Academic Programme Guide

of

Master of Engineering

Microelectronics Engineering

Based on Choice Based Credit System (CBCS)/Elective Course System(ECS)

CHITKARA UNIVERSITY
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NAAC ACCREDITED

w.e.f.
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Index

1. General Information

The academic program Guide is a comprehensive document detailing course scheme, associated credits per course and the distribution of each course in lecture, tutorial and Practical hours. It also details the eligibility criteria for admission, for award of degree, the assessment and evaluation procedures along with a glimpse of the pedagogical aspects of the programs. This Guide is to be used in association with the Academic Regulations of the University to make a complete rule set. The course schemes given in this document are approved by respective Board of Studies and the Academic Council of Chitkara University. The Course code gives information about the course and is derived using Table in Appendix A.

2. Eligibility for Admission

The student seeking admission in ME program should have BE/B. Tech [Electronics /Electrical /CSE/IT] or MSc [CS]/MSc [IT]/MSc (Electronics] or MCA with 60% marks or CGPA of 6 on a scale of 10.The admission is purely based on merit.

3. Admission Process:

Admissions toResearch Induced Fellowship Program (RIFP) are done through a process which has written test, followed by an interview of candidates who qualify in the written test. Written test will be of objective type covering aptitude, test of reasoning and technical.On admission, the students are simultaneously hired on Research Assistant / Teaching Assistant role, for which they are paid performance-linked stipend.

4. Duration and Stages

The duration of the ME program is three years - divided into 6 semesters. There is University end term examination at the end of each semester, except in the case of Integrated Projects (IP) or Research Project (RP), which is evaluated by a jury appointed by the University.

Total time Span= N+2 years for the completion of ME programme. Where “N” stands for minimum or normal duration prescribed for completion of the programme.

The maximum duration of completion of degree is 5 years. In some exceptional circumstances further extensions for one year may be granted on the recommendation of statutory body concerned of the university

5. Rules for attendance

As detailed in Academic Regulations section 6, a minimum attendance of 75% is compulsory for the student to be eligible to appear for end semester examination. 10% concession in this mandatory requirement is possible only in extreme circumstances and at the sole discretion of the Vice Chancellor.

There is no weightage for attendance in evaluation criteria.

Students are encouraged to participate in co-curricular activities conducted by prestigious institutions at national/International level. Such students would be eligible for grant of special Duty Leaves (limited by a cap decided by the Vice Chancellor) to make up for the attendance, in case any class work is missed during this period. This privilege extended to students will not be termed as right and is limited to just the attendance benefit.

6. Pedagogical Aspects

The structural layout of the program and its courses requires that each course be divided in lecture, tutorial and practical sessions. Duration of each session as given in the column against the course in the course scheme is 120 minutes.Lecture sessions: Lectures are delivered by traditional - chalk board method, supplemented by modern Information Communication technology (ICT) methods. The students are encouraged to ask questions and involve in group discussion to the extent allowed by the teacher. In some subjects where case study based methodology is adopted, the lectures are supplemented by discussions on case studies.Tutorial Sessions: The tutorial sessions are small groups of students interacting with the teacher, solving application oriented analytical problems. The tutorial sessions are very interactive and inculcate problem solving skills in the students.

Lab / Practical Sessions: During lab / practical sessions, the students work on prescribed list of experiments and do what they have learnt in the Lecture / Tutorial sessions.

Integrated Projects: The students identify their team mates (at the most 2 in each team) and work on a unique integrated project allotted to them by faculty / group of faculty members. The projects are allotted to them either at the start of each semester or at a later stage (but not later than Sessional test I) in the semester. Integrated projects are designed by the faculty keeping in mind the courses the students have studied so far and are currently studying. Thus, the project statements are made such a way that the students while working on these projects apply the concepts learned so far and the deliverables are multi-faceted. The students work on the Integrated Project during their lab hours.

7. Assessment and Evaluation

The evaluation will be continuous and the weightage of various components are as given in Table 1 (For Theory courses) and in Table 2 (for Practical Courses).

Table 1: Evaluation components for Theory Courses

For Theory Courses	
Quizzes/Assignments/ Presentation/Class Test/ Open Book Test/ Case Study	20
Sessional Tests (STs)	20
End Term Examination	60
Total	**100**

There is only one Sessional Tests (STs) for all theory papers, and considered in final evaluation. The policy on the evaluation component – 'Quizzes / Tutorials / Assignments' is decided by the course coordinator and HOD and is announced separately for each course. The End Term examination for practical courses includes conduct of experiment and an oral examination (viva voce).

Table 2: Evaluation Components for Practical Courses

For Lab Courses	
Lab Performance / File work	40
Internal Viva – Voce	20
End Term	40
total	100

8. Eligibility for award of degree

In addition to conditions given in section 8 of Academic Regulations, a CGPA of 4 and credit of 82 is required to receive degree in any of the Engineering Programs.

Program Name:Master of Engineering -Fellowship in Microelectronics Engineering
Duration: 3 years (Normal)

This postgraduate program in Electronics and Communication Engineering prepares students for the ever expanding Electronics and Telecommunication engineering fields. The postgraduates will have required knowledge to work and teach in telecommunication, embedded systems, Radio frequency and wireless communication/ network and will also be able take up research in related and interdisciplinary areas.The students take in all 15courses of which 8 are core courses and 4 are elective courses and 3 are industry oriented subjects.

The program prepares students on basic and advanced electronics and also builds necessary engineering skills in areas of VLSI, embedded system, RF antennas, wireless communication and network, multimedia processing and data processing etc. The students get an overview of basic and advanced Communication engineering concepts and also learn them to apply in real life telecommunication applications. The VLSI design vertical prepares the students for embedded systems design and designing and testing System on Chip.

Training the students with help of a 100 % application oriented and project based learning approach remains the key strength of the program.

9. Program Objectives:

ME (ECE) postgraduates –

PO1: Possess an ability to apply the knowledge of mathematics science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems.

PO2: Possess an ability to identify, formulate, review research literature, and analyze complex engineering problems using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Possess an ability to design solutions for complex engineering problems and design system components or processes to meet the specific needs with appropriate consideration of the public health and safety, the cultural, societal, and environmental sustainability.

PO4: Possess an ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

PO5: Possess an ability to create, elect, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: Possess an ability to apply reasoning informed by the contextual knowledge of societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practices.

PO7: To understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge and need for sustainable development.

PO8: Possess an ability to apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Possess an ability to function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings**.**

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

PO11: Possess an ability to demonstrate knowledge and understanding of the engineering, management principles and apply these to one's own work, as a member and leader in a team, to

manage projects and in multidisciplinary environments.

PO12: Possess an ability to recognize the need and have ability to engage in independent and lifelong learning in the broadest context of technological change.

10. Scheme of Courses for Master of Engineering -Fellowship In Microelectronics Engineering 2016 Batch

First Year, Semester I

Course Code	Course Title	L T P	Credits
ECL4501 ECP1501	Advanced Digital System Design Advance Digital System Design Lab	4 0 0 0 0 2	5
ECL4630	Semiconductor Material and Devices	4 0 0	4
ECL4629	Microwave and RF Design	4 0 0	4
	Total Credits		13

First Year, Semester II

Course Code	Course Title	L T P	Credits
ECL4607 ECP1607	Mixed Signal Circuit Design Mixed Signal Circuit Design Lab	4 0 0 0 0 2	5
ECL4606 ECP1606	Digital Image Processing Digital Image Processing Lab	4 0 0 0 0 2	5
	Elective-I	4 0 0	4
	Total Credits		14

Second Year, Semester III

Course Code	Course Title	L T P	Credits
CSL4601 CSP1601	Communication Network and Protocols Communication Network and Protocols Lab	4 0 0 0 0 2	5
CSL4602 CSP1602	Machine Learning Machine Learning Lab	4 0 0 0 0 2	5
	Elective II	4 0 0	4
	Total Credits		14

Second Year, Semester IV

Course Code	Course Title	L T P	Credits
ECL4601 ECP1601	Internet of Things and Embedded System Internet of Things and Embedded System Lab	4 0 0 0 0 2	5
	Elective III	4 0 0	4
	Elective IV	4 0 0	4
ECL 2601	Publishing Research	2 0 0	2
	Total Credits		15

Third Year, Semester V

Course Code	Course Title	L T P	Credits
CSL4651	Engineering Education	4 0 0	4
CSL2518	IPR	2 0 0	2
	Total Credits		6

Third Year, Semester VI

Course Code	Course Title	Credits
ECT 9702	Thesis	20
	Total Credits	20

Total Credits: 82

List of Electives

Elective I

Course Code	Course Title	Credits
CS 952	Programming in Python	4
CS 951	Programming in C#	4
CS 953	Programming in R	4
CS 954	Advanced Programming in Java	4

Elective II

Course Code	Course Title	Credits
ECL4631	Rapid Prototyping using FPGA	4
ECL4632	Advanced Wireless Communication System	4

Elective III

Course Code	Course Title	Credits
ECL4616	RF Circuit Design	4
ECL4662	Biomedical Signal Processing	4
ICP4306	Mobile application Development	4
CSL4641	Big Data	4
ECL4663	Sensor Technology and MEMS	4

Elective IV

Course Code	Course Title	Credits
ECL4627	System Implementation of Vision	4
ECL4661	Hardware and Software Co-Design	4
ECL4615	Smart Antennas	4
CSL4653	Pattern Recognition	4
CSL4652	Speech Signal Processing	4
CSL4670	Soft Computing	4

11. Details of Courses

Semester I

Advanced Digital System Design/Lab (4-0-2)	**5.0 credits**

Course Learning Outcomes(CLO):

CLO1: Understand the basics of difference between various systems

CLO2: Skill to implement simple logical operations required for the designing of systems.

