of Schrodinger Equations (8 hours)**	
2.1	One-dimensional potential: Free electron in vacuum, electron in a potential well with infinite barriers, finite barriers and propagation of an electron above the potential well	3
2.2	Tunnelling: propagation of an electron in the region of a potential barrier.	2
2.3	Three- dimensional potential: Electron in a rectangular potential well and spherically-symmetric potential well, Quantum harmonic oscillators	3
3	**Approximation methods and Quantum Computing (8 hours)**	

3.1	Principle of variational method, Time independent and time dependent perturbation theory for non-degenerate and degenerate energy levels	4
3.2	WKB approximation, adiabatic approximation, sudden approximation	1
3.3	Concept of quantum computation, Quantum Qubits, Introduction to nuclear spin, quantum confinement, quantum devices, single electron devices	3
4	**Quantum mechanics of Atoms and Molecules (8 hours)**	
4.1	Hamiltonian and Wave functions for Many-particle systems –Multi electron system	2
4.2	Orbital approximation for multielectron atoms – He atom - Pauli's Anti-symmetry principle – Born –Oppenheimer approximation	3
4.3	Molecular orbital Theory – LCAO - Theory of H2 molecule – H^+-Term Symbols.	3
5	**Quantization effects in Nanostructures (8 hours)**	
5.1	Number and density of quantum states, low-dimensional structures, Quantum states of an electron in low-dimensional structures	3
5.2	DOS for nanostructures, Double-quantum-dot structures, electron in a periodic one-dimensional potential	3
5.3	1D superlattice of quantum dots, 3D superlattice of quantum dots.	2

Reference Books

1. David J. Griffiths, "Introduction to Quantum Mechanics", Second Edition, Pearson, 2009
2. Ajoy Ghatak and S. Lokanathan, "Quantum Mechanics", Fifth Edition, Macmillan, 2009
3. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, Wiley, New York, (2001), ISBN 0-471 48943 3.
4. Vladimir V. Mitin, Dmitry I. Sementsov, Nizami Z. Vagidov, Quantum Mechanics for Nanostructures, Cambridge University Press 2010
5. Molecular Quantum Mechanics (3rd Edition), P.W. Atkins and R. S. Friedman, Oxford University Press, (2004), ISBN: 0-19-566751-4.
6. Introduction to nanotechnology, Henrik Brus, (2004) MIC – Department of Micro and Nanotechnology, Technical University of Denmark.
7. Quantum Mechanics, Vol I and Vol II, Claude Cohen-Tannaoudji, Bernard Diu, Franck Laloe, John Wiley & Sons (2005).
8. Quantum mechanics, J. L. Powell and B. Craseman, Addison-Wesley (1964).

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC058	MOSFET MODELING	PROGRAM ELECTIVE 1	3	0	0	3

Preamble: To provide an understanding of operation, modeling and characterization of MOS devices that are inherent to all VLSI circuits.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Deep insight into device dynamics.
CO 2	Comprehensive idea about small geometry effects.
CO 3	Knowledge about the advanced devices operation.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1					
CO 2	1			2	2	2
CO 3	1			2	2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	30
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	MOS capacitor: C-V characteristics, effect of metal work function, oxide and interface trapped charges, threshold voltage, tunnelling current	8
2	MOSFET: threshold based models of static I-V characteristics, channel length modulation, field-dependent mobility, short channel and narrow width effects,	8
3	subthreshold current, quantum mechanical effects, capacitances, concept of non-reciprocal capacitances, dynamic behaviour under small and large signals, surface potential and charge based models, model parameters and their extraction	8
4	MOSFET Model Parameters: SPICE level 1, level 2, level 3, level 4, level 5, level 6, level 7 and BSIM – Types of Analysis: AC-DC-TF- Frequency - Noise -Transient - Parametric - Sensitivity - Temperature - Worst-case - Monte Carlo Sub circuit.	8

5	CNTFET, Ballistic Transport, Thin Film Transistor, LTPS-TFT, Oxide- TFT, Accumulation-mode Transistors	8
		40 hours

Reference Books

1. Schroder D K, Semiconductor Material and Device Characterisation, 3rd Edition, John Wiley & Sons (2006).
2. Taur Y and Ning T H, Fundamentals of Modern VLSI devices, 2nd Edition, Cambridge (2013).
3. Arora N, MOSFET modeling for VLSI Simulation: Theory and Practice, 1st Edition, World Scientific (2007)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC059	ELECTROMAGNETIC COMPATIBILITY	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: The course Electromagnetic interference and compatibility give the in-depth exposer of unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects such as electromagnetic interference or even physical damage to the operational or impaired function of equipment.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Find solution to EMI Sources, EMI problems in PCB level / Subsystem and system level design.
CO 2	Realize the different types of shielding, grounding methods and material used for the same.
CO 3	To measure emission immunity level from different systems to couple with the prescribed EMC standards

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1			2		
CO 2	1		2	2	1	
CO 3	1			2		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1.	Introduction to EMI and EMC, Intra and inter system EMI, Elements of Interference, Sources and Victims of EMI, Conducted and Radiated EMI emission and susceptibility, Case Histories, Radiation hazards to humans, Various issues of EMC, EMC Testing categories, EMC Engineering Application.	8
2	COUPLING MECHANISM	
2.1	Electromagnetic field sources and Coupling paths, Coupling via the supply network, Common modecoupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling,	3

2.2	Radiative coupling, Ground loop coupling, Cable related emissions and coupling, Cross talk in transmission lines, Transient sources, Automotive transients, Cable routing and connection,	3
2.3	Component selection and mounting, PCB design, Trace routing, Impedance control, decoupling.	2
3	MI MITIGATION TECHNIQUES	
3.1	Working principle of Shielding, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketing and sealing, PCB Level shielding,	4
3.2	Principle of Grounding, Isolated grounds, Grounding strategies for Large systems, Grounding for mixed signal systems, Electrical bonding, Filter types and operation, Surge protection devices, Transient protection.	4
4	STANDARDS AND REGULATION	
4.1	Need for Standards, Generic/General Standards for Residential and Industrial environment, Basic Standards, Product Standards	3
4.2	Single photon transistor using surface plasmon, single emitter as saturable mirror, photon correlation, and integrated systems.	4
5	EMI TEST METHODS AND INSTRUMENTATION	
5.1	Fundamental considerations, Basic principles of RE, CE, RS and CS measurements, EMI Shielding effectiveness tests, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber, EMI test receivers, Spectrum analyzer	4
5.2	EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes, MIL -STD test methods, Civilian STD test methods.	4
		40 hours

Reference Books

1. V Prasad Kodali, “Engineering Electromagnetic Compatibility”, IEEE Press, Newyork, 2001.

2. Henry W. Ott, “Electromagnetic Compatibility Engineering”, John Wiley & Sons Inc, Newyork, 2009.

3. Daryl Gerke and William Kimmel, “EDN’s Designer’s Guide to Electromagnetic Compatibility”, Elsevier Science & Technology Books, 2002.

4. W Scott Bennett, “Control and Measurement of Unintentional Electromagnetic Radiation”, John Wiley & Sons Inc., (Wiley Interscience Series) 1997.

5. Dr Kenneth L Kaiser, “The Electromagnetic Compatibility Handbook”, CRC Press 2005

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC142	HIGH SPEED DIGITAL DESIGN	PROGRAM ELECTIVE 3	3	0	0	3

Preamble: The students will acquire knowledge on design of high speed VLSI circuits

Course Outcomes: After the completion of the course the student will be able to

CO 1	DesignHigh speed digital circuit
CO 2	Analysis Transmission line characteristics and power distribution
CO 3	Analysis clock distribution, timing issues, interconnects, EMC and grounding factors

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1				1		
CO 2				1		
CO 3	1			1		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**TRANSMISSION LINES AND CROSSTALK**	
	Transmission line structures, signal propagation, transmission line parameters, line impedance, propagation delay, Transmission line reflections, Cross talk- Mutual inductance, Mutual capacitance, cross talk induced noise, minimizing cross talk.	8
2	**POWER DISTRIBUTION**	
	Losses, the need for low-impedance planes and decoupling capacitors and their selection	8
3	**CLOCK DISTRIBUTION AND TIMING**	
	High-quality clock signals to components - boards and systems - Common clock timing and source synchronous timing	8
4	**INTERCONNECTS & ELECTROMAGNETIC COMPATIBILITY**	
	Interconnect technologies - Multilevel multilayer interconnects - propagation delay - crosstalk analysis - Designing for EMC - EMC regulations - typical noise path - methods of noise coupling - methods of reducing interference in systems	8

5	**GROUNDING**	
	Safety grounds ,signal grounds, single-point ground systems, multi-point ground systems, hybrid grounds, functional ground layout, practical low frequency grounding, hardware grounds, grounding of cable shields, ground loops, shield grounding at high frequencies.	8
		40 hours

Reference Books

1. Howard Johnson, Martin Graham, "High speed Digital design", Pearson, 2005.
2. Hall S, Hall G and McCall J, "High Speed Digital System Design: A Handbook of Interconnect Theory and Practices", Wiley Interscience,2000
3. Hartmut Grabinski, " Interconnects in VLSI design", Kluwer, 2000
4. Goel A K , "High speed VLSI interconnections", Wiley 2007
5. Bogatin E, "Signal integrity-simplified", Prentice Hall, 2003.
6. Paul CR, "Introduction t Electromagnetic compatibility", Wiley 2006.

SEMESTER II

PROGRAM ELECTIVE IV

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC060	INTRODUCTION TO NANO OPTICS	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: To acquaint with the knowledge of toxic effects of nanotechnology. To understand the current status of rules and regulations related to nanotechnology research

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the physics of linear photonic crystals
CO 2	Demonstrate the fabrication and application of photonic crystals
CO 3	Analyse the physics of nonlinear photonic crystals
CO 4	Familiarize the concepts of plasmonics
CO 5	Describe the principle and application of surface plasmon polariton

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1			2		
CO 2	1		2	2	1	
CO 3	1			2		
CO 4	1			2		
CO 5	1		2	2	1	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Physics of Linear Photonic crystals (9 hours)**	
1.1	Maxwell's Equations, Bloch's Theorem, Photonic Band-Structure and the Electron–Photon Analogy,	3
1.2	Photonic Band- G a p s , and Localized Defect States, Transmission Spectra.	3
1.3	Quantum Energy–Frequency Relations, Nonlinear Optics in Linear Photonic Crystals, Guided Modes in Photonic Crystals Slab	3
2	**Fabrication and Applications of Photonic crystals (9 hours)**	
2.1	Choices of Materials: Semiconductors, Amorphous, and Polymers, Fabrications of Photonic Crystals Structures (1-D,2-D,3-D)	3
2.2	Application of 1-D Photonic Crystals, Couplers, Waveguides, High-Q Cavities	3
2.3	2-D Photonic Crystals , Photonic Crystal Fibers, Tunable Photonic Crystal Filters	3
3	**Physics of Nonlinear Photonic Crystals (7 hours)**	
3.1	1-D Quasi Phase Matching, Nonlinear Photonic Crystal Analysis	3
3.2	Materials: LiNbO3, Chalcogenide Glasses. Wavelength Converters. Applications of Nonlinear Photonic Crystals Devices	4
4	**Plasmonics (7 hours)**	

4.1	Introduction to Plasmonics, Photonics and electronics at nanoscale dimensions, Nanowire surface plasmons- interaction with matter,	3
4.2	Single photon transistor using surface plasmon, single emitter as saturable mirror, photon correlation, and integrated systems.	4
5	**Surface Plasmon Polariton (8 hours)**	
5.1	Surface plasmon polaritons (SPP) – single interface, multilayer systems. Application of SPP, localized surface plasmons, slow guided surface plasmons at telecom frequencies.	4
5.2	All optical modulation by plasmonic excitation of quantum dots, Channel plasmon- polariton guiding by subwavelength metal grooves	4
		40 hours

Reference Books

1. Yuliang Zhao and Hari Singh Nalwa,Nanotoxicology: Interactions of Nanomaterials with Biological Systems, American Scientific Publishers,2007

2. M. Zafar Nyamadzi, -A reference handbook of nanotoxicology, Dominant publisher (2008)

3. Trevor M. Benson, Marian Marciniak, Tomasz Szoplik Photonic Crystals: Physics and Technology Editor: Springer (2008)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC061	PHYSICS OF EXTREME ELECTROMAGNETIC FIELD	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: To impart the knowledge about the physics of extreme magnetic field

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the physics of extreme magnetic field
CO 2	Apply physics of extreme magnetic field
CO 3	Analysis the physics of extreme magnetic field

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2			2		
CO 2						3
CO 3	2		1	2		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1		
1.1	Electrodynamics: Maxwell Equations in Vacuum and Matter Importance of Maxwell equations. Continuity Equation - Importance. Poynting Theorem-Energy distribution in EM waves.	4
1.2	Electromagnetic waves in Vacuum and Matter. Reflection and Transmission at Normal and Oblique Incidences, Complex Refractive Index and Dispersion relation.	4
2	Calculus with constant magnetic field , Solutions of the Dirac equation , Schwinger proper-time method ,Magnetic Catalysis , Direct calculation , Renormalization group analysis , Inverse Magnetic Catalysis , Finite density , Finite temperature ,Toward more realistic descriptions , Solvable example of inhomogeneous magnetic field	8
3		
3	Schwinger Mechanism , Solvable example of time-dependent electric fields ,Worldline instanton approximation ,Chiral Anomaly and Axial Ward Identity , In- and out-states , Electromagnetic realization of the chiral magnetic effect	8
4		

4	Rotating Chiral Fermions , Field-theoretical treatments , Chiral vortical effect ,Floquet Theory , Rotating frame and Magnus expansion , Interpretation as an artificial electric field , Relativistic Gyromagnetic Effects , Chiral Barnett effect , Chiral Einstein–de Haas effect	8
	Management of Innovation for Convergent Technologies - The "Integration/Penetration Model" Governance- Problems of Governance of Nanotechnology –Institutional	
5		
5	Rayleigh Scattering , Scattering by a Small Spherical Particle , Scattering Cross Section , Small Conductive Particle , Mie Scattering , Optical Theorem , Mie Scattering by Spherical Harmonic Expansions , Separation of Variables in Spherical Coordinates	8
		40 hours