CLO3: Skill to design and implement various filters.

Introduction: Introduction to DSP Systems, terminating and Non-Terminating, Representation of DSP programs, Data Flow graphs (DFGs), Single rate and multi rate DFGs, Iteration bound, Loop, Loop Bound, Iteration rate, Critical loop, Critical path Area-Speed-Power trade-offs, Precedence constraints, Acyclic Precedence graph, Longest Path Matrix (LPM) and Minimum Cycle Mean (MCM) Algorithms Pipelining and parallel processing of DSP Systems, Low Power Consumption Algorithmic Transformations: Retiming, Cut-set retiming, Feed-Forward and Feed-Backward, Clock period minimization register minimization, Unfolding, Sample period reduction, Parallel processing. Bit-serial, Digit-serial and Parallel Architectures of DSP Systems. Folding, Folding order, Folding Factor, Folding Bi-quad filters, Retiming for folding. Register Minimization technique, Forward Backward Register Allocation technique. Systolic Architecture Design and Fast Convoltuion: Systolic architecture design methodology, Projection vector, Processor Space vector, Scheduling vector. Hardware Utilization efficiency, Edge mapping, Design examples of systolic architectures. Cook-Toom Algorithm and Modified Cook-Toom Algorithm, Wniograd Algorithm and Modified Winograd Algorithm, Iterated Convolution, Cyclic Convolution. Algorithm Strength Reduction: Introduction, Parallel FIR filters, Polyphase decomposition, Fast FIR filters Algorithms. Discrete Cosine Transform and Inverse Discrete Cosine Transform, Algorithm-Architecture Transformation, DIT Fast DCT. Pipelined and Parallel Recursive and Adaptive Filters, Look-Ahead Computation, Look-Ahead Pipelining. Decompositions, Clustered Look-Ahead Pipelining, Scattered Look-Ahead pipelining. Parallel processing in IIR Filters, Combining Pipelining and Parallelism. Scaling and Round-off Noise: Introduction. State variable description of Digital Systems, Scaling and Round-off Noise Computation, Slow-Down ApproachFixed-point digital filter implementation.

Recommended Books:

1. Parhi, K.K., VLSI Digital Signal Processing Systems: Design and Implementation, John Wiley (2007).
2. Oppenheim, A.V. and Schafer, R.W., Discrete-Time Signal Processing, Prentice Hall (2009) 2nd ed.
3. Chan, P.K. and Mourad, S., 1994. Digital system design using field programmable gate arrays. Prentice-Hall, Inc.
4. Hall, S.H., Hall, G.W. and McCall, J.A., 2000. High-speed digital system design: a handbook of interconnect theory and design practices (pp. 102-154). New York: Wiley.

Semiconductor Material and Devices (4-0-0)	**4.0 credits**

Course Learning Outcomes(CLO):

CLO1: To be able to read and interpret electronic datasheets and diagrams.

CLO2: To be able to measure the electronics & electrical parameters of an amplifier like voltage gain, input & output impedance.

CLO3: Skill to design, construct and troubleshoot transistor based amplifier complex electronic circuits

Energy Bands and Charge Carriers in Semiconductors: Metals, Semiconductors and Insulators, Charge carriers in Semiconductors, Carrier concentrations, Drift of carriers in electric and magnetic fields

Excess Carriers in Semiconductors: Optical absorption, Luminescence, Carrier lifetime and photoconductivity, Diffusion of carriers- Diffusion processes, Diffusion and drift of carriers; Built in fields, Diffusion and recombination; The Continuity Equation, Steady State Carrier Injection; Diffusion Length, The Haynes- Shockley Experiment, Gradients in the Quasi-Fermi Levels Junctions: Fabrication of p-n Junctions, Equilibrium Conditions- The Contact Potential. Equilibrium Fermi Levels, Space Charge at a Junction, Forward and Reverse-Biased Junctions; Steady State Conditions, Reverse-Bias Breakdown, Transient and A-C Conditions, Deviations from the Simple Theory, Metal-Semiconductor Junctions, Heterojunctions Field-Effect Transistors: Transistor Operation, The Junction FET, The Metal-Semiconductor FET- The GaAs MESFET, The high Electron Mobility Transistor (HEMT), Short Channel Effects, The Metal-Insulator- Semiconductor FET – The ideal MOS Capacitor, Effects of Real Surfaces, Threshold Voltage, MOS Capacitance-Voltage Analysis, The MOS Field-Effect Transistor- Output Characteristics, Transfer Characteristics, Short Channel MOSFET I-V Characteristics, Control of Threshold Voltage, Substrate Bias Effects, Subthreshold Characteristics, MOSFET Scaling and Hot Electron Effects, Drain-Induced Barrier Lowering, Short Channel Effect and Narrow Width Effect, Gate-Induced Drain Leakage Bipolar Junction Transistors: Fundamentals of BJT Operation, Minority Carrier Distributions and Terminal Currents, Generalized Biasing, Switching, Other Important Effects, Frequency Limitations of Transistors, Heterojunction Bipolar Transistors Optoelectronic Devices: Photodiodes- Current and Voltage in an Illuminated Junction, Solar Cells, Photodetectors, Gain, Bandwidth, and Signal-to-Noise Ratio of Photodetectors, Light-Emitting Diodes

Recommended Books:

1. Sanjay Banerjee, Solid State Electronic Devices, 6th edition, Ben G Streetman, Pearson publisher
2. S M Sze , Physics of Semiconductor Devices, 3rd edition, New York: Wiley
3. D K Bhattacharaya, Rajnish Sharma Solid State Electronic Devices, , 2nd edition, Oxford University Press.
4. Neamen, D.A., 2003. Semiconductor physics and devices: basic principles. McGraw- hill.

Microwave and RF Design (4-0-0)	**4.0 credits**

Course Learning Outcomes(CLO):

CLO1: Students will gain complete knowledge about the significance, types and characteristics of various microwave devices.

CLO2: Skill to analyze mathematically the operation and working of various tubes or sources for the transmission of the microwave frequencies

CLO3: Students will gain the basic understanding about the principles and working of RADAR.

Introduction to analysis tools for microwave: Smith chart, S-parameters, Reflection coefficient, VSWR, E-Field, H-Field, polarization measurement, power intensity and density Computation tools for microwave: Maxwell's equations, Telegraph equation, Transmission line equation, FEM and FDTD solvers Performance evaluation techniques: Impedance matching, radiation pattern, broadband matching, phase control and axial ratio. Microwave sources: Solid state microwave sources, GUNN Diode, Magnetron, Voltage controlled oscillators and resonators Microwave components: Microwave active and passive diodes, Different type of horn antennas and applicators, directive assembly, directional coupler, circulator, transmission line and waveguides Microwave circuits: Microwave passive devices, microwave resonators, microwave filters, microwave circuits Radiation hazards: Microwave radiation hazards: Hazards of electromagnetic radiation to Personnel (HERP), hazards of electromagnetic radiation to ordnance (HERO), hazards of electromagnetic radiation to fuel (HERF), radiation hazard levels and limits for personnel and radiation protection. Microwave measurements: Microwave measurements: VSWR meter, spectrum analyzer, network analyzer, impedance measurement, power measurement, tunable detector, connectors

Advanced application area: Applications of microwave in radar, satellite, food biomedical and agriculture heating applications.

Recommended Books:

1. Pozar, D.M., 2000. Microwave and RF design of wireless systems. John Wiley & Sons.
2. Steer, M.B., 2010. Microwave and RF design: a systems approach. SciTech Pub.
3. Jarry, P. and Beneat, J., 2008. Advanced design techniques and realizations of microwave and RF filters. John Wiley & Sons.
4. Grebennikov, A., 2015. RF and microwave power amplifier design. McGraw-Hill Education

Semester II

Mixed Signal Circuit Design/Lab(4-0-2)	**5.0 credits**

Course Learning Outcomes(CLO):

CLO1: Apply knowledge of mathematics and engineering to design CMOS analog circuits to achieve desired performance specifications.