Reference Books

1. Fields and Waves in Communication Electronics, S. Ramo, J.R. Whinnery, and T. Van Duzer, 3rd Ed
2. Electromagnetic Wave Theory, J.A. Kong. ECE 350X notes.
3. Theory of Optical and Microwave Guides notes. Waves and Fields in Inhomogeneous Media,
4. Classical Electrodynamics, J.D. Jackson. Electromagnetic Noise and Quantum Optical Measurements, H.A. Hau

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC062	PHYSICS OF SOLAR CELLS	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: The purpose of this course is to introduce the novel concept of Solar cells

Course Outcomes: After the completion of the course the student will be able to

CO 1	Estimate the maximum efficiency of ideal and nonideal solar cells
CO 2	estimate the cost and performance of solar cells
CO 3	Estimate Efficiency of Solar cells

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1		3			2
CO 2	1		3		2	
CO 3	1		3		2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Basics**	
1	Black-body Radiation, Photon Density in a Cavity (Planck's Law of Radiation, Energy Current Through an Area dA into the Solid Angle , Radiation from a Spherical Surface into the Solid Angle , Radiation from a Surface Element into a Hemisphere (Stefan–Boltzmann Radiation Law) , Kirchhoff's Law of Radiation for Nonblack Bodies , Absorption by Semiconductors , The Solar Spectrum , Air Mass , Concentration of the Solar Radiation	8
2	**Conversion of Chemical Energy into Electrical Energy**	
2.1	Maximum Efficiency for the Production of Chemical Energy , Shockley–Queisser Limit , Conversion of Chemical Energy into Electrical Energy - Transport of Electrons and Holes ,Field Current , Diffusion Current ,Total Charge Current ,Separation of Electrons and Holes ,Diffusion Length of Minority Carriers ,Dielectric Relaxation , Ambipolar Diffusion ,Dember Effect , Mathematical Description	8
3	**Structure of Solar Cells**	

3.1	A Chemical Solar Cell ,Basic Mechanisms in Solar Cells ,Dye Solar Cell , The pn-Junction , Electrochemical Equilibrium of Electrons in a pn-Junction in the Dark , Potential Distribution across a pn-Junction ,Current–Voltage Characteristic of the pn-Junction , pn-Junction with Impurity Recombination, Two-Diode Model ,Heterojunctions ,Semiconductor–Metal Contact , Schottky Contact , MIS Contact ,The Role of the Electric Field in Solar Cells , Organic Solar Cells ,Structure of Organic Solar Cells.	8
4	**Energy Conversion in Solar Cells**	
4	Maximum Efficiency of Solar Cells , Efficiency of Solar Cells as a Function of Their Energy Gap ,The Optimal Silicon Solar Cell ,Light Trapping , Thin-film Solar Cells ,Minimal Thickness of a Solar Cell ,Equivalent Circuit , Temperature Dependence of the Open-circuit Voltage , Intensity Dependence of the Efficiency, Efficiencies of the Individual Energy Conversion Processes	8
5	**Efficiency of Solar Cells**	
5	Tandem Cells ,The Electrical Interconnection of Tandem Cells, Concentrator Cells ,Thermophotovoltaic Energy Conversion , Impact Ionization,Hot Electrons from Impact Ionization ,Energy Conversion with Hot Electrons and Holes, Two-step Excitation inThree-level Systems ,Impurity Photovoltaic Effect 2,Up- and Down-conversion of Photons	8
		40 hours

Reference Books

1. *Photovoltaics Fundamentals, Technology, and Practice* , Konrad Mertens , Wiley , 2018 , ISBN No. 13: 978- 1119401049
2. *Physics of Solar Cells: An Atoms-to-Farm Perspective* , M.A. Alam
3. *Solar Cells: Operating Principles, Technology and System Applications* , 13: 978-0138222703 , Prentice Hall , 1986 , ISBN No. Martin A. Green

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC063	QUANTUM OPTICS	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: To impart the knowledge about the quantum optics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Introduction to quantum optics
CO 2	Analysis nano optics system
CO 3	Introduce fundamental principles optic

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1			2		
CO 2	1			3		
CO 3	1			2		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed
Original publications (minimum 10 publications shall be referred): 15 marks Course based task/Seminar/Data collection and interpretation: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1		
1.1	Electromagnetic field quantization: Quantum fluctuation and Quadrature operators of a single mode field, Thermal fields, Vacuum fluctuation and zero point energy, Quantumphase	2
1.2	Coherent and squeezed states of radiation field: Properties and phase space picture of coherent state, Generation of a coherent state, Squeezed state physics, generation and Detection of squeezed light, Schrodinger cat states, Multi-mode squeezing, Broadband squeezed light, Squeezing via non-linearprocess	6
2		
	Atom-field interaction: Rabi model (Semi-classical model for atom-field interaction), Jaynes-Cummings model (fully quantum mechanical model for atom- field interaction), Dressed states, Density operator approach, Hanle effect, Coherent trapping, electromagnetically induced transparency, Four wavemixing	8
3		
	Quantum coherence function: photon detection and quantum coherence functions, First order coherence and Youngs type double source experiment, Second order coherence, physics of Hanbury-Brown-Twiss effect, Experiments with single photon, Quantum mechanics of beam splitter, interferometry with singlephoton	8
4		

	Optical test of quantum mechanics: photon sources: spontaneous parametric down-conversion, Hong-Ou-Mandel interferometer, Superluminal tunneling of photons, EpR paradox and optical test of Bell.stheorem	2
5		
	Mechanical effects of light, Laser cooling, atom interferometry, atoms in cavity, Experimental realization of Jaynes-Cummingsmodel Entanglementandinter ferometric measurements,Quantum teleportation, Quantum cryptography, an optical realization of some quantumgates	2
		40 hours

Reference Books

1. Introductory Quantum Optics by C. C. Gerry and P. L. Knight, Cambridge University press
2. Quantum Optics by M. O. Scully and M. S. Zubairy, Cambridge University press
3. Quantum Optics by M. Fox, Oxford Master series in atomic, Optical and Laserphysics
4. Quantum Theory of Light by R. Loudon, Oxford science publication

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC064	THEORY OF NONLINEAR OPTICS	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: Provides an introduction to the field of nonlinear optics, exploring the physical mechanisms, applications, and experimental techniques.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Develop working knowledge on nonlinear optical processes
CO 2	Analyze the phase matching condition and conversion efficiency of various wave mixing and harmonic generation processes
CO 3	Understand the application of nonlinear optics

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1		1	3		
CO 2	1		1	3		
CO 3	1		1	3		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

1. Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
2. Course based task/Seminar/Data collection and interpretation: 15 marks

3. Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1		
	Classical theory of nonlinear optical interactions, Intensity dependent refractive index, Molecular origins of Nonlinear optical response, Nonlinear effects from various orders of susceptibilities	8
2		
	Photon-phonon scattering, Electro and Acousto-Optic effects, Non-linear optics in guided wave devices, Self-phase/Cross-phase modulation,	8
3		
	Four-wave mixing, Stimulated Raman/Brillouin scattering, Introduction to ultrafast optics, Theory of mode-locking, Effects of Dispersion, Ultrafast Pulse Measurement, Ultrafast Pulse Shaping, Ultrafast Phenomena	8
4		
	Light propagation in linear media ,Classical models of atomic polarizability. Electromagnetic theory of nonlinear interactions.	8
5		
	Harmonic oscillator model. Spontaneous and stimulated scattering. Stimulated scattering in optical fibers. Raman spectroscopy.	8
		40 hours

Reference Books

1. Robert W. Boyd, Nonlinear Optics, Elsevier (2003)
2. Govind P. Agrawal, Nonlinear Fiber Optics, Elsevier (2007)
3. Andrew M Weiner, Ultrafast Optics, Wiley (2008)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC065	OPTOELECTRONIC CARBON NANOSTRUCTURES	PROGRAM ELECTIVE 4	3	0	0	3

Preamble: To acquaint the students with the vibrant applications of CNT in optics

Course Outcomes: After the completion of the course the student will be able to

CO 1	Make acquaintance with the concept of optics in CNT
CO 2	Demonstrate the knowledge of nano- based optical systems
CO 3	Describe various applications of CNT

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1		1	3		
CO 2	1		1	1		
CO 3	1		1	1		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

1. Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks
2. Course based task/Seminar/Data collection and interpretation: 15 marks

3. Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Carbon nanotubes**	
	Structures of Carbon nanotubes - Synthesis of carbon nanotubes ,Optical properties of carbon nanotubes , Photoluminescence . , Electroluminescence , Optical gain in 1300 nm and 1550 nm , Nonlinear Effects ,Purification of carbon nanotubes	8
2	**Material optimization and post processing**	
	Polymer assisted technique for semiconducting SWCNT extraction: HiPco, Optimization of the sonication step, Effect of the tip sonication time, Optimization of ultracentrifugation time, Post processing. Ultra concentrated solutions	8
3	**Hybrid integration with photonic structures**	
	Waveguide geometry: strip vs slot ring resonators, Polarization effect in strip silicon ring resonators, Small mode volume cavities: 2D Hollow-core Photonic Crystal Cavity, Collinear excitation: Waveguide-waveguide configuration on silicon nitride platform	8
4	**Electroluminescence and photodetection in CNT**	
	Silicon micro disk devices, Electroluminescence, Photodetection, Integrated transceiver,	8
5	**Nonlinear effects in SWCNTs**	
	Nonlinear optics, Measurements, analysis of kerr effect in SWCNTs	8
		40 hours

Reference Books

1. Carbon Nanotubes Science and Applications, Edited by M.Meyappan, CRC Press, 2005
2. Introduction to Nanophotonics, Sergey V. Gaponenko, Cambridge UniversityPress, New York, ISBN-13 978-0-521-76375-2 (2010)
3. Silicon-Waveguide-Integrated Carbon Nanotube Optoelectronic System on a Single Chip Ze Ma, Leijing Yang, Lijun Liu, Sheng Wang*, and Lian-Mao Peng

COURSE CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222PEC100	MINI PROJECT	PROJECT	0	0	4	2

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs.The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor and Guide.

Sl. No	Type of evaluations	Mark	Evaluation criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	
3	Final evaluation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level(not more than 25%)
5	Supervisor/Guide	10	
	Total Marks	100	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222LEC005	MICROELECTRONICS LAB	LABORATORY	3	0	0	3

Preamble: To acquaint with the knowledge microelectronics simulation

Course Outcomes: After the completion of the course the student will be able to

CO 1	Understand the physics of low dimensional Device
CO 2	Analysis analog circuits
CO 3	Analyse digital circuits

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	1			2		
CO 2	1		2	2	1	
CO 3	1			2		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	100		

Continuous Internal Evaluation: 100 marks

Continues evaluation

Syllabus and Course Plan

1. Experiments with MOSFET characterization ,
2. Experiments on Vt variations,
3. CMOS Inverter Simulation
4. Experiments on Digital arithmetic circuits
5. Experiments on CMOS CM circuits
6. Experiments on CMOS Amplifier circuits
7. Experiments on CMOS OPAMPS circuits
8. Experiments on CMOS SC Filters circuits
9. Experiments on CMOS ADC circuits
10. Experiments on CMOS DAC circuits

SEMESTER II

INTERDISCIPLINARY ELECTIVE

CODE	COURSE	CATEGORY	L	T	P	CREDIT
222EEC083	AUTOMOTIVE ELECTRONICS	INTER-DISCIPLINARY ELECTIVE	3	0	0	3

Preamble: The purpose of this course is to provide an awareness of Automotive Electronics. As an outcome of the course the students will be aware of the technical details of Electronics Engineering in Automotive industry, the current trends and challenges.

Course Outcomes: After the completion of the course the student will be able to:

CO#	CO
CO1	Understand the fundamentals of vehicle electronic systems and integration of electronic components in vehicle system architecture.
CO2	Understand the various communication technologies on board vehicles
CO3	Understand the working of various control algorithms implemented in vehicles for the purpose of automation
CO4	Apply the knowledge of electronics for safety and security in vehicle automation
CO5	Understand the emerging trends in automotive electronics

Program Outcomes:

PO#	PO
PO1	An ability to independently carryout research/investigation and development work in engineering and allied streams
PO2	An ability to communicate effectively,write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with Society at large.
PO3	An ability to demonstrate a degree of mastery over the area as per the specialization of the program.The mastery should be at a level higher than the requirements in the Appropriate bachelor's program
PO4	An ability to apply stream knowledge to design or develop solutions for real-world problems by following the standards
PO5	An ability to identify, select and apply appropriate techniques, resources and state-of-the-art tools to model, analyze and solve practical engineering problems.

PO6	An ability to engage in life long learning for the design and development related to the stream-related problems taking into consideration sustainability, societal, ethical and environmental aspects
PO7	An ability to develop cognitive load management skills related to project management and finance which focus on Entrepreneurship and Industry relevance.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	M	L	L	L	L	M	
CO2	M	L	L	L	L	M	
CO3	M	L	L	L	L	M	
CO4	M	L	L	L	L	M	
CO5	M	L	L	L	L	M	

Assessment Pattern

Bloom's Category		**Continuous Assessment Tests**	**End Semester Examination**
		Test [%] (10 marks)	**University Exam[%] (60 marks)**
Remember	K1	20	20
Understand	K2	60	60
Apply	K3	20	20
Analyse	K4		
Evaluate			
Create			

Mark distribution

Total Marks	**CIE**	**ESE**	**ESE Duration**
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern (Elective):

Preparing a review article based on peer-reviewed original publications(minimum10 publications shall be referred): 15 marks
Course-based task/Seminar/Data collection and interpretation: 15marks
(Group projects not permitted)
Test paper, 1 No. : 10 marks
Test paper shall include a minimum of 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts: Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions, with a minimum of one question from each module of which students should answer any five. Each question can carry 7marks.

Model Question Paper

PAGES: 1 **Slot**

Name: **Reg No:**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

SECOND SEMESTER M.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: 222EEC083

Course Name: A u t o m o t i v e E l e c t r o n i c s

Max.Marks: 60 **Duration: 2.5Hours**

PART A

Answer all Questions. Each question carries 5 marks

1. a) State the functions of Motronic engine-management.
   b) Explain the working principle of fuel injector.
2. Illustrate basic CAN module with block diagram and explain.
3. Explain the principle of on board diagnostics in automotive electronics.
4. Illustrate the concept of anti slip regulation in automotive safety systems.
5. Explain the concept of V2V communication.