CLO2: Skilled to identify, formulates, and solve engineering problems in the area of mixed-signal design.

CLO3: Design and implement various types of mixed-signal integrated circuit for real world applications during their employment and entrepreneurship.

CLO4: Applications for real world applications.

CLO5: Applications for societal problem solving and employability.

Introduction: Basic CMOS Comparator Design, Characterizing the Comparator, Clocked Comparators, Input Buffers Revisited , Analog Multipliers PLL- Simple PLL, Phase Detector, Basic PLL technology, Dynamics of simple PLL, charge-pump PLLs, Problem of lock acquisition, Phase/Frequency detector and charge pump, basic charge pump PLL, Applications Switched Capacitor Circuits: Switched Capacitor circuits, switched capacitor amplifier, switched capacitor integrator Sample-and-Hold Circuits Fully-Differential Circuits, Gain, Common-Mode Feedback, Coupled Noise Rejection, Other Benefits of Fully-Differential Op-Amps, A Fully-Differential Sample-and-Hold Data Convertor Fundamentals: Analog Versus Discrete Time Signals , Converting Analog Signals to Digital Signals , Sample-and-Hold (S/H) Characteristics , Digital- to-Analog Converter (DAC) Specifications, Analog-to-Digital Converter (ADC) Specifications D/A converter architectures: DAC Architectures : Digital Input Code , Resistor String, Mismatch Errors Related to the Resistor-String DAC, Integral Nonlinearity of the Resistor-String DAC, Differential Nonlinearity of the Worst-Case Resistor- String DAC, R-2R Ladder Networks, Current Steering, Mismatch Errors Related to Current-Steering DACs A/D converter architectures: ADC Architectures : Flash ,Accuracy Issues for the Flash ADC, The Two-Step Flash, Accuracy Issues Related to the Two-Step Flash Converter, Accuracy Issues Related to Operational Amplifiers, The Pipeline ADC , Accuracy Issues Related to the Pipeline Converter, Integrating ADCs, Single-Slope Architecture, Accuracy Issues Related to the Single-Slope ADC, Dual-Slope Architecture, Accuracy Issues Related to the Dual-Slope ADC, The Successive Approximation ADC, The Charge-Redistribution Successive Approximation ADC Filtering Topologies: The Bilinear Transfer Function, The Biquadratic Transfer Function, Filters using noise shaping

Recommended Books:

1. Phillips E. Allen, Douglas R. Holberg, “CMOS Analog Circuit Design”, Oxford University Express, 2nd Edition.
2. R.Jacob Baker, “CMOS Mixed-signal Circuit Design”, Wiley Student Edition, Wiley Interscience, 2009.
3. Baker, R.J., 2008. CMOS: mixed-signal circuit design. john Wiley & sons.
4. Mohanty, S.P., 2015. Nanoelectronic mixed-signal system design (No. 0071825711). New York: McGraw-Hill Education.

Digital Image Processing/Lab(4-0-2)	**5.0credits**

Course Learning Outcomes(CLO):

CLO1: After the completion of the course student will be able to understand the fundamental concepts of a digital image processing system like Image formation, Image sampling and quantization

CLO2: Students will develop the skill to analyze the different images in the frequency domain using various transforms

CLO3: Students will be able to realize the importance of filters for the images and also they will be able to differentiate between the different types of filters.

CLO4: Applications of image processing in recognition

Fundamentals of Image Processing: What is Digital Image Processing? Fundamental steps in Digital Image Processing, Application fields and Components of an image processing system. Digital Image Fundamentals: Elements of Visual Perception, Simple image formation model, Image Sampling and Quantization, Basic relationship between pixels, Linear and Non-Linear operations. Image Enhancement: Basic gray level transformations, Histogram processing, Enhancement using Image subtraction and averaging. Basics of spatial and frequency domain filtering, Smoothing and sharpening filters.Homomorphic Filtering. Image Restoration: A Model of Image Degradation / restoration process. Algebraic approach to restoration: Inverse filtering, Minimum Mean Square Error (Wiener) Filtering. Image Restoration: A Model of Image Degradation / restoration process. Algebraic approach to restoration: Inverse filtering, Minimum Mean Square Error (Wiener) Filtering. : Image Segmentation: Detection of Discontinuities, Point, Line and Edge detection, Edge linking and Boundary Detection, Thresholding, Region Based segmentation. : Basic geometric transformations: Introduction to Fourier Transform and DFT, FFT, Walsh-Hadamard Transform, Discrete Cosine Transform. Color Image Processing: Fundamentals, Color Models, Pseudocolor Image Processing. Basics of full color image processing, Color Transformations, Smoothening and Sharpening. Image Compression: Fundamentals, Lossless compression: Variable length coding, LZW coding, Bit plane coding, Lossless predictive coding, Lossy compression: Lossy Predictive Coding, Transform coding, Wavelet coding, Image & Video compression standards. Case Study: Morphological Image Processing: Dilation, erosion, Opening & Closing, Basic Morphological Algorithms.

Recommended Books:

1. Rafael C. Gonzalez & Richard E. Woods, Digital Image Processing, Pearson Education (2nd edition).
2. Pitas, I., 2000. Digital image processing algorithms and applications. John Wiley & Sons
3. Jensen, J.R., 1986. Introductory digital image processing: a remote sensing perspective. Univ. of South Carolina, Columbus
4. Niblack, W., 1985. An introduction to digital image processing. Strandberg Publishing Company.

Elective I

Programming in Python (4-0-0)	**4.0 credits**

Course Learning Outcomes(CLO):

- **CO1:** Recognize the characteristics of machine learning that make it useful to real-world problems and learn skills.
- **CO2:** Characterize machine learning algorithms as supervised, semi- supervised, and unsupervised.
- **CO3:** Skilled to effectively use machine learning toolboxes.
- **CO4:** Implement machine learning solutions to classification, regression, and clustering problems.
- **CO5:** Understand how to perform evaluation of learning algorithms and model selection.

Introduction: Variables, expressions, and statements: Values and types, Variables, Variable names and keywords, Statements, Operators and operands, Expressions. Order of operations, Expressions, Order of operations, Modulus operator, String operations, Asking the user for input, Comments, Choosing mnemonic variable names.Conditional execution: Boolean expressions, Logical operators, Conditional execution, Alternative execution, Chained conditionals, Nested conditionals, catching exceptions using try and except, Short-circuit evaluation of logical expressions.Functions: Function calls, Built-in functions, Type conversion functions, Random numbers, Math functions, Adding new functions, Definitions and uses, Flow of execution,
Parameters and arguments. Flow of execution, Parameters and arguments. Iteration: Updating variables, while statement, Infinite loops, “Infinite loops” and break, Finishing iterations with continue, Definite loops using for, Loop patterns.Strings: Intoduction, Getting the length of a string using len, Traversal through a string with a loop, String slices, Strings are immutable, Looping and counting, The in operator, String comparison, string methods, Parsing strings, Format operator.Files: Persistence, Opening files, Text files and lines, Reading files Searching through a file, Using try, except, and open, Writing files.Lists, tuples and dictionaries: list operators, replacing, inserting, removing an element searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.Classes and OOP: classes, objects, attributes and methods; defining classes; design with classes, data modeling; persistent storage of objects, inheritance, polymorphism, operator overloading (_eq_,_str_, etc); abstract classes; exception handling, try block.Project using Python.

Recommended Books:

1. Programming in Pyhton: A complete introduction to the python Language (second edition)”, Mark Summerfield, ISBN:978-0-321-68056-3(pbk: all paper).
2. Core Pyhton Programming”, Wesley.J.Chun (First edition), ISBN: 0-13-0260-36-3, 816 pages.

Programming in C# (4-0-0)	4.0 credits

Course Learning Outcomes(CLO):

CLO1: Students will gain an in-depth knowledge about overall syntax and semantics of .NET programs

CLO2: Students will be skilled to use an IDE to compile, load, save, and debug a .NET program

CLO3: Students will develop technical thinking and problem solving ability to find an appropriate solution for a problem.

CLO4: Students will be able to demonstrate the ability to create test cases to determine that a solution produces expected outputs for given inputs

CLO5: Incorporation of programming in real time applications that will increase their employability.

Understanding .NET: The C# Environment: The .Net Strategy, The Origins of .NET Technology, The .NET Framework, The Common Language Runtime, Framework Base Classes, User and Program Interfaces, Visual Studio .NET, .NET Languages, Benefits of the .NET Approach, C# and the .NETOverview of C#: What is C#, Why C#, Evolution andCharacteristics of C#, Applications of C#, How does C# Differ from C++ and Java, Introduction to C# Program, Namespaces, Adding Comments, Main Returning a Value, Using Aliases for Namespace Classes, Passing String Objects to WriteLine Method, Command Line Arguments, Main with a Class, Providing Interactive Input, Using Mathematical Functions, Multiple Main Methods, Compile Time Errors, Program Structure, Program Coding Style. Literals, Variables and Data Types: Introduction to Literals, Variables, Data Types, Value Types, Reference Types, Declaration of Variables, Initialization of Variables , Default Values, Constant Variables, Scope of Variables, Boxing and Unboxing. Operators and Expressions: Arithmetic Operators, Relational Operators, Logical Operators, Assignment Operators, Increment and Decrement Operators, Conditional Operator, Bitwise Operators, Special Operators, Arithmetic Expressions, Evaluation of Expressions, Precedence of Arithmetic Operators, Type Conversions, Operator Precedence and Associativity, Mathematical Functions. Decision Making and Branching: Decision Making with if Statement , Simple if Statement , The if... else Statement , Nesting of if. else Statements , The else if Ladder , The Switch Statement , The ? : Operator , The while Statement ,The do Statement , The for Statement , The foreach Statement , Jumps in Loops. Methods in C#: Declaring Methods , The Main Method , Invoking Methods, Nesting of Methods, Method Parameters , Pass by Value, Pass by Reference, The Output Parameters, Variable Argument Lists, Methods Overloading. Handling Arrays and Manipulating Strings: One-Dimensional Arrays , Creating an Array , Two- Dimensional Arrays , Variable-Size Arrays , The System. Array Class , ArrayList Class, Creating Strings , String Methods , Inserting Strings , Comparing Strings , Finding Substrings , Mutable Strings , Arrays of Strings , Regular Expressions. Structures and Enumerations: Structures, Structs with Methods, Nested Structs, Differences between Classes and Structs, Enumerations, Enumerator Initialization , Enumerator Base Types , Enumerator Type Conversion. Classes and Objects: Basic Principles of OOP , Defining a Class , Adding Variables , Adding Methods , Member Access Modifiers , Creating Objects , Accessing Class Members , Constructors , Overloaded Constructors , Static Members , Static Constructors , Private Constructors , Copy Constructors , Destructors , Member Initialization , The this Reference , Nesting of Classes , Constant Members , Read-only Members , Properties , Indexers. Inheritance and

Polymorphism: Classical Inheritance , Containment Inheritance , Defining a Subclass , Visibility Control , Defining Subclass Constructors , Multilevel Inheritance , Hierarchical Inheritance , Overriding Methods , Hiding Methods , Abstract Classes , Abstract Methods, Sealed Classes: Preventing Inheritance , Sealed Methods , Polymorphism. Interfaces: Multiple Inheritance and Operator Overloading: Defining an Interface , Extending an Interface , Implementing Interfaces , Interfaces and Inheritance , Explicit Interface Implementation, Abstract Class and Interfaces, Overloadable Operators, Need for Operator Overloading, Defining Operator Overloading , Overloading Unary Operators ,Overloading Binary Operators , Overloading Comparison Operators. Delegates and Managing Console I/O Operations: Delegates , Delegate Declaration , Delegate Methods , Delegate Instantiation , Delegate Invocation , Using Delegates , Multicast Delegates , Events, The Console Class, Console Input, Console Output, Formatted Output, Numeric Formatting, Standard Numeric Format, Custom Numeric Format. Windows and Web-based Application Development on .NET: Understanding Microsoft Visual Studio, Creating and Running a SampleWinApp Windows Application, Creating and Running a SampleWinApp2 Windows Application, Web- based Application on .NET. Project using C#

Recommended Books:

1. Summerfield, M., 2010. Programming in Python 3: a complete introduction to the Python language. Addison-Wesley Professional.
2. Lindstrom, G., 2005. Programming with python. IT Professional Magazine, 7(5), p.10
3. Langtangen, H.P. and Langtangen, H.P., 2011. A primer on scientific programming with Python (Vol. 1). Berlin/Heidelberg: Springer.
4. Guzdial, M.J. and Ericson, B., 2015. Introduction to computing and programming in python. Pearson

Programming in R (4-0-0)	**4.0 credits**

Course Learning Outcomes(CLO):

CLO1: Students will gain an in-depth knowledge about overall syntax and semantics of R programs.

CLO2: Students will be skilled to use an IDE to compile, load, save, and debug a Rprogram.

CLO3: Students will develop technical thinking and problem solving ability to find an appropriate solution for a problem.

CLO4: Students will be able to demonstrate the ability to create test cases to determine that a solution produces expected outputs for given inputs

CLO5: Incorporation of programming in real time applications that will increase their employability.

Basic R features; introduction to the main data types and visualization, More on vectors and other data typesIntroduction to functions. More on lists and data frames, Programming structures: relational and logical operations; flow control, Environment and scope, more on data framesMath and simulations in R, Debugging, introduction to strings and regular expressionsIntroduction to graphics, the Grammar of Graphics, Data shaping and transformation; split-transform-recombine, Reshaping and tidying data, exploring large data setsDates and times, statistical models in R, Overview of main domain-specific libraries, TBA. Project using R.

Recommended Books:

1. Benjamin M. Bolker. Ecological Models and Data in R. Princeton University Press, 2008. ISBN 978- 0-691-12522-0.
2. Peter Dalgaard. Introductory Statistics with R. Springer, 2nd edition, 2008. ISBN 978-0-387-79053- 4.
3. Brian Everitt and Torsten Hothorn. A Handbook of Statistical Analyses Using R. Chapman & Hall/CRC, BocaRaton, FL, 2006. ISBN 1-584-88539-4.
4. John Maindonald and John Braun. Data Analysis and Graphics Using R. Cambridge University Press, Cambridge, 2nd edition, 2007. ISBN 978-0-521-86116-8.

Advanced Programming in Java(4-0-0)	**4.0 credits**

Course Learning Outcomes(CLO):

CLO1: Students will gain an in-depth knowledge about overall syntax and semantics of Java programs

CLO2: Students will be skilled to use an IDE to compile, load, save, and debug a Java program

CLO3: Students will develop technical thinking and problem solving ability to find an appropriate solution for a problem.

CLO4: Students will be able to demonstrate the ability to create test cases to determine that a solution produces expected outputs for given inputs

CLO5: Incorporation of programming in real time applications that will increase their employability.

Collections: Collection Interfaces, Concrete Collections, The Collections FrameworkMultithreading: Creating thread and running it, Multiple Thread acting on single object, Synchronization, Thread communication, Thread group, Thread priorities, Daemon Thread, Life Cycle of thread.Java Database Connectivity (JDBC): Merging Data from Multiple Tables: Joining, Manipulating Databases with JDBC, Prepared Statements, Transaction Processing, Stored Procedures CNetworking : Internet Addressing, InetAddress, Factory Methods, Instance Methods, TCP/IP Client Sockets, URL, URL Connection, TCP/IP Server Sockets, DatagramsServlets: Servlet Overview and Architecture, Interface Servlet and the Servlet Life Cycle, Handling HTTP get Requests, Handling HTTP post Requests, Redirecting Requests to Other Resources, Session Tracking, Cookies, Session Tracking with HttpSessionJavaServer Pages (JSP): Introduction, JavaServer Pages Overview, A First JavaServer Page Example, Implicit Objects, Scripting, Standard Actions, Directives, Custom Tag LibrariesEnterprise Java Bean: Preparing a Class to be a JavaBean, Creating a JavaBean, JavaBean Properties, Types of beans, Stateful Session bean, Stateless Session bean, Entity beanRemote Method Invocation: Defining the Remote Interface, Implementing the Remote Interface, Compiling and Executing the Server and the ClientCommon Object Request Broker Architecture (CORBA): Technical/Architectural Overview, CORBA Basics, CORBA servicesIntroduction Smart Phone Application Development: Introduction to android platform, Creating application template, adding activity, intent, services to application, using Google map APIProject

Recommended Books:

1. Herbert Schildt by Herbert Schildt “Java 2: The Complete Reference”, Fifth Edition: Book
2. “Java Server Programming J2EE Edition”, Dreamtech Software team, published by Dreamtech Press.
3. James L. Weaver and James P. Crume “Beginning J2EE from Novice to Professiona”l by published by Apress
4. Eck, D.J., 2015. Introduction to programming using Java. David J. Eck.

Semester III

Communication Network and Protocols/Lab(4-0-2)	**5.0 Credits**

Course Learning Outcomes(CLO):

CLO1: Understand the small networks by following the top-down approach from application to physical layer.