(5x5=25Marks)

PART B

Answer any 5 questions. Each question carries 7 marks

6. Illustrate Electronic ignition system configuration with suitable diagram.
7. Justify the need for a communication network in a vehicle.
8. a) Differentiate between Cruise control and Traction Control. (4)
   b) Explain the concept of Actuator Limiting. (3)
9. Illustrate the principle of interfacing an A/D converter with a temperature sensor. State the specifications of the modules used.
10. a) Explain blind spot detection in vehicles. (4)
    b) Identify the pedestrian safety measures available in modern cars (3)
11. Illustrate the autonomous driving system architecture with block diagram.
12. Explain the working of hybrid vehicles with a block diagram,.

(5x7=35Marks)

Syllabus

Module 1: Introduction to Automotive Electronics (7Hrs)
Overview of vehicle electronic systems,Integration of electronic components and systems in vehicles, Vehicle System Architecture – Sensors – Actuators – Embedded processors and micro-controllers, Introduction to Electronic Instrumentation for sensors: temperature, distance, velocity, speedometer, anti-collision. limitations, topologies and processing for sensors, DA/AD converters, Interfacing ADC/DAC to peripherals and sensors

Module 2: Automotive Communications Systems (7Hrs)
Introduction to communications standards, Introduction to networks, safety critical issues and reliability, Communication protocols for automotive applications, CAN- protocol layers, content based addressing, Hardware- basic CAN module, Basic block level working principle of LIN, MOST, Bluetooth & FlexRay, Telematics for automotive applications, GPRS, GPS in automotive environment

Module 3: Automotive Control and Power Systems (7Hrs)
ECU – Electronic Engine Control, Electronic control methods (analog and digital), Stability algorithms for control-cruise control, traction control, Actuator limiting, wind-up and gain scheduling. Energy management strategies: regenerative braking, start-stop, torque boost, Sensing and control systems, Automotive Diagnostics- OBD – Onboard Diagnostics

Module 4: Automotive Safety Systems and ADAS (7Hrs)
Introduction to safety systems, Passive system electronics: Airbag and sensors, Active systems electronics: Anti lock braking system (ABS), Electronic Stability Program (ESP), Anti-slip regulation (ASR), Driver Assistance Systems**:** Advanced active systems electronics: ACC , Active safety system applications: lane detection, blind spot, crash avoidance control electronics, Basics of ADAS, Power Steering, Automatic climate control

Module 5: Advancements in automotive electronics (7Hrs)
Introduction to Autonomous driving-system architecture overview, Navigation systems –VANET, vision intelligence, computational intelligence, smart traffic systems, security, EV- classification, benefits and challenges, Basic concepts and challenges of Hybrid vehicles, fuel cell powered vehicles.

Text Books:

1. William B.Ribbens, “Understanding Automotive Electronics”, 6thEdition, Elsevier Publishing.
2. Robert Bosch Gmbh (Ed.) Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive, 5th edition, Springer Vieweg, John Wiley Sons.

References:

1. Hybrid & Electric Vehicles -A CRC Press FREEBOOK
2. Creating Autonomous Vehicle Systems -SYNTHESIS LECTURES ON COMPUTER SCIENCE MORGAN & CLAYPOOL PUBLISHERS
3. A Progressive Review: Emerging Technologies for ADAS Driven Solutions- Jaswanth Nidamanuri , Chinmayi Nibhanupudi, Rolf Assfalg, and Hrishikesh Venkataraman, IEEE TRANSACTIONS ON INTELLIGENT VEHICLES, VOL. 7, NO. 2, JUNE 2022
4. Hillier’s Fundamentals of Motor Vehicle Technology5th Edition Book 3,V.A.W. Hillier & David R. Rogers

Course Plan

	Topic	No.of Lectures
	Module 1: Introduction to Automotive Electronics (7Hrs)	
1.1	Overview of vehicle electronic systems	1
1.2	Integration of electronic components and systems in vehicles - Description of VSA- Sensors – Actuators- Embedded processors and micro controllers	1
1.3	Sensors in detail: temperature, distance, velocity, speedometer, anti-collision, limitations, topologies and processing for sensors	2
1.4	DA/AD converters,	1
1.5	Interfacing ADC to peripherals and to sensors	1
1.6	Interfacing DAC to peripherals and to sensors	1
	Module 2: Automotive Communications Systems (7Hrs)	
2.1	Introduction to communications standards , networks, safety critical issues and reliability	1
2.2	Communication protocols for automotive applicationCAN	2
2.3	Basic block level working principle of LIN, MOST, Bluetooth, & FlexRay	2
2.4	Telematics for automotive applications	1
2.5	GPRS, GPS for use in and automotive environment	1
	Module 3: Automotive Control and Power Systems (7Hrs)	
3.1	ECU, Electronic control methods (analog and digital)	1
3.2	Stability algorithms for control (cruise control, traction control)	2
3.3	Actuator limiting, wind-up, gain scheduling	1
3.4	Energy management strategies: regenerative braking, start-stop, torque boost, Sensing and control systems	2
3.5	Automotive diagnostics-OBD	1
	Module 4: Automotive Safety Systems and ADAS (7Hrs)	
4.1	Introduction to safety systems: Passive and Active systems electronics.	1
4.2	Antilock-braking system (ABS), Electronic Stability Program (ESP), Anti-slip regulation (ASR)	1
4.3	Driver Assistance Systems: Advanced active systems electronics: ACC, Basics of ADAS	2
4.4	Active safety system applications: lane detection, blind spot, crash avoidance control electronics	2
4.5	Power Steering , Automatic climate control	1

	Module 5: Advancements in automotive electronics (7Hrs)	
5.1	Introduction to Autonomous driving-system architecture-overview	1
5.2	Navigation systems, VANET,.vision intelligence, computational intelligence	2
5.3	Smart traffic systems, security	**1**
5.4	Basics of EV- classification, benefits, challenges	**1**
5.5	Basic concepts and challenges of Hybrid vehicles, fuel cell powered vehicles	**2**

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC084	MEMS AND SENSORS	INTERDISCIPLINARY ELECTIVE	3	0	0	3

Course Objectives

- Introduces students to the need of rapidly emerging, area of MEMSand microsystem in engineeringand its applications in sensor technology
- Enable the students to understand the various sensing and actuation mechanisms.

Prerequisite: nil

Course Outcomes: After the completion of the course the student will be able to

CO1	Identify structural and sacrificial materials for MEMS
CO2	Describe the fabrication steps in designing of various MEMS devices.
CO3	Apply principles for the design of Sensor and actuators
CO4	Apply MEMS for different applications in various fields of engineering

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	*PO5*
CO1					
CO2					
CO3					
CO4					

Assessment Pattern

Bloom'sCategory	Continuous Assessment Tests		End Semester Examination [%] (60Marks)
		Test1 [%] (10Marks)	
Remember		10	20
Understand		20	40
Apply		10	20
Analyse		10	20
Evaluate			
Create			

Mark distribution

Total Marks	CIE (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Micro project : 15 marks

Test paper 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The end semester examination will be conducted by the respective college.

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

SYLLABUS

1	**MODULE I**

Introduction: Introduction to MEMS and Microsystems, MEMS Classification, MEMS versus Microelectronics, Applications of MEMS in Various Industries, Some Examples of Microsensors, Microactuators, and Microsystems, Materials for MEMS, Laws of Scaling in miniaturization

2	**MODULE II**

MEMS Fabrication: Structure of Silicon, Single Crystal Growth Techniques, Photolithography, Oxidation, Diffusion, Ion Implantation, Physical Vapor Deposition, Chemical Vapor Deposition, Bulk Micromachining: Overview of Etching, Isotropic and Anisotropic Etching, Wet Etchants, Etch Stop Techniques, Dry Etching, Surface Micromachining, LIGA, SLIGA, Wafer Bonding, Electroplating

3	**MODULE III**

Microsensors and Microactuators: Basic Modeling Elements in Mechanical, Electrical and Thermal Systems, Types of Beams: Cantilevers, Bridges, Fixed-Guided beams, Electrostatic sensing and Actuation: Parallel plate capacitor, Applications of parallel plate capacitors: Inertial sensor, Pressure sensor, Flow sensor, Parallel plate Actuators, Piezoresistive Sensors: Origin and Expressions of Piezoresistivity, Piezoresistive Sensor Materials, Applications of Piezoresistive Sensors, Piezoelectric Sensing and Actuation, Thermal Sensing and Actuation: Sensors and Actuators based on Thermal Expansion, Thermocouples, Thermoresistors, Shape Memory Alloy, Applications: Inertial sensors, Flow sensors, Infrared sensors

4	**MODULE IV**

Layout, Simulation Tools, Packaging and Characterization techniques: Introduction of layout, Simulation Tools, General considerations in Packaging , Bonding techniques for MEMS and Various Characterization Techniques for MEMS Devices

5	**MODULE V**

Advances in MEMS:RF-MEMS: MEMS devices for RF Applications: RF MEMS Switches and their applications, High-Q Capacitors and Inductors and Their

Applications in RF Circuits, Overview of Optical MEMS , Chemical-Bio MEMS and Nanoelectromechanical Systems

Text books

- MEMS and Microsystems design and manufacture by Tai-Ran Hsu, Tata McGraw Hill.
- MEMS by N. P. Mahalik, Tata McGraw Hill.
- Foundations of MEMS by Chang Liu, Pearson Prentice Hall.

Reference books

- Sensors and Transducers by M. J. Usher, McMillian Hampshire.
- Analysis and Design Principles of MEMS Devices by Minhang Bao, Elsevier.
- Fundamentals of Microfabrication by M. Madou, CRC Press.
- Microsensors by R.S. Muller, Howe, Senturia and Smith, IEEE Press.
- Semiconductor Sensors by S. M. Sze, Willy Inderscience Publications.

COURSE CONTENTS AND LECTURE SCHEDULE

No.		No. of Hours
	MODULE 1	
1.1	Introduction to MEMS and Microsystems, MEMS Classification, MEMS versus Microelectronics,	1
1.2	Applications of MEMS in Various Industries, Some Examples of Microsensors, Microactuators, and Microsystems	1
1.3	Materials for MEMS,	2
1.4	Laws of Scaling in miniaturization	1
	MODULE II	
2.1	Structure of Silicon, Single Crystal Growth Techniques,	1
2.2	Photolithography, Oxidation,	1
2.3	Diffusion, Ion Implantation,	1
2.4	Physical Vapor Deposition, Chemical Vapor Deposition,	1
2.5	Bulk Micromachining: Overview of Etching, Isotropic and Anisotropic Etching,	1
2.6	Wet Etchants, Etch Stop Techniques, Dry Etching	1

2.7	Surface Micromachining	1
2.8	LIGA, SLIGA	2
2.9	Wafer Bonding, Electroplating	1
MODULEIII		
3.1	Microsensors and Microactuators: Basic Modeling Elements in Mechanical, Electrical and Thermal Systems,	1
3.2	Types of Beams: Fixed-Free (Cantilevers), Fixed-Fixed (Bridges), Fixed-Guided beams,	1
3.3	Electrostatic sensing and Actuation: Parallel plate capacitor,	1
3.4	Applications of parallel plate capacitors: Inertial sensor,	1
3.5	Pressure sensor, Flow sensor, Parallel plate Actuators,	1
3.6	Piezoresistive Sensors: Origin and Expressions of Piezoresistivity, Piezoresistive Sensor Materials,	1
3.7	Applications of Piezoresistive Sensors,	1
3.8	Piezoelectric Sensing and Actuation,	1
3.9	Thermal Sensing and Actuation: Sensors and Actuators based on Thermal Expansion,	1
3.10	Thermocouples, Thermoresistors,	1
3.11	Shape Memory Alloy, Applications: Inertial sensors, Flow sensors, Infrared sensors	2
MODULEIV		
4.1	Introduction of layout, Simulation Tools,	1
4.2	General considerations in Packaging and bonding techniques in MEMS	2
4.3	Various Characterization Techniques for MEMS Devices	1
MODULEV		
5.1	Advances in MEMS: RF-MEMS: MEMS devices for RF Applications:	1
5.2	RF MEMS Switches and their applications,	1

5.3	High-Q Capacitors and Inductors and Their Applications in RF Circuits,	1
5.4	Overview of Optical MEMS ,	1
5.5	Chemical-Bio MEMS and Nanoelectromechanical Systems	1

Model Question Paper

A P J Abdul Kalam Technological University
Second Semester M.Tech Degree Examination
Course: 222EEC084MEMS and Sensors
Time: 150 Minutes Max. Marks: 60

PART A
Answer All Questions

1	Mention the criteria for selecting materials for the masks used in etching. List four materials used as masks.	5
2	Define etch stop? List different methods used to stop etching and explain one with sketches	5
3	Explain with neat sketches the type of mechanical beams and boundary conditions associated with supports	5
4	State the various levels of micro system packaging	5
5	With neat sketches explain the construction and working of a shunt type RF MEMS switch.	5

PART B
Answer any five question

6	A silicon substrate is doped with phosphorus ions at 100 KeV. Assume the maximum concentration after the doping is 30 x $10^{18}/cm^3$. Find: (a) the dose, Q, (b) the dopant concentration at the depth 0.15 μm, (c) the depth at which the dopant concentration is at 0.15% of the maximum value. (Given: Rp = 135 nm and ΔRp = 53.5 x 10^{-7}cm at 100 KeV energy level).	*7*
7	Explain in the light of scaling, assuming a 10 times reduction of size of the actuator. Which of the electrostatic and electromagnetic forces are best suited for micro device actuation and why?	*7*
8	Explain the purpose of micro cantilevers in MEMS systems. What is the relevance of Spring constant (k) of the mechanical structure in the microsystems.	*7*

9	Explain the principle of operation of the following micro sensors (i) Comb drives (ii) Shape Memory Alloys	*7*
10	Explain the challenges involved in BioMEMS. List three applications of BioMEMS.	*7*
11	Explain Various bonding techniques associated with MEMS and their implications on packaging	*7*
12	Explain the LIGA process associated with MEMS fabrication with suitable sketches	*7*