CLO2: Acquire theoretical knowledge about the different network technologies

CLO3: Skilled to understand the functioning of different layers in OSI model and TCP/IP .

CLO4: Identify various system security and protection issues that enhance employability.

Introduction: Network systems, Peer-to-peer network, Client-server network, Connection-oriented and connectionless services, Circuit switching vs. packet switching.Internetworking: Motivation, Concept, Goals, IP addressing, Classes of Networks: Class A, Class B, Class C, Class D, Class E; Address Binding with ARP, IP Datagram, Encapsulation IP Fragmentation and Reassembly, ICMP, TCP, UDP concept and datagram protocols. TCP/IP Network Interface Layer Protocol: Point to Point Protocols(PPP), ARP and RARP Protocol, SLIP, IPV4, IPV6, Transition from IPV4 to Ipv6, IP Network Address Translation Protocol,ICMP Protocols. Routing and Application Layer Protocols: Interior protocol : Routing Information Protocol (RIP), Bellman Ford Distance Vector Routing; Exterior Routing Protocols: Exterior Gateway Protocol (EGP) and Border Gateway Protocol (BGP), SMTP and FTP protocols, TFTP Protocols, Hypertext Transfer Protocols. Fundamentals: 4G Networks and Composite Radio Environment. AD HOC Wireless Networks: Introduction, Issues in Ad Hoc Wireless Networks. MAC Protocols: Fundamentals of MAC protocols, Requirement and design constraints for wireless MAC protocols, Classification of MAC protocols: Contention-based protocols, Schedule-based protocols, Bluetooth. Adhoc Routing Protocols: Introduction, Requirement and design constraints for Ad Hoc routing protocols, Classification of Routing Protocols, Table driven protocols: Cluster Gateway Switch Routing (CGSR), Destination Sequenced Distance Vector Routing (DSDV), Wireless Routing, Protocol(WRP); Source Initiated On-demand driven protocols: Adhoc On demand distance vector routing (AODV), Dynamic Source Routing(DSR), Temporally ordered routing algorithm(TORA);

Recommended Books:

1. Glisic, Savo G., Advanced Wireless Networks, John Wiley and Sons (2006).
2. C K Toh, “Adhoc mobile wireless networks, Protocols and Systems”, 2nd Edition, Pearson Education, 2009.
3. G.J.Holtzmann, “Design and validation of Computer protocols”, Prentice Hall, New York, 1991.
4. Quarterman, J.S., 1990. The matrix: Computer networks and conferencing systems worldwide. Digital Press.

Machine Learning/Lab(4-0-2)	**5.0 credit**

Course Learning Outcomes(CLO):

CLO1: After Completing this course, the students will have skill to be able to analyze the data, identify the problems.

CLO2: The students will able to choose the relevant models and algorithms to turn available data into valuable and useful information.

CLO3: The students will be skilled to apply different machine learning problems that will increase their employability.

CLO4: The students will be able to evaluate the performance of models.

Mathematical Preliminaries: Eigen Value and Eigen Vectors, Probability and Bayes Theorem, Distributions of Data. Normalization. Learning: Well-Posed Learning Problem, Designing a Learning System, Choosing the Training Experience, Choosing the Target Function Choosing a Representation for the Target Function, Choosing a Function Approximation Algorithm, The Final Design, Perspective Issues in Machine Learning Concept Learning and General-to-Specific Ordering: Introduction, A Concept Learning Task, Notation, The Inductive Learning Hypothesis, Concept Learning as Search, General-to-Specific Ordering of Hypothesis, FIND-S: Finding a Maximally Specific Hypothesis. LIST-THEN-ELIMINATE Algorithm, Candidate Elimination Algorithm, Inductive Bias, A Biased hypothesis Scope, An Unbiased Learner, The Futility of Bias-Free Learning. Supervised Learning - Classification: Binary and multiclass classification, Linear and Non-Linear Decision Boundaries, Training Set, Test Set. Linear classifiers, Logistic regression, Naive Bayes classifier, perceptron. Support Vector Machines, K-Nearest Neighbor, Decision Tree Classifier, Artificial Neural Networks. Unsupervised Learning - Clustering: Basics of Clustering, Clustering vs. Classification, Similarity/Dissimilarity Measures, Clustering Criteria. K-Means Algorithm, Hierarchical Clustering, K-Medoids, DBSCAN, When to do clustering. Feature Selection: Problem Statement and Uses, Sequential Forward and Backward Selection, Feature Selection Criteria Function: Interclass Distance Based. Performance Evaluation: Types of Errors, Confusion Metric, Performance Evaluation Parameters, Comparison between performances of Classifiers. Recent Advances and Applications: Recent Advances, Applications of Machine Learning, Examples of Real-Life Dataset.

Recommended Books:

1. Tom Mitchell ‘Machine Learning’, , McGraw Hill, 1997, ISBN 0-07-042807-7.
2. Christopher Bishop **‘**Pattern Recognition and Machine Learning’, , Springer-Verlag New York, ISBN: 978-0-387-31073-2.
3. Jajuga, Krzystof, Sokolowski 'Classification, Clustering, and Data Analysis', , Andrzej, Bock, Hans- Hermann , Springer-Verlag Berlin Heidelberg, ISBN: 978-3-540-43691-1.
4. Richard O. Duda, Peter E. Hart, David G. Stork ‘Pattern Classification', 2nd Edition, ‚John Wiley & Sons, ISBN: 978-0-471-05669-0.

Elective II

Rapid Prototyping using FPGA(4-0-0),	**4.0 Credits**

Course Learning Outcomes(CLO):

CLO1: The students completing this course are expected to understand the structure of various number systems and its application in digital design.

CLO2: Students will be able to design the appropriate truth table from a description of a combinational logic function

CLO3: Students will be skilled to analyze and design various combinational and sequential circuits like Comparators, Multiplexers, Encoders etc.

CLO4: Students will be skilled to design the synchronous circuits like Pulse train generator, Pseudo Random Binary Sequence generator that will increase their employability.

Introduction to FPGA: From discrete logic to FPGAs, flexibility and functionality, FPGA vs Programmable DSPs, FPGA technology - roadmap, clocking, data and sample rates, slices and configurable logic blocks, memory and registers, performance ratings, families DSP and FPGAs: FPGA elements for DSP algorithms, Signal Flow Graph techniques, Digital filtering for FPGAs. Review of Combinational and sequential circuits (with VHDL implementation examples): Binary codes, Mux,demux, decoder, encoder, adder, subtractor, latches, flip-flops, counters and shift registers, Classification of sequential circuits, Registers(SIPO,SISO,PISO and PIPO). Design & analysis of synchronous and asynchronous sequential circuits: Counters. Using VHDL for synthesis of digital hardware: data types, operators, Multiplexers, decoders, adders, Subtractor, de-multiplexers, flip-flops, counters, state machine, ALU with adder/Subtractor and shifter, multiply and divide hardware synthesis, memory, using a test bench for verification and simulation Concept of state machine and VHDL implementation, simulation synthesis, verification. A simple computer design: computer programs and instructions, processor, fetch, decode and execute cycle simulation of the microprocessor. Arithmetic circuits: n-bit addition, subtraction, multiplication and division. Various algorithms and VHDL implementation. Embedded Systems & FPGAs: FPGA as a systems on chip platform, FPGA on -chip network standards, FPGAs as custom microcontroller and hybrid DSP microcontroller devices, Multiple cock domains on chip, DAC, ADC, & pre_amp, DDR SDRAM, Timing Constraints, using IP cores: instantiation and simulations.

Recommended Books:

1. C. Maxfield, “The Design Warrior's Guide to FPGAs: Devices, Tools and flows”, Newnes, 2004.
2. Zainalabedin Navabi, "Digital Design and Implementation with Field Programmable Devices", Springer, 2004.
3. R. Cofer and B. Harding, “Rapid System Prototyping with FPGAs: Accelerating the Design Process”, Newnes, 2005.
4. Hamblen, J.O, Hall, T.S, and Furman, M.D. "Rapid Prototyping of Digital Systems, SOPC Edition." Springer, 2007
5. Jean- Pierre Deschamps, Gery Jean Antoine Bioul, Gustavo D. Sutter, “Synthesis of Arithmetic Circuits-FPGA ASIC and Embedded Systems” , a John Wiley & sons, inc, publication.

Advanced Wireless Communication System(4-0-0)	**4.0 Credits**

Course Learning Outcomes(CLO):

CLO1: The students would be able to apply the knowledge of mobile communication engineering to solve coverage and call failure problems in cell phones.

CLO2: They would be skilled to implement the cellular concept and antenna system design consideration aspects in optimizing the cellular architecture as per user needs during their employment.

CLO3: The students would possess in-depth knowledge to select and use optimum multiple access technique for interference-free communication.