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
222EEC085	NANO MATERIALS FOR DRUG DELIVERY	INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: To inspire the students with interest to investigate role of new nanomaterials and devices drug delivery.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Familiarize the concepts of nano materials for drug delivery
CO 2	Investigate the use of nano materials for drug delivery
CO 3	Investigate the use of nanodevices for drug targeting

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3			
CO 3			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern

Micro project/Course based project : 20 marks
Course based task/Seminar/Quiz : 10 marks
Test paper, 1 no. : 10 marks
The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A will contain 5 short answer questions with 1 question from each module, having 5 marks for each question. Students should answer all questions. Part B will contain 7 questions with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Syllabus and course plan

No	Topic	No. of Lectures
1	**Nanomedicines**	
1.1	Basic concepts in the design, specification and desired features of nanomedicine and general process steps involved in their preparation Nanomedicines for various disease conditions: infectious diseases, neurological diseases, pulmonary disorders, cardiovascular diseases	4
1.2	cancer: nano-chemotherapy, - radiation therapy, - immunotherapy, -nuclear medicine therapy, -photodynamic therapy, - photothermal and RF hyperthermia therapy, scintillation therapy, gene-therapy: DNA, RNA delivery. Theranostic nanomedicines: Basic concept, multifunctional nanomedicines for theranosis	4
2	**Drug Delivery Systems**	
2.1	Administration Routes: Oral Drug Delivery, Features of Gastrointestinal tract (GI), Targeting of drugs in the GI tract.	4
2.2	Design and fabrication of oral systems - Dissolution controlled, diffusion controlled, osmotic controlled, chemically controlled release, Intravenous Drug Delivery - Factors controlling pharmacokinetics of IV formulations, Concept of opsonization	4
3	**Drug Delivery Devices**	
3.1	Transdermal Drug Delivery, Structure of human skin and theoretical advantages of the transdermal route, Transdermal penetration of drugs, adhesion, bioactivity.	4
3.2	Intranasal Drug Delivery - Nasal physiology and intranasal Drug Administration, Nasal drug delivery devices, Ocular Drug Delivery devices; Miscellaneous Drug Delivery	4
4	**Advanced Drug Delivery**	
4.1	Concept of Drug Targeting; Prodrug and Bioconjugation; Nanoscale Drug Delivery Systems - Advantages of nanodrug delivery – Improvements in pharmacokinetics, bioavailability, biodistribution; Concepts of controlled and sustained drug delivery, How nanoparticles pass barriers; Surface modification of nanoparticulate carriers	4

4.2	Nanocarriers for drug delivery - Lipid based pharmaceutical nanoparticles – Liposomes, Solid Lipid Nanoparticles, Nanostructured Lipid Carriers, Cubosomes and Hexosomes, Polymeric Micelles, DNA- Based Nanomaterials, Dendrimers, Polymeric nanoparticles, Inorganic nanoparticles, Hydrogels for controlled drug delivery	4
5	**Active and passive nanocarriers**	
5.1	Concept of targeting, Site Specific Drug delivery utilizing Monoclonal Antibodies, Peptides, Other Biomolecules, Stimuli-Responsive Target Strategies; Implants; Protein and Peptide Drug Delivery; Delivery of Nucleic Acids	3
5.2	Delivery of Vaccines; Aptamers in Advanced Drug Delivery; Biomimetic Self-Assembling Nanoparticles	2
5.3	Nanotechnology Challenges; Regulatory Considerations and Clinical Issues in Advanced Drug Delivery	3

Books-

1. Drug Delivery Systems, Pieter Stroeve and MortezaMahmoudi, World Scientific Series: From
2. Biomaterials towards Medical Devices, Vol I, 2018.
3. Nanoparticulates as Drug Carriers, Vladimir Torchillin, Imperial College Press, 2006
4. Drug Delivery Systems, Third Edition, Vasant V Ranade, John B. Cannon, by CRC Press, 2011

SEMESTER III

SEMESTER III

Slot	Course code	Courses	Marks		L-T-P	Hours	Credit
			CIE	ESE			
TRACK 1							
A*	223MxxXXX	MOOC	To be completed successfully		--	--	2
B	223AGEXXX	Audit Course	40	60	3-0-0	3	-
C	223Ixx100	Internship	50	50	--	--	3
D	223Pxx100	Dissertation Phase 1	100	--	0-0-17	17	11
TRACK 2							
A*	223MxxXXX	MOOC	To be completed successfully		--	--	2
B	223AGEXXX	Audit Course	40	60	3-0-0	3	-
C	223Ixx100	Internship	50	50	---	--	3
D	223Pxx001	Research Project Phase1	100	--	0-0-17	17	11
TOTAL			**190**	**110**		**20**	**16**

Teaching Assistance: 6 hours

*MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1).

AUDIT COURSE

AUDIT COURSE						
SLOT	**SL NO**	**COURSE CODE**	**COURSE NAME**	**L-T-P**	**HOURS**	**CREDIT**
B	1	223AGE100	ACADEMIC WRITING	3-0-0	3	-
	2	223AGE001	ADVANCED ENGINEERING MATERIALS	3-0-0	3	-
	3	223AGE002	FORENSIC ENGINEERING	3-0-0	3	-
	4	223AGE003	DATA SCIENCE FOR ENGINEERS	3-0-0	3	-
	5	223AGE004	DESIGN THINKING	3-0-0	3	-
	6	223AGE005	FUNCTIONAL PROGRAMMING IN HASKELL	3-0-0	3	-
	7	223AGE006	FRENCH LANGUAGE (A1 LEVEL)	3-0-0	3	-
	8	223AGE007	GERMAN LANGUAGE (A1 LEVEL)	3-0-0	3	-
	9	223AGE008	JAPANESE LANGUAGE (N5 LEVEL)	3-0-0	3	-
	10	223AGE009	PRINCIPLES OF AUTOMATION	3-0-0	3	-
	11	223AGE010	REUSE AND RECYCLE TECHNOLOGY	3-0-0	3	-
	12	223AGE011	SYSTEM MODELING	3-0-0	3	-
	13	223AGE012	EXPERT SYSTEMS	3-0-0	3	-

MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC according to their convenience, but shall complete it by third semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

TEMPLATE FOR SYLLABUS

CODE		CATEGORY	L	T	P	CREDIT
223AGE100	**ACADEMIC WRITING**	AUDIT COURSE	3	0	0	NIL

Preamble: Learning academic writing sharpens minds, teaches students how to communicate, and develops their thinking capacities and ability to understand others. Writing is thinking, and every student deserves to be a strong thinker. It can also make them think more carefully about what they write. Showing work to others can help to foster a better culture of learning and sharing among students. It also gives students a sense of how they are contributing to the body of work that makes up an academic subject.

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the course the student will be able to

CO 1	Understand the principles of scientific/ academic writing
CO 2	Analyse the technique of scientific writing from the reader's perspective
CO 3	Apply the concepts of setting expectations and laying the progression tracks
CO 4	Evaluate the merits of a title, abstract , introduction, conclusion and structuring of a research paper
CO 5	Justify the need using a project proposal or a technical report
CO 6	Prepare a review paper, an extended abstract and a project proposal

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1		3	1				
CO 2		3	1				
CO 3		3	1			2	
CO 4		3	1				
CO 5		3	2	2		2	
CO 6	1	3	3	2		2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	30%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 marks

The examination will be conducted by the respective College. The examination willbe for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. Each question can carry 12 marks.

Model Question paper

		SET1	**Total Pages:**
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024			
Course Code: 223AGE100			
Course Name: Academic Writing			
Max. Marks: 60			Duration: 2.5 Hours
Answer any five full questions, each carries 12 marks.			

1 a)	Make clear-cut distinctions between 6 factors that take their toll on readers' memory.	6
1 b)	How can you sustain the attention of the reader to ensure continuous reading?	6
2 a)	What are the different methods by which you can create expectations in the reader?	6
2 b)	Give an account of the topic and non-topic based progression schemes.	6
3 a)	Bring out the differences between an abstract and the introduction of a research paper.	8
3 b)	How are the title of the research paper and its structure related?	4
4	What are 7 principles for including visuals in your research paper. What are the recommended constituents of a conclusion segment of a research paper?	12

5	Give a detailed description of the process and contents of a project proposal for funding.	12
6 a)	What are the contexts recommended for choosing between active and passive voices in technical writing?	8
6 b)	What are the different visual forms that are relevant in a research paper and how do you choose them?	4
7	Give the design of a research paper with the purposes each part serves.	12
	****	

Syllabus and Course Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

Syllabus:

CODE 223AGE100	**ACADEMIC WRITING**	**Audit**
Module No.	Topics in a module	Hours
1	Fundamentals of Academic writing from a reader's perspective: acronyms, synonyms, pronouns, disconnected phrases, background ghettos, abusive detailing, cryptic captions, long sentences : all that take their toll on readers' memory.	6
2	Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption	6
3	How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings	6
4	Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing	6
5	Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report.	6

Course Plan:

No	Topic	No. of Lectures
1	Fundamentals of Academic writing from a reader's perspective: acronyms, synonyms, pronouns, disconnected phrases, background ghettos, abusive detailing, cryptic captions, long sentences all take their toll on readers' memory.	
1.1	The Reading tool-kit to reduce memory required; reduce reading time	1
1.2	Acronyms, Pronouns, Synonyms; Background, broken couple, words overflow	1
1.3	Sustain attention: Keep the story moving forward; Twists, shouts, Pause to clarify, recreate suspense	2

1.4	Keep the reader motivated: Fuel and meet Expectations; Bridge knowledge gap: ground level; Title words; Just In Time to local background	2
2	Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption	
2.1	Setting expectations of the reader from Grammar, from theme	1
2.2	Progression tracks for fluid reading: Topic & stress; topic and non topic based progression tracks; pause in progression	2
2.3	Detection of sentence fluidity problems: No expectations/ Betrayed expectations	2
2.4	Controlling reading energy consumption: the energy bill; Energy fuelling stations: Pause	1
3	How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings	
3.1	Title: Face of the paper: Techniques, Qualities & Purpose of title; Metrics	1
3.2	Abstract: Heart of the paper: 4 parts; coherence; tense of verbs, precision; purpose & qualities of the abstract; Metrics	2
3.3	Structure: Headings & sub-headings: Skeleton of the paper: principles for a good structure; Syntactic rules; Quality & Purpose of structures; Metrics	1
3.4	Introduction: Hands of the paper: Start, finish; scope, definitions; answers key reader questions; As a personal active story; Traps, qualities; Metrics	2
4	Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing	
4.1	Visuals as the voice of your paper: principles; purpose & qualities of visuals; metrics	2
4.2	Conclusion: contents; purpose, quality; metrics; Abstracts Vs. Conclusion; examples, counter-examples	1
4.3	References, Bibliography: Styles, punctuation marks, quotes, citations	1
4.4	Grammar in Technical writing: Articles, Syntax, Main and subordinate clauses; Active & passive voices; some commonly made mistakes in technical writing.	2
5	Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report.	
5.1	Extended abstract: abstract and keywords, introduction and objective, method, findings and argument, conclusion and suggestions and references.	1
5.2	Project Proposal:Types, executive summary, background including status, objectives, solution, milestones, deliverables, timelines, resources, budgeting, conclusion	2
5.3	Research paper: writing an overview article: provide a comprehensive foundation on a topic; explain the current state of knowledge; identify gaps in existing studies for potential future research; highlight the main methodologies and research techniques	2

5.4	Writing Technical Reports: Title page; Summary; Table of contents; Introduction; Body; Figures, tables, equations and formulae; Conclusion; Recommendations.	1
		30

Reference Books

1. SCIENTIFIC WRITING 2.0 A Reader and Writer's Guide: Jean-Luc Lebrun, World ScientiVic Publishing Co. Pte. Ltd., 2011

2. How to Write and Publish a ScientiVic Paper: Barbara Gastel and Robert A. Day, Greenwood publishers, 2016

3. Grammar, Punctuation, and Capitalisation; a handbook for technical writers and editors. www.sti.nasa.gov/publish/sp7084.pdf www.sti.nasa.gov/sp7084/contents.html

4. Everything You Wanted to Know About Making Tables and Figures. http://abacus.bates.edu/%7Eganderso/biology/resources/writing/ HTWtableVigs.html

223AGE001	ADVANCED ENGINEERING MATERIALS	CATEGORY	L	T	P	CREDIT
		AUDIT COURSE	3	0	0	-

Preamble: This course is designed in a way to provide a general view on typically used advanced classes of engineering materials including metals, polymers, ceramics, and composites.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse the requirement and find appropriate solution for use of materials.
CO 2	Differentiate the properties of polymers, ceramics and composite materials.
CO 3	Recognize basic concepts and properties of functional materials.
CO 4	Comprehend smart and shape memory materials for various applications.
CO 5	Appraise materials used for high temperature, energy production and storage applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	□				□	□	
CO 2	□				□	□	
CO 3	□				□	□	
CO 4	□				□	□	
CO 5	□				□	□	

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	60%
Apply	20%
Analyse	20%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 marks

The examination will be conducted by the respective College. The examination willbe for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Vive. Each question can carry 12 marks.

Model Question paper

AUDIT COURSE

223AGE001 - ADVANCED ENGINEERING MATERIALS

(Answer any five questions. Each question carries 12 Marks)

1.	a) State the relationship between material selection and processing.	**5**
	b) Write about the criteria for selection of materials with respect to the cost and service requirements for engineering applications.	**7**
2.	a) Differentiate thermosetting and thermoplastics with suitable examples.	**5**
	b) Briefly discuss about the properties and applications of polymer nano composite materials.	**7**
3.	a) Write about the potential application areas of functionally graded materials.	**5**
	b) With a neat sketch describe any one processing technique of functionally graded materials.	**7**
4.	a) "Smart materials are functional"? Justify the statement.	**5**
	b) Explain the terms electrostriction and magnetostriction with its application.	**7**

5.	a) What are the factors influencing functional life of components at elevated temperature?	**5**
	b) What are super alloys and what are their advantages?	**7**
6	a) What is a shape memory alloy? What metals exhibit shape memory characteristics?	**4**
	b) Explain about the detection capabilities and uses of pyroelectric sensors.	**8**
7	a) Differentiate between conventional batteries and fuel cells.	**4**
	b) Explain the construction and working of a Li-ion battery.	**8**

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	Requirements / needs of advanced materials. Classification of materials, Importance of materials selection, Criteria for selection of materials; motivation for selection, cost basis and service requirements. Relationship between materials selection and processing.	**5**	**20**
II	Classification of non-metallic materials. Polymer, Ceramics: Properties, processing and applications. Nano Composites - Polymer nanocomposites (PNCs), Processing and characterisation techniques – properties and potential applications.	**7**	**20**
III	Functionally graded materials (FGMs), Potential Applications of FGMs, classification of FGMs, processing techniques. limitations of FGMs.	**6**	**20**
IV	Smart Materials: Introduction, smart material types - pyroelectric sensors, piezoelectric materials, electrostrictors and magnetostrictors, shape memory alloys – associated energy stimulus and response forms, applications.	**5**	**20**
V	High Temperature Materials: super alloys – main classes, high temperature properties of superalloys, applications. Energy Materials: materials for batteries.	**7**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Selection of materials for engineering applications**	
1.1	Benefits of advanced materials, classification of materials, importance of materials selection	2
1.2	Selection of materials for different properties, strength, toughness, fatigue and creep	1
1.3	Selection for surface durability, corrosion and wear resistance	1
1.4	Relationship between materials selection and processing	1
2	**Classification of non-metallic materials & nano composites**	
2.1	Rubber: properties, processing and applications.	1
2.2	Plastics: thermosetting and thermoplastics, applications and properties.	2
2.3	Ceramics: properties and applications.	1
2.4	Introduction to nano composites, classification	1
2.5	Processing and characterisation techniques applicable to polymer nanocomposites.	2
3	**Functionally graded materials**	
3.1	General concept, Potential Applications of FGMs	2
3.2	Classification of FGMs	1
3.3	FGMs processing techniques: powder metallurgy route, melt-processing route	2
3.4	Limitations of FGMs	1
4	**Smart materials**	
4.1	Introduction to smart materials, types	1
4.2	Pyroelectric sensors-material class, stimulus, detection capabilities and uses	1
4.3	Piezoelectric materials- material class, stimulus, sensing and actuating applications	1
4.4	Electrostrictors and magnetostrictors - material class, stimulus, micro positioning capabilities and applications	1
4.5	Shape memory alloys (SMAs) - material class, stimulus, temperature sensing and high strain responses, applications.	1
5	**High Temperature Materials and Energy Materials**	
5.1	Characteristics of high-temperature materials, superalloys as high-temperature materials	1
	superalloys - properties and applications	2
5.2	Introduction to lithium-ion battery (LIBs), operating mechanisms and applications	2
5.3	Introduction to Zn-based battery system, types and existing challenges	2

Reference Books

1. DeGarmo et al, “Materials and Processes in Manufacturing”, 10th Edition, Wiley, 2008.
2. R.E. Smallman and A.H.W. Ngan, Physical Metallurgy and Advanced Materials, Seventh Edition, Butterworth-Heinemann, 2007
3. Vijayamohanan K. Pillai and Meera Parthasarathy, “Functional Materials: A chemist’s perspective”, Universities Press Hyderabad (2012).
4. M.V. Gandhi, B.S. Thompson: Smart Materials and Structures, Chapman & Hall, 1992.
5. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials) Springer; 1 edition (May 19, 2000)
6. Inderjit Chopra, Jayant Sirohi, “Smart Structures Theory”, Cambridge University Press, 2013

223AGE003	DATA SCIENCE FOR ENGINEERS	CATEGORY	L	T	P	CREDIT
		AUDIT COURSE	3	0	0	0

Preamble: This course covers essentials of statistics and Linear Algebra and how to prepare the data before processing in real time applications. The students will be able to handle missing data and detection of any outliers available in the dataset. This course explores data science, Python libraries and it also covers the introduction to machine learning for engineers.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Study Data Science Concepts and statistics
CO 2	Demonstrate Understanding of Mathematical Foundations needed for Data Science
CO 3	Understand Exploratory analysis and Data Visualization and Preprocessing on given dataset
CO 4	Implement Models such as Naive Bayes, K-Nearest Neighbors, Linear and Logistic Regression
CO 5	Build real time data science applications and test use cases

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7
CO 1	2		2			2	
CO 2	2		2	1		2	
CO 3	2		2	2	2	2	
CO 4	2		2	2	3	2	
CO 5	2		2	3	3	3	2

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	50%
Apply	30%
Analyse	20%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:**60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 mark.

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	**Statistics for Data science** Probability: Basic concepts of probability, conditional probability, total probability, independent events, Bayes' theorem, random variable, Population, Sample, Population Mean, Sample Mean, Population Distribution, Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Measure of Dispersion, Variance, Standard Deviation, Gaussian/Normal Distribution, covariance, correlation.	**6**	**20**
II	**Linear Algebra** Vectors and their properties, Sum and difference of Vectors, distance between Vectors, Matrices,Inverse of Matrix, Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition	**6**	**20**
III	**Hypothesis Testing** Understanding Hypothesis Testing, Null and Alternate Hypothesis, Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method, Types of Errors-Type1 Error,Type2 Error, Types of Hypothesis Test Z Test, Chi-Square	**6**	**20**

IV	**Exploratory Data Analysis** Data Collection –Public and Private Data, Data Cleaning-Fixing Rows and Columns, Missing Values, Standardizing values, invalid values, filtering data, Data-Integration,Data-Reduction,Data Transformation	**6**	**20**
V	**Machine Learning and Python for Data Science** Python Data structures-List, Tuple, Set, Dictionary, Pandas, Numpy, Scipy, Matplotlib, Machine Learning-Supervised Machine Learning, Unsupervised Machine Learning,Regression, Classification, Naïve-Bayes	**6**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Statistics for Data science**	
1.1	Probability: Basic concepts of probability, conditional probability, total probability	1
1.2	independent events, Bayes' theorem, random variable, Population	1
1.3	Sample, Population Mean, Sample Mean, Population Distribution	1
1.4	Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Propositional logic and predicate logic	1
1.5	Measure of Dispersion, Variance, Standard Deviation	1
1.6	Gaussian/Normal Distribution, covariance, correlation.	1
2	**Linear Algebra**	
2.1	Vectors and their properties,	1
2.2	Sum and difference of Vectors, distance between Vectors	1
2.3	Matrices,Inverse of Matrix,	2
2.4	Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition	2
3	**Hypothesis Testing**	
3.1	Understanding Hypothesis Testing, Null and Alternate Hypothesis	1
3.2	Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method,	2
3.3	Types of Errors-Type1 Error,Type2 Error,	1
3.4	Types of Hypothesis Test Z Test, Chi-Square,	2
4	**Exploratory Data Analysis**	
4.1	Data Collection –Public and Private Data	1
4.2	Data Cleaning-Fixing Rows and Columns	1
4.3	Missing Values	1
4.4	Standardizing values	1
4.5	Invalid values, filtering data	1
4.6	Data Integration, Data Reduction, Data Transformation	1

5	**Machine Learning and Python for Data Science**	
5.1	Python Data structures-List, Tuple, Set,	1
5.2	Dictionary, Pandas, Numpy, Matplotlib	2
5.3	Machine Learning-Supervised Machine Learning, Unsupervised Machine Learning	1
5.4	Regression, Classification	1
5.5	Naïve-Bayes	1

Reference Books

1. Python Data Science Handbook. Essential Tools for Working with Data, Author(s): Jake VanderPlas, Publisher: O'Reilly Media, Year: 2016
2. Practical Statistics for Data Scientists: 50 Essential Concepts, Author(s): Peter Bruce, Andrew Bruce, Publisher: O'Reilly Media, Year: 2017
3. Practical Linear Algebra for Data Science, by Mike X Cohen, Released September 2022, Publisher(s): O'Reilly Media, Inc.
4. Data Science from Scratch 'by Joel Grus, Released, April 2015, Publisher(s): O'Reilly Media, Inc.
5. Hands-On Exploratory Data Analysis with Python, by Suresh Kumar Mukhiya, Usman Ahmed, Released March 2020,Publisher(s): Packt Publishing

SET1 **Total Pages:**

Reg No.:_ Name:_____

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024

Course Code: 223AGE003

Course Name: DATA SCIENCE FOR ENGINEERS

Max. Marks: 60 Duration: 2.5 Hours

Answer any five full questions, each carries 12 marks.

1	a) It is observed that 50% of mails are spam. There is software that filters spam mail before reaching the inbox. It accuracy for detecting a spam mail is 99% and chances of tagging a non-spam mail as spam mail is 5%. If a certain mail is tagged as spam finds the probability that it is not a spam mail.	5
	b) Depict the relevance of measures of central tendency in data wrangling with a suitable example	7
2.	a) Calculate the inverse of the Matrix 2 4 -6 7 3 5 1 -2 4	4
	b)Find all Eigenvalues and Corresponding Eigenvectors for the matrix if 2 -3 0 2 -5 0 0 0 3	8
3.	a) A statistician wants to test the hypothesis H0: $\mu = 120$ using the alternative hypothesis Hα: $\mu > 120$ and assuming that $\alpha = 0.05$. For that, he took the sample values as n =40, $\sigma = 32.17$ and $\bar{x} = 105.37$. Determine the conclusion for this hypothesis?	5
	b) Hypothesis testing is an integral part of statistical inference, list out the various types of hypothesis testing and also mentions their significances in data science.	7
4.	a) Brief in detail directional and non-directional hypothesis	6
	b) Differentiate null and alternate hypothesis and also elaborate on type 1 and type 2 errors	6
5.	a) Explain the concepts of Tuple, List and Directory in python with example	6
	b) Elucidate reinforcement learning and application in real world.	6

6. a) What is Feature Engineering , demonstrate with an example 6

b) Describe in detail different steps involved in data preprocessing. 6

7. a) Illustrate supervised learning model with linear regression model 5

b) Predict the probability for the given feature vector if an accident will happen or not? 7

Weather condition: rain, Road condition: good, Traffic condition: normal, Engine problem: no, the task is to predict using Naïve Bayes classification.

SNo.	Weather condition	Road condition	Traffic condition	Engine problem	Accident
1	Rain	bad	high	no	yes
2	snow	average	normal	yes	yes
3	clear	bad	light	no	no
4	clear	good	light	yes	yes
5	snow	good	normal	no	no
6	rain	average	light	no	no
7	rain	good	normal	no	no
8	snow	bad	high	no	yes
9	clear	good	high	yes	no
10	clear	bad	high	yes	yes

223AGE004	DESIGN THINKING	CATEGORY	L	T	P	CREDIT
		AUDIT COURSE	3	0	0	-

Preamble:

This course offers an introductory exploration of fundamental engineering concepts and techniques, the design process, analytical thinking and creativity, as well as the fundamentals and development of engineering drawings, along with their application in engineering problems.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Identify and frame design challenges effectively.
CO 2	Generate creative ideas through brainstorming and ideation
CO 3	Iterate on designs based on user insights
CO 4	Apply Design Thinking to real-world problems and projects.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1				2		2	2
CO 2	2		2	2			2
CO 3		2		2		2	2
CO 4	2		2	3	2		2

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40
Analyse	30
Evaluate	30
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

AUDIT COURSES

Continuous Internal Evaluation Pattern: 40 marks

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 marks

The examination will be conducted by the respective College. The examination willbe for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

Model Question paper

		SET1	**Total Pages:**
Reg No.:_____			Name:_____
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024			
Course Code: 223AGE004			
Course Name: DESIGN THINKING			
Max. Marks: 60			Duration: 2.5 Hours
Answer any five full questions, each carries 12 marks.			

1 a)	How can a multidisciplinary team collaborate effectively to implement design principles?	7
1 b)	What are the key differences between human-centred design and other design methodologies?	5
2 a)	How do you measure the success of a design project in terms of user satisfaction and impact?	7
2 b)	How does the iterative nature of the design process contribute to better outcomes	5

3 a)	What are the fundamental principles of effective brainstorming, and how do they differ from traditional problem-solving approaches?	7
3 b)	What are some key principles of ergonomic design, and how do they contribute to the usability and comfort of products?	5
4 a)	Enumerate some examples of successful and unsuccessful market testing scenarios, and what lessons can be learned from these experiences to improve future product or service launches?	7
4b)	What is the primary purpose of creating prototypes in the design and development process?	5
5	What strategies and methodologies can designers use to embrace agility and respond quickly to changing user needs and market dynamics?	12
6	Illustrate any four examples of successful bio-mimicry applications in various industries.	12
7	What ethical considerations should designers keep in mind when designing for diverse user groups?	12
	****	

Syllabus:

Module 1

Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking, Role of design thinking in the human-centred design process. Design space, Design Thinking in a Team Environment, Team formation.

Module 2

Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test. The importance of empathy, Building a user-centred mindset. Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications.

Module 3

Generating Ideas, Brainstorming techniques, Application of Aesthetics and Ergonomics in Design. Bio-mimicry, Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.

Module 4

Use of prototyping, Types of prototypes, Rapid prototyping techniques, User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest

Module 5

Entrepreneurship/business ideas, Patents and Intellectual Property, Agility in design, Ethical considerations in design. Overcoming common implementation challenges

Corse Plan SyllabusandCorsePlan (For 3credit courses, thec ontent can be for 40 hrs and for2credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30hours).

No	Topic	No. of lectures
1	**Design process:**	
1.1	Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking.	3
1.2	Role of design thinking in the human-centred design process. Design space,	2
1.3	Design Thinking in a Team Environment, Team formation.	2

2	**Design Thinking Stages:**	
2.1	Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test.	2
2.2	The importance of empathy, Building a user-centred mindset.	2
2.3	Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications.	3
3	**Ideation**	
3.1	Generating Ideas, Brainstorming techniques.	2
3.2	Application of Aesthetics and Ergonomics in Design. Bio-mimicry.	3
3.3	Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.	2
4	**Prototyping and testing**	
4.1	Use of prototyping, Types of prototypes, Rapid prototyping techniques.	3
4.2	User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest	2
5	**IPR in design**	
5.1	Entrepreneurship/business ideas, Patents and Intellectual Property.	2
5.2	Agility in design, Ethical considerations in design. Overcoming common implementation challenges	2

Reference Books

1. Christoph Meinel, Larry Leifer and Hasso Plattner- "Design Thinking: Understand – Improve – Apply", Springer Berlin, Heidelberg, 2011.
2. Thomas Lockwood and Edgar Papke – "Design Thinking: Integrating Innovation, Customer Experience, and Brand Value", Allworth Press, 2009.
3. Pavan Soni – "Design Your Thinking", Penguin Random House India Private Limited, 2020.
4. Andrew Pressman- "Design Thinking : A Guide to Creative Problem Solving for Everyone", Taylor & Francis, 2018.
5. N Siva Prasad, "Design Thinking Techniques an Approaches" Ane Books Pvt. Ltd.,2023

SYLLABUS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
223AGE005	FUNCTIONAL PROGRAMMING IN HASKELL	AUDIT COURSE	3	0	0	-

Preamble: This course introduces a functional programming approach in problem solving. Salient features of functional programming like recursion, pattern matching, higher order functions etc. and the implementation in Haskell are discussed.