CLO4: The students would possess ability and technical skills necessary to understand digital cellular standards and architecture designs.

CLO5: The students would have acquired adequate knowledge about major aspects of 3G/4G digital cellular networks.

Review of Wireless Communications: Background of wireless communication, Advantages, Disadvantages, and Applications, Cellular Telephone Systems, Spectrum Allocations for Systems, Cellular System Fundamentals, Channel Reuse, cell splitting, handoff mechanism, Orthogonal Systems, Non-Orthogonal Systems Interference Reduction Techniques, Dynamic Channel Assignment. Coding for wireless channel: linear block codes: binary LBC, generator matrix, syndrome testing, cyclic code; non-binary block codes: convolution coding and decoding, trellis diagram; Error control channel coding: LDPC codes; Burst error correction technique: interleaving, RS codes and Turbo codes. Spread Spectrum communications: principles of spread spectrum modulation, spread spectrum techniques: frequency hopping, FHSS with BFSK, Direct sequence spread spectrum, comparison of FHSS and DSSS, Applications of DSSS multiuser system: code acquisition and tracking and multiuser DS-CDMA system. Multicarrier Modulation: Data Transmission using Multiple Carriers, Overlapping Sub channels, Mitigation of Sub Carrier Fading, orthogonal division multiplexing technique. Emerging wireless network technologies: Wireless LANs, Broadband Wireless access, IEEE 802.15 WPAN, IEEE 802.16 WMAN, MANETs, IEEE802.21 standard-an overview, SDR, Cognitive radio.

Recommended Books:

1. Goldsmith Andrea, Wireless Communications, Cambridge University Press (2005).
2. T.L Singal, Wireless Communications, McGraw Hill Education (2010)
3. Tse, David and Viswanath, Pramod, Fundamentals of Wireless Communication, Cambridge University Press (2006).
4. Rappaport, T.S., Wireless Communications, Pearson Education (2007)
5. T.L Singal, Digital Communication, McGraw Hill higher education (2015).

Semester IV

Internet of Things and Embedded System/Lab (4-0-2)	**5.0 Credits**

Course Learning Outcomes(CLO):

CLO1: Understand fundamental concepts and technologies related to embedded system and IoT based devices

CLO2: Understand the fundamentals of RTOS and application development techniques.

CLO3: Skill to write fast-executing embedded code that utilizes the CPU, memory and peripheral resources efficiently

CLO4: Understand the various communication and networking protocols used for developing IoT enabled devices during their employment.

Embedded Concepts, Architecture of embedded systems, ARM Architecture, Cortex-M3 Basics, Exceptions, Instruction Sets, NVIC, Interrupt Behaviour, Cortex -M3/M4 Programming, Exception Programming, Memory Protection Unit and other Cortex-M3 features..

Recommended Books:

1. The Definitive Guide to the ARM Cortex-M3, Joseph Yiu, Second Edition, Elsevier Inc. 2010.
2. Andrew N Sloss, Dominic Symes, Chris Wright, “ARM System Developer's Guide -Designing and Optimizing System Software”, 2006, Elsevier.
3. Singh, D., Tripathi, G. and Jara, A.J., 2014, March. A survey of Internet-of-Things: Future vision, architecture, challenges and services. In 2014 IEEE world forum on Internet of Things (WF-IoT) (pp. 287-292). IEEE
4. Fortino, G. and Trunfio, P. eds., 2014. Internet of things based on smart objects: Technology, middleware and applications. Springer Science & Business Media.

Elective III

RF Circuit Design (4-0-0)	4 Credits

Course Learning Outcomes(CLO):

CLO1: Understanding the design concept of various RF/Microwave devices.

CLO2: Knowledge of Microwave Circuit Analysis and Impedance matching.

CLO3: Understanding the behavior of non-linear RF/Microwave Devices.

CLO4: Ability to design discrete RF/ Microwave Devices that will increase their employability.

Introduction to RF and Wireless Technology: Complexity Comparison, Design Bottle Necks, Applications, Analog And Digital Systems, Choice Of Technology. Basic Concepts In Rf Design: Nonlinearity And Time Variance, ISI, Random Process And Noise, Sensitivity And Dynamic Range, Passive Impedance Transformation. Multiple Access: Techniques And Wireless Standards, Mobile RF Communication, FDMA, TDMA, CDMA, Wireless Standards. Transceiver Architectures: General Considerations, Receiver Architecture, Transmitter Architecture, Transceiver Performance Tests, Case Studies.Amplifiers, Mixers And Oscillators: Lnas, Down Conversion Mixers, Cascaded Stages, Oscillators, Frequency Synthesizers. Power Amplifiers: General Considerations, Linear And Nonlinear Pas, Classification, High Frequency Power Amplifier, Large Signal Impedance Matching, Linearization Techniques.

Recommended Books:

1. BehzadRazavi, RF Microelectronics Prentice Hall of India, 2001.
2. Thomas H. Lee, The Design of CMOS Radio Integrated Circuits, Cambridge University.
3. Li, R.C., 2008. RF circuit design (Vol. 90). John Wiley & Sons.
4. Bowick, C., 2011. RF circuit design. Elsevier.
5. Gilmore, R. and Besser, L., 2003. Practical RF Circuit Design for Modern Wireless Systems: Active Circuits and Systems, Volume 2 (Vol. 1). Artech House.

Biomedical Signal Processing (4-0-0) 4.0 Credits

Course Learning Outcomes(CLO):

CLO1: The student will be skilled to model a biomedical system

CLO2: The student will be able to understand various methods of acquiring bio signals.

CLO3: The student will be able to understand various sources of bio signal distortions and its remedial techniques.

Introduction to biomedical signals: Nature of biomedical signals, examples of biomedical signals– EMG,ECG, EEG, ERPs, PCG,VMG, VAG, objectives of biomedical signal analysis, difficulties in biomedical signal analysis, concurrent, coupled, and correlated processes, illustration of the problem with case-studies, filtering for removal of artifacts.

Filters for biomedical signals: Time-domain filters, frequency-domain filters, optimal filtering, wiener filter, adaptive filters for removal of interference, selecting an appropriate filter.

Application of filters in biomedical signal processing: Removal of artifacts in the ECG, event detection, detection of events and waves in EEG, correlation analysis of EEG channels, cross- spectral techniques. The matched filter, detection of the P wave, homo-morphic filtering, application- ECG rhythm analysis, identification of heart sounds, wave shape and waveform complexity, analysis of event-related potentials, morphological analysis of ECG waves, envelope extraction and analysis of activity, application- normal and ectopic ECG beats, analysis of exercise ECG.

Frequency-domain characterization: The Fourier spectrum, estimation of the power spectral density function, measures derived forms PSDs.

Pattern classification: Diagnostic decision pattern classification, supervised pattern classification, unsupervised pattern classification, probabilistic models and statistical decision, logistic regression analysis, the training and test steps, neural networks, measures of diagnostic accuracy and cost, reliability of classifier and decisions.

Recommended Books:

1. Reddy, ‘Biomedical Signal Processing: Principles and Techniques’ by Tata McGraw-Hill
2. E. N. Bruce ‘Biomedical Signal Processing and Signal Modeling’ by, Wiley publications.
3. Rangaraj M. Rangayyan& John Wiley and Sons I ‘Biomedical Signal Analysis A Case Study Approach.
4. Bioelectrical Signal Processing in Cardiac and Neurological Applications (Biomedical Engineering), Leif Sornmo.

Mobile application Development(4-0-0)	**4.0 Credits**

Course Learning Outcomes(CLO):

CLO1: Model and manage mobile application development using range of methods.

CLO2: Student will be able to learn about the different frameworks.

CLO3: The student will be able to develop mobile applications that will increase their employability.