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Understand the functional programming paradigm which is based on the mathematics of lambda calculus.
CO 2	Develop Haskell programs using functions, guards and recursive functions
CO 3	Apply the concept of tuples, lists and strings in Haskell programming
CO 4	Apply the concept of algebraic data types, abstract data types, modules, recursive data types and user defined data types in Haskell programming
CO 5	Develop Haskell programs with files for reading input and storing output

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1					3		
CO 2	2			2	3		
CO 3	2			2	3		
CO 4	2			2	3		
CO 5	2			2	3		

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	40%
Evaluate	20%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Course based task : 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus**.**

End Semester Examination: 60 marks

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

Model Question paper

			Total Pages:
Reg No.:_____		Name:_____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2023			
Course Code: 223AGE005			
Course Name: Functional Programming in Haskell			
Max. Marks: 60		Duration: 2.5 Hours	
Answer any five full questions, each carries 12 marks.			

1 a.	Explain the basic differences between imperative style programming and functional style programming.	3
1 b.	Analyse each of the following lambda expressions to clarify its structure. If the expression is a function, identify the bound variable and the body expression, and then analyse the body expression. If the expression is an application, identify the function and argument expressions, and then analyse the function and argument expressions: i) λa.(a λb.(b a)) ii) λx.λy.λz.((z x) (z y)) iii) (λf.λg.(λh.(g h) f) λp.λq.p)	9
2 a.	Design a recursive function to find 2^n where n is a natural number.	4

2 b.	Explain various forms of function definitions in Haskell with the help of examples.	8
3 a.	Explain any three list operations along with function definitions and examples.	6
3 b.	Write a program to duplicate only even numbers among the elements of a list using a Haskell function by (i) Recursion (ii) List Comprehension and explain. Example : λ> dupli [1, 2, 3] ANS: [2,2]	6
4	Write Recursive definitions along with an explanation for the below arithmetic operations. Illustrate the recursive flow with the help of a diagram. i. add x y ii. mult x y iii. div x y	12
5	Write the Haskell code to split a list into two lists such that the elements with odd index are in one list while the elements with even index are in the other list.	12
6 a	Give the type definition of a binary tree along with explanation of two functions on binary trees.	6
6 b	Define a queue data type in Haskell along with any two operations on it with examples.	6
7 a.	Explain the basic steps of reading from files and writing to files in Haskell.	4
7 b.	Write a Haskell program to read from the file "input.txt", display the contents on the screen and write the contents to another file "output.txt".	8
****		

Syllabus and Corse Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

Module 1 (5 Hrs)

Introduction to Functional Programming: Programming language paradigms, imperative style programming, comparison of programming paradigms.
Functional programming, Functions - Mathematical concepts and terminology, Lambda calculus, Function definitions, programs as functions, Functional programming Languages. Haskell basics, GHCi interpreter.

Module 2 (6 Hrs)

Programming in Haskell: Expressions and evaluation, Lazy evaluation, let expressions, scopes.

Basic data types in Haskell, operators, infix operators, associativity and precedence, Arithmetic functions.

types, definitions, currying and uncurrying, type abstraction.

Function definitions, pattern matching, guards, anonymous functions, higher order functions.

Recursion, Programming exercises.

Module 3 (7 Hrs)

Data types: tuples and lists: Tuples , Lists: building lists, decomposing lists, functions on lists, built-in functions on lists, primitive and general recursion over lists, infinite lists.

Strings: functions on strings.

Polymorphism and overloading, conditional polymorphism

Module 4 (6 Hrs)

Type classes, Algebraic data types, Modules, Recursive data types.

User defined data types, Records, Stacks, Queues, Binary trees, Constructors, Destructors.

Module 5 (6 Hrs)

Functor, Applicative functor, Monad

Programming with actions: Functions vs actions, Basics of input / output, the do notation, interacting with the command line and lazy I/O, File I/O.

No	Topic	No. of Lectures
1	**Introduction to Functional Programming**	
1.1	Programming language paradigms, imperative style programming, comparison of programming paradigms	1
1.2	Functional programming, Functions - Mathematical concepts and terminology	1
1.3	Lambda calculus	1
1.4	Function definitions, programs as functions, Functional programming Languages	1
1.5	Haskell basics, GHCi interpreter	1
2	**Haskell basics**	
2.1	Expressions and evaluation, Lazy evaluation	1
2.2	let expressions, scopes, Basic data types in Haskell	1
2.3	operators, infix operators, associativity and precedence, Arithmetic	1

	functions	
2.4	types, definitions, currying and uncurrying, type abstraction.	1
2.5	Function definitions, pattern matching, Guards	1
2.6	anonymous functions, higher order functions, Recursion	1
3	**Data types: tuples and lists**	
3.1	Tuples , Lists: building lists, decomposing lists	1
3.2	functions on lists, built-in functions on lists	1
3.3	primitive and general recursion over lists	1
3.4	infinite lists	1
3.5	Strings: functions on strings	1
3.6	Polymorphism and overloading	1
3.7	conditional polymorphism	1
4	**User defined data types**	
4.1	Type classes, Algebraic data types, Modules	1
4.2	Recursive data types	1
4.3	User defined data types, Records	1
4.4	Stacks, Queues	1
4.5	Binary trees	1
4.6	Constructors, Destructors	1
5	**Programming with actions**	
5.1	Functor, Applicative functor,	1
5.2	Monad	1
5.3	Programming with actions: Functions vs actions, Basics of input / output, the do notation	1
5.4	interacting with the command line and lazy I/O	1
5.5	File I/O	2

Reference Books

[1] Richard Bird, “Introduction to functional programming using Haskell', second edition, Prentice hall series in computer science

[2] Bryan O'Sullivan, Don Stewart, and John Goerzen, “Real World Haskell”

[3] Richard Bird, “Thinking Functionally with Haskell”, Cambridge University Press, 2014

[4] Simon Thompson, “Haskell: The Craft of Functional Programming”, Addison-Wesley, 3rd Edition, 2011

[5] H. Conrad Cunningham, “Notes on Functional Programming with Haskell”, 2014

[6] Graham Hutton, “Programming in Haskell”, Cambridge University Press, 2nd Edition, 2016

[7] Alejandro Serrano Mena, “Practical Haskell: A Real-World Guide to Functional Programming”, 3rd Edition, Apress, 2022

[8] Miran Lipovaca, “Learn You a Haskell for Great Good!: A Beginner's Guide”, No Starch Press, 2011

223AGE010	REUSE AND RECYCLE TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		AUDIT COURSE	3	0	0	-

Preamble: "Reuse and Recycle Technology" typically focuses on sustainable practices and technologies aimed at reducing waste, conserving resources, and promoting environmental responsibility.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the principles and technologies behind waste reduction, resource conservation, and sustainable practices
CO 2	Describe and Analyze waste generation and management.
CO 3	Apply the knowledge of various reuse strategies and their application in different industries and Analyze various recycling technologies
CO 4	Appraise the methods of E-waste management and Eco friendly packaging
CO 5	Comprehend Environmental Regulations and Policies**,** Understand the importance of environmental regulations and policies in addressing environmental challenges

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2				3		
CO 3				3		
CO 4					3	
CO 5			3			

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	60%
Apply	20%
Analyse	20%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task : 15 marks
Seminar/Quiz : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 marks

The examination will be conducted by the respective College. The examination willbe for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

Model Question paper

AUDIT COURSE

223AGE010 - REUSE AND RECYCLE TECHNOLOGY

Answer any five full questions, each carries 12 marks.

1.	(a) What are the 3 pillars of sustainability? *(b)* What is sustainable waste management? What makes sustainable waste management so important?	5 7
2.	(a)How do the three categories of municipal solid waste differ? *(b)* Discuss the municipal waste collection and management?	5 7
3.	(a)Explain the major differences between Reuse and Recycle? *(b)* Give an overview of recycling technologies used for any two materials. Discuss the Process involved.	5 7
4.	(a)What are the common source of E-waste *(b)* What are the challenges and opportunities in E-waste management	5 7
5.	(a)What is the case law for waste recycling in India *(b)* Discuss sustainable packaging and its environmental impacts	5 7
6.	Explain the various environmental regulations in India for addressing Environmental challenges	12
7.	a) Give examples of water reuse technologies in circular economy b) How can we reduce e-waste with sustainable solutions	5 7

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	**Introduction to Sustainability**, Understanding sustainability and its importance, The three pillars of sustainability: Environmental, Social, and Economic. Biodiversity conservation, Climate change and mitigation Sustainable resource management.	**6**	**20**
II	**Waste Management,** Definition and classification of waste, Waste Generation and Composition**,** Waste Collection and Transportation, Waste Segregation and Sorting. Waste Disposal Methods Historical perspectives on waste management, The three Rs: Reduce, Reuse, and Recycle.	**6**	**20**
III	**Recycling and Reuse:** Importance of reuse, Application of reuse in various industries, Challenges and opportunities in reuse, Overview of recycling technologies, Circular economy, Sorting and processing of recyclable materials, Advanced recycling methods. Emerging technologies in recycling.	**6**	**20**
IV	**E-waste Recycling,** Challenges and environmental impact of electronic waste, E-waste recycling methods and regulations, Sustainable electronics design, **Sustainable Packaging,** Packaging materials and their environmental impact, Eco-friendly packaging alternatives, Packaging design for sustainability	**6**	**20**
V	**Environmental Regulations and Policies,** Understand the importance of environmental regulations and policies in addressing environmental challenges, National and international waste and recycling regulations, Compliance and enforcement, Industry standards and certifications	**6**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Sustainability (6)**	
1.1	Understanding sustainability and its importance	1
1.2	The three pillars of sustainability: Environmental, Social, and Economic.	3
1.3	Biodiversity conservation, Climate change and mitigation	1
1.4	Sustainable resource management	1
2	**Waste Management (6)**	
2.1	Definition and classification of waste	1
2.2	Waste Generation and Composition	1
2.3	Waste Collection and Transportation.	1
2.4	Waste Segregation and Sorting.	1
2.5	Waste Disposal Methods	1
2.6	Historical perspectives on waste management, The three Rs: Reduce, Reuse, and Recycle.	1
3	**Recycling and Reuse (6)**	
3.1	Importance of reuse, Examples of reuse in various industries.	1
3.2	Challenges and opportunities in reuse	1
3.3	Overview of recycling technologies, Sorting and processing of recyclable materials	2
3.4	Advanced recycling methods	1
3.5	Emerging technologies in recycling.	1
4	**E-waste Recycling (6)**	
4.1	Challenges and environmental impact of electronic waste	1
4.2	E-waste recycling methods and regulations	1
4.3	Sustainable electronics design	1
4.4	Packaging materials and their environmental impact	1
4.5	Eco-friendly packaging alternatives	1
4.6	Packaging design for sustainability	1
5	**Environmental Regulations and Policies (6)**	
5.1	Importance of environmental regulations and policies in addressing environmental challenges	2
5.2	National and international waste and recycling regulations	2
5.3	Industry standards and certifications, Compliance and enforcement	2

Reference Books

1. Sustainable Engineering: Concepts, Design and Case Studies, David T. Allen, Pearson Publication.
2. A Comprehensive Book on Solid Waste Management with Application, Dr. H.S. Bhatia , Misha Books, 2019
3. "Cradle to Cradle: Remaking the Way We Make Things" by William McDonough and Michael Braungart.
4. "Recycling of Plastic Materials" edited by Vijay Kumar Thakur
5. E-waste: Implications, Regulations and Management in India and Current Global Best Practices, Rakesh Johri, TERI
6. "Sustainable Packaging", Subramanian Senthilkannan Muthu , Springer Nature.
7. **I**ndian Environmental Law: Key Concepts and Principles " Orient Black swan Private Limited, New Delhi.

223AGE012	EXPERT SYSTEMS	CATEGORY	L	T	P	CREDIT
		AUDIT COURSE	3	0	0	-

Preamble: The course aims to provide an understanding of the basic concepts of Artificial Intelligence (AI) and Expert Systems. The course also covers the knowledge representation in expert systems, classes of expert systems, applications of expert systems.

Course Outcomes: After the completion of the course the student will be able to:

CO 1	Explain the concepts of Artificial Intelligence and different ways of knowledge representations.
CO 2	Explain the components of expert systems, development stages of expert systems and tools available for expert system design.
CO 3	Apply the concept of knowledge representation in expert systems
CO 4	Differentiate the classes of expert systems and examine properties of existing systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7
CO 1	1		2	1	2	2	
CO 2	1		1	3	2	2	
CO 3	1		1	2	2	2	
CO 4	2		2	2	3	2	

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	60%
Apply	20%
Analyse	20%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:**60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 mark.

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024		
Course Code: 223AGE012		
Course Name: EXPERT SYSTEMS		
Max. Marks: 60	Duration: 2.5 Hours	
Answer any five full questions, each carries 12 marks.		
1	a) What are the types of AI? Explain with examples .	6
	b) What do you mean by knowledge in AI and explain the different ways of knowledge representation used in AI?	6
2.	a) Write note on semantic network.	6
	b) What are Predicates? Explain its syntax and semantics.	6
3.	a) Write notes on different tools available for expert system design.	6
	b). What are the different stages in the development of an expert system?	6
4.	a) Illustrate Conceptual Dependencies with an example.	6
	b) Illustrate with an example the Structured Knowledge representation of an Expert System.	6
5.	a) What do you mean by Frame based Expert System? Explain	6
	b)Explain the architecture of MYCIN	6
6.	a)Explain Fuzzy based expert systems	6
	b) Explain the neural network based expert systems	6
7.	a) Explain any two applications of expert systems?	6
	b)What are the limitations of expert system ? Explain	6

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	Overview of Artificial Intelligence (AI): Definition & Importance of AI. Knowledge general concepts: Definition and Importance of knowledge, Knowledge-Based Systems, Knowledge organization, Knowledge Manipulation and acquisition. Knowledge Representation: Introduction, Syntax and Semantics- Propositional logic and predicate logic.	**6**	**20**
II	Basic concepts of expert systems-Introduction to expert systems, Components of expert systems. Features of Expert System, Stages in the development of expert system, Types of tools available for expert system design	**6**	**20**
III	Knowledge representation in expert systems: Structured Knowledge representation: Graphs, Frames and related structures, Associative networks, Conceptual dependencies, Examples of structured knowledge representation.	**6**	**20**
IV	Classes of expert systems: Rule-based expert systems, Example- MYCIN, Frame-based expert system, terminologies, IF-THEN structure. Fuzzy and Neural network based expert systems(basic concepts)	**7**	**20**
V	Currents trends in expert systems, Advantages and limitations of expert systems, Applications of expert systems.	**5**	**20**

Course Plan

No	Topics	No. of Lectures
1	**Overview of Artificial Intelligence& Knowledge general concepts**	
1.1	Definition & Importance of AI	1
1.2	Definition and Importance of Knowledge,	1
1.3	Knowledge-Based Systems, Knowledge Organization	1
1.4	Knowledge Manipulation and acquisition	1
1.5	Knowledge Representation: Introduction, Syntax and Semantics	1
1.6	Propositional logic and predicate logic	1
2	**Basic concepts of expert systems**	
2.1	Introduction to Expert System, Components of expert systems	2
2.2	Features of Expert System, Stages in the development of expert system	2
2.3	Types of tools available for expert system design	2
3	**Knowledge representation in expert systems**	
3.1	Structured Knowledge representation	1
3.2	Graphs, Frames and Related Structures	2
3.3	Associative Networks, Conceptual Dependencies	2
3.4	Examples of structured knowledge representation	1
4	**Classes of expert systems**	
4.1	A rule-based expert system -Introduction	1
4.2	MYCIN	1
4.3	IF-THEN structure	1
4.4	Frame-based expert system	2
4.5	Fuzzy based expert systems	1
4.6	Neural network based expert systems	1
5	**Currents trends and applications of expert systems**	
5.1	Currents trends of expert systems	2
5.2	Advantages and limitations of expert systems	1
5.3	Applications of expert systems	2

Reference Books

1. E. Rich & K. Knight - Artificial Intelligence, 2/e, TMH, New Delhi, 2005.
2. P.H. Winston - Artificial Intelligence, 3/e, Pearson Edition, New Delhi, 2006.
3. D.W. Rolston - Principles of AI & Expert System Development, TMH, New Delhi
4. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE) ", McGraw Hill – 2010
5. Dan W Patterson, 'Introduction to Artificial intelligence and Expert systems', Prentice Hall of India Pvt. Ltd,2007
6. Russel (Stuart), 'Artificial Intelligence- Modern approach, Pearson Education series in AI', 3rd Edition, 2009.
7. I. Gupta, G. Nagpal · Artificial Intelligence and Expert Systems, Mercury Learning and Information -2020

223AGE011	SYSTEM MODELLING	CATEGORY	L	T	P	CREDIT
		AUDIT COURSE	3	0	0	-

Preamble: Study of this course provides the learners a clear understanding of fundamental concepts in simulation and modelling. This course covers the different statistical models, importance of data collection and various types of simulations. The course helps the learners to find varied applications in engineering, medicine and bio-technology.

Course Outcomes: After the completion of the course the student will be able to

CO 1	Analyse the requirement and find appropriate tool for simulation.
CO 2	Differentiate the different statistical models.
CO 3	Discuss the different techniques for generating random numbers.
CO 4	Analyse the different methods for selecting the different input models..
CO 5	Discuss the different measures of performance and their estimation

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		1	1	2	
CO 2	2		1	1	1	
CO 3	1					
CO 4	1		1	1		
CO 5	2		1	1	1	

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	60%
Apply	20%
Analyse	20%

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Course based task (Project/Assignments/Simulations/Case studies): 15 marks
Seminar/Quiz: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

Model Question paper

AUDIT COURSE

223AGE001 – SYSTEM MODELLING

Answer any five questions Each carries 12 marks

PART A

1. a. Discuss the advantages and disadvantages of simulation. (5marks)

   b. What are the areas of applications of simulation (7 marks)

2. a.A bus arrives every 20 minutes at a specified stop beginning at 6:40 A.M. and continuing until 8:40 A.M. A certain passenger does not know the schedule, but arrives randomly (uniformly distributed) between 7:00A.M. and 7:30 A.M. every morning. What is the probability that the passenger waits more than 5 minutes for a bus? (5 marks)
   b. A production process manufactures computer chips on the average at 2% nonconforming. Every day, a random sample of size 50 is taken from the process. If the sample contains more than two nonconforming chips, the process will be stopped. Compute the probability that the process is stopped by the sampling scheme. (7 marks)

3. a.Discuss the different types of tests for random numbers. (5 marks)

   b. Generate random numbers using multiplicative congruential method with X0 = 5, a 11, and m = 64. (7 marks)

4. a. What are the different methods of data collection. (4marks)

   b. Records pertaining to the monthly number of job-related injuries at an underground coalrnine were
   being studied by a federal agency. The values for the past 100 months were as follows:

Injuries per Month	Frequency of Occurrence
0	35
1	40
2	13
3	6
4	4
5	1
6	1

(a) Apply the chi-square test to these data to test the hypothesis that the underlying distribution is Poisson. Use the level of significance α== 0.05.
(b) Apply the chi-square test to these data to test the hypothesis that the distribution is Poisson with mean 1.0. Again let α = 0.05. ·
c) What are the differences between parts (a) and (b), and when might each case arise? (8 marks)

5. a.What is the difference between validation and verification.(5 marks)
   b. Discuss the different measures of performance and their estimation(7 marks)
6. a. Discuss the different methods of parameter estimation(5 marks)
   b. With an example, describe the Poisson process.(7 marks)
7. a. Distinguish between discrete and continuous systems(5 marks)
   b.What are the different components of a simulation system(7 marks)

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	When simulation is the appropriate tool. Advantages and disadvantages of Simulation; Areas of application, Systems and system environment; Components of a system; Discrete and continuous systems, Model of a system; Types of Models, Discrete-Event System Simulation, Steps of a simulation study.	**6**	**20**
II	Review of terminology and concepts, Useful statistical models, Discrete distributions. Continuous distributions, Poisson process, Empirical distributions. (basic idea only)	**6**	**20**
III	Properties of random numbers; Generation of pseudo-random numbers, Techniques for generating random numbers, Tests for Random Numbers	**6**	**20**
IV	Data Collection; Identifying the distribution with data, Parameter estimation, Goodness of Fit Tests, Fitting a non-stationary Poisson process, Selecting input models without data, Multivariate and Time-Series input models.	**6**	**20**
V	Measures of performance and their estimation, Output analysis for terminating simulations, Output analysis for steady-state simulations, Verification, calibration and validation	**6**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Introduction**	
1.1	When simulation is the appropriate tool	1
1.2	Advantages and disadvantages of Simulation;	1
1.3	Areas of application, Systems and system environment;	1
1.4	Components of a system; Discrete and continuous systems,	1
1.5	Model of a system; Types of Models,	1
1.6	Discrete-Event System Simulation ,Steps of a simulation study	1
2	**Statistical Models in Simulation**	
2.1	Review of terminology and concepts, Empirical distributions. (basic idea only)	1
2.2	Useful statistical models,	1
2.3	Discrete distributions.	1
2.4	Continuous distributions,.	1
2.5	Poisson process	1
2.6	Empirical distributions	1
3	**Random Number Generation**	
3.1	Properties of random numbers;	1
3.2	Generation of pseudo-random numbers,	
3.3	Techniques for generating random numbers	1
3.4	Techniques for generating random numbers(cont)	1
3.5	Tests for Random Numbers	1
3.6	Tests for Random Numbers(cont)	1
4	**Input Modelling**	
4.1	Data Collection;	1
4.2	Identifying the distribution with data.	1
4.3	Parameter estimation, Goodness of Fit Tests	1
4.4	Fitting a non-stationary Poisson process	1
4.5	Selecting input models without data,	1
4.6	Multivariate and Time-Series input models	1
5	**Measures of Performance and their Estimation**	
5.1	Measures of performance and their estimation	1
5.2	Measures of performance and their estimation(cont)	1
5.3	Output analysis for terminating simulations	1
5.4	Output analysis for steady-state simulations	1
5.5	Verification, calibration and validation	1
5.6	Verification, calibration and validation(cont)	1

Textbooks:

1. Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event System Simulation, 5th Edition, Pearson Education, 2010.

Reference Books:

1. Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course, Pearson Education, 2006.

2. Averill M. Law: Simulation Modeling and Analysis, 4 th Edition, Tata McGraw-Hill, 2007

3. System Modelling and Response by Ernest O. Doebelin

4. Averill M Law, "Simulation Modeling and Analysis",McGraw-Hill Inc,2007 Geoffrey Gorden, "System Simulation",Prentice Hall of India,1992.

223AGE009	Principles of Automation	CATEGORY	L	T	P	CREDIT
		CREDIT COURSE	3	0	0	0

Preamble:

This course deals in detail with the various aspects of automation such as sensors, actuators, controllers, mechanical and electrical elements and their integration for automating new and existing manufacturing and process industries and applications. This course will be beneficial to students in designing automation schemes for industries and to design automated systems

Course Outcomes: After the completion of the course the student will be able to

CO 1	Explain the fundamentals of sensor systems and to choose a suitable sensor system for the given application based on the evaluation of the constraints.
CO 2	Explain the fundamentals of signal conditions and to design a suitable signal conditioning scheme for given application.
CO 3	Describe the characteristics of various actuator systems and to decide the right type of actuator for the given application.
CO 4	Describe the importance of an industrial robot and fundamentals of numerical control in automation.
CO 5	Explain the fundamentals of controllers used in industrial automation and to construct simple automation schemes by ladder logic programs.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	2		2	2	2		
CO 2	2		2	2	2		
CO 3	2		2	2	2		
CO 4	2		2	2	2		
CO 5	2		2				

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	70 %
Apply	30 %

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern:**60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

Model Question Paper

223AGE009 Principles of Automation

Time 2.5 Hrs Marks 60

Answer any five questions Each carries 12 marks

1. (a) Differentiate the static and dynamic characteristics of a temperature sensor and explain how it affects the selection of a suitable temperature sensor. (6 marks)
   (b) Explain the working of a strain-gauge. (6marks)

2. (a) Explain why anti-aliasing filters are used in analog to digital converters. (3 marks)
   (b) Design a first order low pass filter with a cutoff frequency of 2 kHz. (9 marks)

3. (a) What are the factors to consider while deciding choosing between hydraulic, pneumatic or electrical actuation systems for an automation scheme? (4 marks)
   (b) Explain the working of a three-way pressure reducing valve. (4 marks)
   (c) Explain the working of solenoids. In what applications would you use a Solenoid valve. (4 marks)

4. (a) Explain the principle of the Touch sensor and also mention how they are used in robots. (5 marks)
   (b) Explain the basic terminologies in robotic system and also explain the components of robotic system. (7 marks)

5. (a)With neat schematic explain the architecture of the PLC. (6 marks)
   (b) Explain the use of an up-down counter in PLC with a suitable example. (6 marks)

6. (a) Write short note on SCADA. What is difference PLC and SCADA? (3 marks)

   (b)Construct a ladder logic for controlling a process tank as per the logic given below;
   i.The tank should be filled by a valve V1 when low level float switch L1 is ON and an external input S1 is received.

ii.V1 should be closed when the liquid level reaches a high-level float switch L2.
iii. An agitator motor should be turned on after a delay of 5sec after L2 is triggered.
iv. After agitating for 30mins, contents of the tank should be emptied by opening another valve V2.
v. The temperature should be maintained at 70℃ using a thermostat T1 and Heater H (9 marks)

7. (a) Explain the levels of Automation. (6 marks)
(b) Explain the working of Flow sensor (6 marks)

Syllabus and Course Plan

No	Topics	No. of Lectures
1	**Introduction to Industrial Automation**	
1.1	Basic Elements of an Automated System, Levels of Automation	2
1.2	Hardware components for Automation: Sensors, classification, Static and dynamic behaviour of sensors.	2
1.3	Basic working principle of different sensors: Proximity sensors, Temperature sensors, flow sensors, Pressure sensors, Force sensors. Position sensors	4
2	**Signal conditioning**	
2.1	Need for signal conditioning, Types of signal conditioning.	2
2.2	Signal conditioning using operational amplifier-Amplifier (Inverting and Non-inverting) and Filter circuits (Basic concepts). Design of first order low pass filter.	2
2.3	Signal conditioning for data acquisition systems, anti-aliasing filters, Analog–Digital Conversions, Analog-to-Digital Converters (ADC)- Steps in analog-to-digital conversion, Successive Approximation Method, Digital-to-Analog Converters (DAC)- Steps in digital to analog conversion, Zero-order and first order data hold circuits	4
3	**Actuators**	
3.1	Types of actuators- mechanical, electrical, pneumatic and hydraulic actuators. (Basic working principle)	2
3.2	Mechanical systems for motion conversion, transmission systems	3
3.3	Solenoids, Electric and stepper motors control.	3
4	**Robotics and Automated Manufacturing Systems**	
4.1	Robot Anatomy and Related Attributes: Joints and Links, Common Robot Configurations, Joint Drive Systems, Sensors in Robotics (Basic concepts)	3
4.2	Robot Control Systems, Applications of Industrial Robots- Material handling	4
4.3	Fundamentals of Numerical control (NC) Technology	1
5	**Discrete Control and Programmable Logic Controllers**	

5.1	Discrete Process Control: Logic and Sequence control	2
5.2	Ladder Logic Diagrams, Programmable Logic Controllers: Components of the PLC, PLC Operating Cycle, Programming the PLC (Basic concepts only)	4
5.3	Introduction to Distributed control system (DCS) and Supervisory Control and Data Acquisition Systems (SCADA)	2

Reference Books

1. Mikell Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2019.
2. Yoram Koren, "Computer Control of Manufacturing Systems",TataMcGraw Hill Edition2005.
3. S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education: New York, 2010.
4. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" - PrenticeHall- 2013 - 5th Edition.
5. Doebelin, E.O. and Manic, D.N., "Measurement Systems: Applications and Design", 7th Edition, McGraw Hill, 2019.
6. Krishna Kant, Computer Based Industrial Control-, EEE-PHI,2nd edition,2010.
7. Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
8. Salivahanan, S., and VS Kanchana Bhaaskaran. Linear integrated circuits. McGraw-Hill Education, 2nd edition, 2014.
9. Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005
10. Chapman and Hall, "Standard Handbook of Industrial Automation", Onsidine DM C & Onsidine GDC", NJ, 1986

223AGE002	FORENSIC ENGINEERING	CATEGORY	L	T	P	CREDIT
		Audit Course	3	0	0	-

Preamble: This course explores various aspects of Forensic Engineering and different methods ,tools and procedures used by Engineers to investigate and analyze . The students will learn to develop their awareness in Forensic Engineering .