Introduction: Introduction to Mobile Computing, Introduction to, Android Development Environment Factors in Developing Mobile Applications, Mobile Software Engineering, Frameworks and Tools, Generic UI Development, Android User, More on UIs, VUIs and Mobile Apps, Text-to-Speech Techniques, Designing the Right UI, Multichannel and Multimodal UIs. Intents and Services, Android Intents and Services, Characteristics of Mobile Applications, Successful Mobile Development, Storing and Retrieving Data, Synchronization and Replication of Mobile Data, Getting the Model Right, Android Storing and Retrieving Data, Working with a Content Provider, Communications Via Network and the Web, State Machine, Correct Communications Model, Android Networking and Web; Telephony, Deciding Scope of an App, Wireless Connectivity and Mobile Apps, Android Telephony, Notifications and Alarms, Performance, Performance and Memory Management, Android Notifications and Alarms, Graphics, Performance and Multithreading, Graphics and UI Performance, Android Graphics and Multimedia, Mobile Agents and Peer-to-Peer Architecture, Android Multimedia, Location, Mobility and Location Based Services Android, Putting It All Together (as time allows), Packaging and Deploying, Performance Best Practices, Android Field Service App, Security and Hacking (as time allows), Active Transactions, More on Security, Hacking Android, Platforms and Additional Issues (as time allows), Development Process, Architecture, Design, Technology Selection, Mobile App Development Hurdles, Testing

Recommended Books:

1. Bill Phillips, Chris Stewart, Brian Hardy, and Kristin Marsicano, Android Programming: The Big Nerd Ranch Guide, Big Nerd Ranch LLC, 2nd edition, 2015.
2. Christian Keur and Aaron Hillegass, iOS Programming: The Big Nerd Ranch Guide, 5th edition, 2015.
3. Valentino Lee, Heather Schneider, and Robbie Schell, Mobile Applications: Architecture, Design and Development, Prentice Hall, 2004.
4. Tomasz Nurkiewicz and Ben Christensen, Reactive Programming with RxJava, O'Reilly Media, 2016.

Big Data (4-0-0)	**4.0 Credits**

Course Learning Outcomes(CLO):

CLO1: Student will be able to Learn predictive modelling and its applications across domains.

CLO2: Student will be able to Learn the concepts and metrics to evaluate and optimise digital marketing efforts.

CLO3: The student will be able to Understand how to use data analytics to forecast, plan and optimise inventories.

Overview of big data analytics: Introduction to big data, Big data analytics applications. Technologies and tools for big data analytics: Introduction to MapReduce/Hadoop, Data analytics using MapReduce/Hadoop, Data visualization techniques, Spark. Theory and methods for big data analytics Selected machine learning and data mining methods (such as support vector machine and logistic regression), Statistical analysis techniques (such as conjoint analysis and correlation analysis), Time series analysis D. Big data graph analytics. Case studies.

Recommended Books:

1. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2011.
2. Ron Bekkerman, Mikhail Bilenko and John Langford, Scaling up Machine Learning: Parallel and Distributed Approaches, Cambridge University Press, 2011.
3. Tom White, Hadoop: The Definitive Guide, O‟Reilly Media, Third Edition, 2012.
4. Bill Franks, Taming The Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, Wiley, 2012.

Sensor Technology and MEMS(4-0-0)	4.0 Credits

Course Learning Outcomes (CLO):

CLO1: Student will be able to understand the operation of micro devices, micro systems and their applications

CLO2: Student will be skilled to design the micro devices, micro systems using the MEMS fabrication process.

CLO3: The student will be able to Gain the technical knowledge required for computer-aided design, fabrication, analysis and characterization of nano-structured materials, micro- and nano-scale devices that will increase their employability.

Introduction to MEMS & Microelectronics- Introduction to MEMS, Evaluation of MEMS, Micro- fabrication for MEMS, Micro-Sensors, Market Survey, Microelectronics for MEMS, Micromachining for MEMS. MEMS Material & Sensors: MEMS Material-1(Primary materials), MEMS Material 2(Packaging), MEMS material for layers, Etch Stop Techniques & Micro- Structure, MEMS Pressure & Flow Sensors, MEMS Capacitive Sensors, MEMS Gyro, MEMS Inertial Sensors. MEMS Applications: Interface Electronics for MEMS, Bio-MEMS, Polymer- MEMS, MEMS for Space Applications. MEMS Tools &Techniques: Introduction to Software Builder, MEMS Sensor designs, MEMS for Mechanical designs, Project Model.

Recommended Books:

1. Tai-Ran Hsu, MEMS AND Microsystems: Design and Manufacture 1st Edition,, McGraw Hill Education (India) Private Limited
2. MAHALIK N P, MEMS:, McGraw Hill Education (India) Private Limited
3. Reza Ghodssi,MEMS Materials and Processes Handbook, Pinyen Lins.
4. ·Gaura, E. and Newman, R., 2006. Smart MEMS and sensor systems. World Scientific

Elective IV

System Implementation of Vision(4-0-0)	4.0 Credits

Course Learning Outcomes(CLO):

CLO1: Student will be able to identify basic concepts, terminology, theories, models and methods in the field of computer vision

CLO2: Student will be able to describe known principles of human visual system,

CLO3: The student will be able to describe basic methods of computer vision related to multi-scale representation, edge detection and detection of other primitives, stereo, motion and object recognition.

Practical significance of Fourier transform and convolution in image understanding, The algorithm to track lines in the image, Pattern recognition techniques, Introduction to Python and its implementation, Constants and Variables , First Program, Conditional Programming, Loops and Iterations, Image Acquisition, Implementing pattern recognition, Decision making, Motion Vision, Shaping with binary and shaded images, Binary image processing, Stereo photogrammetry, Computational Vision (Machine learning and vision), Performance Evaluation, Projects using Machine vision (Any of the following), Vision in Agriculture, Vision in Natural Language Processing, Vision in Biomedical, Vision in Education.

Recommended Books:

1. Liu, Z., Ukida, H., Ramuhalli, P. and Niel, K., 2015. Integrated Imaging and Vision Techniques for Industrial Inspection. Springer.
2. Whelan, P.F. and Molloy, D., 2001. Machine vision algorithms in Java: techniques and implementation. Springer Science & Business Media.
3. Snyder, W.E. and Qi, H., 2004. Machine vision (Vol. 1). Cambridge University Press.
4. Bisiani, R., 1987. Fundamentals in computer understanding: speech and vision. CUP Archive

Hardware and Software Co-Design (4-0-0) 4.0 Credits

Course Learning Outcomes(CLO):

CLO1: Student will be able to analyze and explain the control-flow and data-flow of a software program and a cycle-based hardware description,

CLO2: Student will be able to identify performance bottlenecks in a given hardware-software architecture and optimize them by transformations on hardware and software components

CLO3: The student will be skilled to use simulation software to co-simulate software programs with cycle-based hardware descriptions.

Co- Design Issues: Co- Design Models, Architectures, Languages, A Generic Co-design Methodology. Co- Synthesis Algorithms:Hardware software synthesis algorithms: hardware – software partitioning distributed system cosynthesis. Prototyping and Emulation: Prototyping and emulation techniques, prototyping and emulation environments, future developments in emulation and prototyping architecture specialization techniques, system communication infrastructure. Target Architectures: Architecture Specialization techniques, System Communication infrastructure, Target Architecture and Application System classes, Architecture for control dominated systems (8051-Architectures for High performance control), Architecture for Data dominated systems (ADSP21060, TMS320C60), Mixed Systems. Compilation Techniques and Tools for Embedded Processor Architectures: Modern embedded architectures, embedded software development needs, compilation technologies, practical consideration in a compiler development environment. Design Specification and Verification: Design, co-design, the co- design computational model, concurrency coordinating concurrent computations, interfacing components, design verification, implementation verification, verification tools, interface verification, Languages for System – Level Specification and Design-I: System – level specification, design representation for system level synthesis, system level specification languages, Languages for System – Level Specification and Design-II: Heterogeneous specifications and multi-language co-simulation, the cosyma system and lycos system.

Recommended Books:

1. Wayne Wolf , Hardware / Software Co- Design Principles and Practice – Jorgen Staunstrup, 2009, Springer.
2. DeMicheli, G. and Sami, M.G. eds., 2013. Hardware/software Co-design (Vol. 310). Springer Science & Business Media.
3. De Micheli, G., Ernst, R., Wolf, W. and Wolf, M., 2002. Readings in hardware/s.
4. Niemann, R., 1998. Hardware/software co-design for data flow dominated embedded systems. Springer Science & Business Media.

Smart Antennas(4-0-0)	**4.0 Credits**

Course Learning Outcomes(CLO):

CLO1: Student will be able to analyze the behavior of EM Wave through different medium such as Transmission Lines and Waveguides.

CLO2: Skill to solve transmission line impedance mismatching problems in communication and power transmission using stub matching and Smith chart

CLO3: The student will be able to understand the basic parameters & properties of Antennas, Antenna Types, and Antenna Arrays for Antenna Gain and Directivity Enhancement.