Pre-requisite: Nil

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Identify the fundamental aspects of forensic Engineering
CO 2	Apply forensic Engineering in Practical work flow and Investigation
CO 3	Apply methods and analysis in Forensic Investigation
CO 4	Develop practical strategies and standards of Investigation
CO 5	Create an awareness in criminal cases and create Engineering expertise in court room on forensic Engineering

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7
CO 1	2	2	3	3	3	3	
CO 2	2	2	3	3	3	3	1
CO 3	3	3	3	3	3	3	1
CO 4	3	3	3	3	3	3	1
CO 5	3	3	3	3	3	3	

Assessment Pattern

Bloom's Category	Continuous Internal Evaluation	End Semester Examination
Apply	40 %	60 %
Analyse	40 %	40 %
Evaluate	20 %	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 marks

Course based task :15marks

Seminar/Quizz :15marks

Test paper :10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

Model Question paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER M. TECH DEGREE EXAMINATION

Course Code: 223AG002

Course Name: FORENSIC ENGINEERING

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

		Answer any 5 questions, each question carries 12 marks.	**Marks**
1.	(a)	What are the uses of forensic engineering in legal laws ?	(7)
	(b)	Discuss the professional responsibility of a forensic Engineer .	(5)
2.	(a)	What are the steps in preliminary on site Investigation ?	(7)
	(b)	With suitable examples, explain photo cataloguing?	(5)
3.	(a)	Discuss STEP method .	(7)
	(b)	Explain root cause Analysis	(5)
4.	(a)	Detail about EDAX Method.	(7)
	(b)	Enlist the uses of NDT in forensic Analysis with example	(5)
5.	(a)	Differentiate NFPA & FMV Standards	(7)
	(b)	Briefly discuss the term Email Phishing ?	(5)
6.		Define the responsibility and duty of a forensic expert in the court.	(12)
7.		Explain Forensic Engineering workflow with examples	(12)

Syllabus and Course Plan

Module No	Topic	No. of Lectures (Hours)
1	**Module 01: Introduction to Forensic Engineering (6 Hours)**	
1.1	Forensic Engineering-Definition, Investigation Pyramid, Eyewitness Information, Role in Legal System	2
1.2	Scientific Method-Applying scientific methods in Forensic Engineering-Engineer as expert Witness-Scientific methods and legal system	2
1.3	Qualification of Forensic Engineer-Technical- Knowledge- Oral-written-Communication- other skills-Personality Characteristics	1
1.4	Ethics and professional responsibilities.	1
2	**Module 02: Forensic Engineering Workflow and Investigation Methods (6 Hours)**	
2.1	Forensic Engineering Workflow-Team &planning-preliminary onsite investigation. Sampling-selection of sample-collection- packing-sealing of samples.	2
2.2	Source and type of evidence - Paper documentation- digital documentation-electronic data. Physical Evidence-Collection of photograph-cataloguing -Recognizing the Evidence-organizing-Evidence Analysis -Reporting	2
2.3	Investigation Methods- Cause and Causal mechanism analysis-Time and event sequence-STEP method. Human Factors, Human errors - Analysis of Operative Instruction and working Procedures	2
3	**Module 03: Physical Product Failure & Analytical Methods (6 Hours)**	
3.1	Introduction to typical Forensic Engineering Tool box-NDT, Crack detection and human eye -Hardness testing- and Destructive testing Methods with case studies	2
3.2	Indirect stress strain Analysis-Brittle lacquer technique, Contact Radiography-Metallography-EDAX method	1
3.3	Forensic Optical Microscopy-Examination- Magnification-USB Microscopy -Wifi Enabled microscopy -Reflected microscopy	2
3.4	Novel Tools and System -Contour Method-Flash Thermography-Thermographic signal reconstruction (TSR)-Electromagnetically induced acoustic Emission (EMAE)-Pulsed Eddy Current (PEA)-Theory only	1
4	**Module 04: Cyber Forensic , Civil ,Electrical Accidents & Standards (6 Hours)**	
4.1	Basics of Digital & Cyber forensics: Technical concepts; labs and tools; collecting evidence Operating System Forensic basics with - Windows, Linux -Mobile Forensic-Anti forensics-Malware- Web attack forensics with Email Crimes-Cyber Laws	3
4.2	Different types of Forensic accident investigations- Civil Engineering-Structural- Road accidents -Fire accidents - Water related accidents-Electrical accidents and Investigation methods	2
4.3	Protocol for forensic Investigations-Standard guides-scope significance -use -procedures- reports. Standards – ASTM standards -FMV Standards -SAE Standards -Relevant Standards -NFPA Standards -International Standards	1

5	**Module 05: Engineer in the Court room& Criminal Cases (6 Hours)**	
5.1	Role of an Engineering Expert-Report-pre trial meetings-Alternative dispute resolution-Single joint expert. Engineer in the court room	2
5.2	Criminal Cases-Introduction-Counterfeit coins-fraudulent road accidents-Fraudulent Insurance claims.	2
5.3	Cyber Crimes and Cases- SIM Swapping -ATM Cloning-Microsoft Internal Spam- Intellectual property cases.	2

Reference Books

1. Colin R Gagg, *Forensic EngineeringThe Art &Craft of a failure detective* , Taylor & Francis Publishing, 2020
2. Luca Fiorentini ,Luca Marmo *Principles of Forensic Engineering Applied to Industrial Accidents* , Wiley, 2019
3. Harold Franck, Darren Franck , *Forensic Engineering Fundamentals* ,Taylor & Francis publishing 2013
4. Randall K Noon , *Forensic Engineering Investigation*, CRC press limited , 2001
5. Stephen E Petty , *Forensic Engineering: Damage assessment for residential and commercial structures* CRC press 2nd edition , 2017
6. Joshua B Kardon , *Guideliness for forensic Engineering practice* , ASCE, 2012
7. Richard W. Mclay and Robert N. Anderson, *Engineering standards for forensic Applications* , Academic Press; 1st edition 2018
8. Max M Houck ,*Forensic Engineering (Advanced forensic Science),* Academic press 1st edition 2017
9. Niranjan Reddy - Practical Cyber Forensics. *An Incident-based Approach to Forensic Investigations-Apress (2019)*
10. Peter Rhys Lewis, Ken Reynolds, Colin Gagg - *Forensic Materials Engineering Case Studies-CRC Press (2003) (1)*

INTERNSHIP

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialisation after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Objectives

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

Benefits of Internship

Benefits to Students

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom

teaching.

- Helps them decide if the industry and the profession is the best career option

  to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

Benefits to the Institute

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/

  students.
- Improvement in teaching learning process.

Benefits to the Industry

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.

- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

Types of Internships

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

Guidelines

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
    - Report of work done
    - Internship certificate copy
    - Feedback from employer / internship mentor
    - Stipend proof (in case of paid internship).

Total Marks 100: The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Student's diary - 25 Marks

Evaluation done by the industry - 25 Marks

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivatethe habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations,

impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

The format of student's diary

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

Day	Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

Attendance Sheet

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	...
Month & Year																					
Month & Year																					

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.

Evaluation done by the Industry (Marks 25)

Format for Supervisor Evaluation of Intern

Student Name :_____ Date:_____

Supervisor Name :_____ Designation:_____

Company/Organization :_____

Internship Address: _____

Dates of Internship: From_____ To _____

Please evaluate intern by indicating the frequency with which you observed the following parameters:

Parameters **Marks**	Needs improvement (0 – 0.25 mark)	Satisfactory (0.25 – 0.50 mark)	Good (0.75 mark)	Excellent (1 mark)
Behavior				
Performs in a dependable Manner				
Cooperates with coworkers and supervisor				
Shows interest in work				
Learns quickly				
Shows initiative				
Produces high quality work				
Accepts responsibility				
Accepts criticism				
Demonstrates organizational skills				
Uses technical knowledge and expertise				
Shows good judgment				
Demonstrates creativity/originality				
Analyzes problems effectively				
Is self-reliant				
Communicates well				
Writes effectively				
Has a professional attitude				
Gives a professional appearance				
Is punctual				
Uses time effectively				

Overall performance of student

Intern (Tick one) : Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) / Good (1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks) :

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

End Semester Evaluation (External Evaluation): 50 Marks

Internship Report	-	25 Marks
Viva Voce	-	25 Marks

Internship Report: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

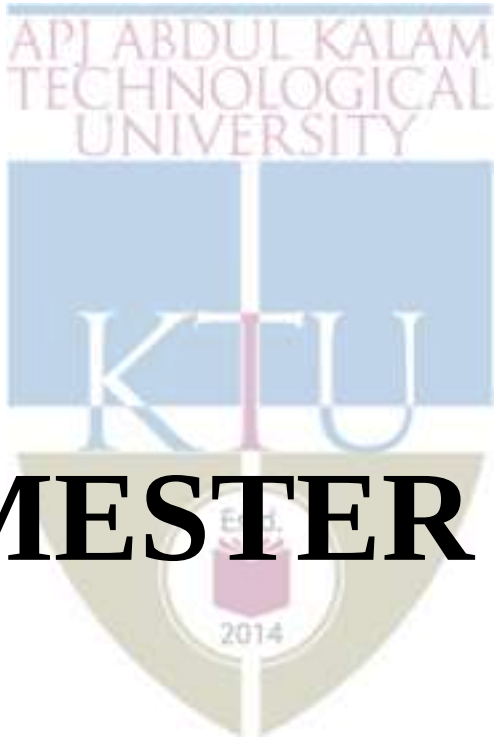
RESEARCH PROJECT/DISSERTATION

Research Project: Students choosing track 2 shall carry out the research project in their parent Institution only under the guidance of a supervisor assigned by the DLAC.

Dissertation: All categories of students in track 1 are to carry out the dissertation in the Institute they are studying or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

Mark Distribution:

Phase 1: Total marks: 100, only CIA



SEMESTER - IV

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
224PBT100	DISSERTATION PHASE II	Project Work	0	0	24	16

All categories of students in track 1 are to carry out the DISSERTATION PHASE II in the institute they are studying or in any Industrial/ R&D organization/any other reputed institute which have facilities for dissertation work in the area proposed. DISSERTATION PHASE II shall not compulsorily continuation of DISSERTATION PHASE I. The student has to publish a research article in a conference or a reputed journal before appearing for the end-semester examination. The eligibility criteria for registering to the end semester examination are attendance in the course and no pending disciplinary action. The minimum attendance for appearing for the end semester examination is 75%. Students who do not meet these eligibility criteria are ineligible (identified by FE grade) to appear for the ESE. Students, who have completed a course but could not appear for the end semester examination, shall be awarded 'AB' Grade, provided they meet other eligibility criteria The pass minimum for the course is 45% for ESE and 50% for (CIA and ESE) put together.

Continuous Internal Assessment (CIA) Total Marks: 100

The evaluation committee comprises

1- Project Coordinator(s)
2- A Senior faculty member
3- Supervisor of the student

Pattern (CIA)

Zeroth evaluation by the Evaluation Committee	-
Interim evaluation by the Evaluation Committee	30 marks
Final evaluation by the Evaluation Committee	50 marks
Project progress evaluation by supervisor	20 marks

Evaluation by the supervisor

The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. In case it is found that progress is unsatisfactory it shall be reported to the Department Evaluation Committee for necessary action.

Student's Diary/ Log book: The main purpose of writing diary/log book is to cultivate the habit of documenting and to encourage the students to search for details. The activity diary shall be signed after every week by the supervisor.

End Semester Evaluation (ESE) Total Marks: 100

The evaluation committee comprises

1- Project Coordinator(s)
2- An external expert (from Industry or research/academic institute)
3- Supervisor of the student

Pattern (ESE)

1. **Innovation and Originality (10 marks):**

Assessment of the uniqueness and innovation demonstrated in the project work.
Original contributions, if any, to the field or problem area.

2. **Implementation and Execution (20 marks):**

Evaluation of the actual implementation or execution of the project, including:

- Quality of work done
- Demonstrated skills and techniques applied
- Adherence to project timelines and milestones

3. **Project Documentation (25 marks):**

Comprehensive project report evaluation including:

- Introduction and problem statement
- Literature review
- Methodology and approach
- Results and analysis
- Conclusion and recommendations
- References and citations
- Details of the publications
- Plagiarism certificate

The Plagiarism level in the project report shall be less than 25%.

4. **Presentation and Defence (40 marks):**

Oral presentation of the project to a panel of examiners, including:

- Clarity and effectiveness of the presentation
- Ability to explain the project objectives, methodologies, and findings
- Handling questions and providing satisfactory answers during the defence

5. **Publication of the work either in a conference or in a journal (5 marks)**

SYLLABUS:

DETAILS	HOURS
` 1. Literature study/survey of published literature on the assigned topic 2. Topic Selection and Proposal 3. Formulation of objectives 4. Research and Planning 5. Formulation of work plan and task allocation. 6. Execution 7. Documentation and Reporting 8. Project Showcase reflecting on the project experience and lessons learned	200

Dissertation outside the Institute: For doing dissertation outside the Institution, the following conditions are to be met:

i. They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
ii. The student has to get prior approval from the DLAC and CLAC.
iii. Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
iv. They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.
v. The student has to furnish his /her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned internal supervisor.
vi. The external supervisor is to be preferably present during all the stages of evaluation of the dissertation.