Fundamental Parameters of Antenna and cellular concepts: Radio communication link with transmission and receiving antenna, radiation patterns, antenna equivalent circuits, reciprocity theorem, beam area, beam width, directivity, gain, antenna apertures, effective height, field zones, radiation resistance, radiation efficiency, antenna polarization. Potential functions and the electromagnetic fields, oscillating electric dipole-derivations for E and H field components in spherical co-ordinate systems, power radiated by a current element, Principal operation of a cellular mobile system, analogue and digital cellular mobile radio systems.Mobile antennas and mobile Radio Propagation and Modelling: Introduction and basics of mobile radio propagation, free-space propagation model, link budget design, propagation models, types of small-scale fading, statistical models for multipath propagation. Antennas for Mobile Communication: Mean effective gain, Human body interactions and specific absorption rate, mobile satellite antennas, Macrocell antennas, microcell antennas, Picocell antennas, femtocell antennas, space diversity antennas.Need for smart antennas, standards for smart antennas, types of smart antennas, features and benefits ,architecture, advantages and disadvantages of smart antennas, introduction to orthogonal signals, signal propagation: multipath and co-channel InterferenceIntroduction to Smart Antennas: Spatial Processing for Wireless Systems : The Vector Channel Impulse Response and the Spatial Signature, Spatial Processing Receivers, Fixed Beam forming networks, Switched Beam SystemsAdaptive Antenna Systems: Wideband Smart Antennas, Spatial Diversity, Diversity Combining, and Sectoring, Transmission Beam forming, Array Calculation. Smart Antennas Techniques for CDMA: Non-Coherent CDMA Spatial Processors, Coherent CDMA Spatial Processors and the Spatial Processing Rake Receiver, Multi-User Spatial Processing, multi- carrier communication, Dynamic Re-sectoring Using Smart Antennas, Downlink Beam-forming for CDMA. CDMA System Range and Capacity Improvement Using Spatial Filtering: Range Extension in CDMA, Reverse Channel Performance of Multi-cell Systems with Spatial Filtering at the Base Station, Range and Capacity Analysis Using Smart Antennas – A Vector Based Approach. RF Position Locating Systems: Direction finding PL systems, True ranging PL Systems, Elliptical PL Systems, Hyperbolic PL Systems, Hyperbolic Vs DF PL Systems, TDOA Estimation Techniques: General Model for TDOA Estimation, Measures of Position Location Accuracy: Circular Error Probability and Geometric Dilution of Precision.

Recommended Books:

1. J.D. Krauss,Antennas for all applications, 3rd edition, by TMH.
2. K.D. Prasad,Antenna & Wave Propagation, Satyaprakash publications.

3. Gottapu Sashibhushana Rao, Mobile cellular communication,, Pearson Publications.

4. Theodore S. Rappaport,Wireless Communications: Principles and practice, 2nd edition, PHI.

Pattern Recognition(4-0-0)	4.0 Credit

Course Learning Outcomes(CLO):

CLO1: Student will be able to Explain and compare a variety of pattern classification, structural pattern recognition, and pattern classifier combination techniques.

CLO2: The student will be skilled to apply pattern recognition techniques to real-world problems such as document analysis and recognition

CLO3: The student will be able to Apply performance evaluation methods for pattern recognition, and critique comparisons of techniques made in the research literature

Pattern Recognition Overview Pattern Recognition, Classification And Description—Patterns And Feature Extraction With Examples—Training And Learning In PR Systems—Pattern Recognition Approaches. STATISTICAL PATTERN RECOGNITION Introduction To Statistical Pattern Recognition—Supervised Learning Using Parametric And Non Parametric Approaches. LINEAR DISCRIMINANT FUNCTIONS AND UNSUPERVISED LEARNING AND
CLUSTERING (9 Hours) Introduction—Discrete And Binary Classification Problems—Techniques To Directly Obtain Linear Classifiers -- Formulation Of Unsupervised Learning Problems— Clustering For Unsupervised Learning And Classification. SYNTACTIC PATTERN RECOGNITION Overview Of Syntactic Pattern Recognition—Syntactic Recognition Via Parsing And Other Grammars–Graphical Approaches To Syntactic Pattern Recognition—Learning Via Grammatical Inference. NEURAL PATTERN RECOGNITION Introduction To Neural Networks—Feedforward Networks And Training By Back Propagation—Content Addressable Memory Approaches And Unsupervised Learning In Neural PR.

Recommended Books:

1. Robert Schalkoff, “Pattern Recognition: Statistical Structural and Neural Approaches”, John wiley & sons , Inc,1992.
2. Earl Gose, Richard johnsonbaugh, Steve Jost, “Pattern Recognition and Image Analysis”, Prentice Hall of India,.Pvt Ltd, New Delhi, 1996.
3. Duda R.O., P.E.Hart & D.G Stork, “ Pattern Classification”, 2nd Edition, J.Wiley Inc 2001.
4. Duda R.O.& Hart P.E., “Pattern Classification and Scene Analysis”, J.wiley Inc, 1973.
5. Bishop C.M., “Neural Networks for Pattern Recognition”, Oxford University Press, 1995.

Speech Signal Processing(4-0-0)	**4.0 Credits**

Course Learning Outcomes(CLO):

CLO1: To acquire knowledge of audio and speech signals.

CLO2: Skill to develop understanding of speech generation and recognition models.

CLO3: Skill to relate human physiology and anatomy with signal processing paradigms.

Digital Models For The Speech Signal: Process of speech production, Acoustic theory of speech production, Lossless tube models, and Digital models for speech signals. Time Domain Models for Speech Processing: Time dependent processing of speech, Short time energy and average magnitude, Short time average zero crossing rate, Speech vs silence discrimination using energy & zero crossings, Pitch period estimation, Short time autocorrelation function, Short time average magnitude difference function, Pitch period estimation using autocorrelation function, Median smoothing. Digital Representations of the Speech Waveform: Sampling speech signals, Instantaneous quantization, Adaptive quantization, Differential quantization, Delta Modulation, Differential PCM, Comparison of systems, direct digital code conversion. Short Time Fourier Analysis: Linear Filtering interpretation, Filter bank summation method, Overlap addition method, Design of digital filter banks, Implementation using FFT, Spectrographic displays, Pitch detection, Analysis by synthesis, Analysis synthesis systems. Homomorphic Speech Processing: Homomorphic systems for convolution, Complex cepstrum, Pitch detection, Formant estimation, Homomorphic vocoder. Linear Predictive Coding of Speech: Basic principles of linear predictive analysis, Solution of LPC equations, Prediction error signal, Frequency domain interpretation, Relation between the various speech parameters, Synthesis of speech from linear predictive parameters, Applications. Speech Enhancement: Spectral subtraction & filtering, Harmonic filtering, parametric re-synthesis, Adaptive noise cancellation.Speech Synthesis: Principles of speech synthesis, Synthesizer methods, Synthesis of intonation, Speech synthesis for different speakers, Speech synthesis in other languages, Evaluation, Practical speech synthesis. Automatic Speech Recognition: Introduction, Speech recognition vs. Speaker recognition, Signal processing and analysis methods, Pattern comparison techniques, Hidden Markov Models, Artificial Neural Networks. Audio Processing: Auditory perception and psychoacoustics - Masking, frequency and loudness perception, spatial perception, Digital Audio, Audio Coding - High quality, low-bit-rate audio coding standards, MPEG, AC- 3, Multichannel audio - Stereo, 3D binaural and Multichannel surround sound.

Recommended Books:

1. L. R. Rabiner and R. W. Schafer, “Digital Processing of Speech Signals", Pearson Education (Asia) Pte. Ltd., 2004.
2. D. O’Shaughnessy, “Speech Communications: Human and Machine”, Universities Press, 2001.
3. L. R. Rabiner and B. Juang, “Fundamentals of Speech Recognition”, Pearson Education (Asia) Pte. Ltd., 2004. Z. Li and M.S. Drew, “Fundamentals of Multimedia”, Pearson Education (Asia) Pte. Ltd., 2004.
4. Chen, C.H. ed., 1988. Signal processing handbook (Vol. 51). CRC Press.

Soft Computing(4-0-0)	**4.0 Credits**

Course Learning Outcomes(CLO):

CLO1: To Learn about soft computing techniques and their applications

CLO2: Skill to analyze various neural network architectures.

CLO3: Understand perceptrons and counter propagation networks..

Intelligent Agents: Agents Behavior and Environments, Structure of Agents, Planning Problem, Planning with state Space Search, Partial order Planning, GRAPHPLAN, Planning in logic, Planning in non-deterministic domains, hierarchical task planning, Multi agent planning, execution. Probabilistic Reasoning Fuzzy Logic: Knowledge representation under uncertainty, Bayesian theorem, Bayesian Networks, Dempster Shafer theory, Representing vagueness, Fuzzy sets, operation on fuzzy sets, reasoning with fuzzy logic, Fuzzy Automata, Fuzzy Control methods, Fuzzy decision making, inference in temporal models, Hidden Markov Models, Kalman Filters.Neural Networks: Basic concepts, Single layer perception, Multilayer Perception, Supervised and Unsupervised learning – Backpropagation networks - Kohnen's self-organizing networks - Hopfield network. Introduction to Artificial Neural Systems - Perceptron - Representation - Linear separability - Learning – Training algorithm -Adaptive networks based Fuzzy interface systems - Classification and Regression Trees - Data clustering algorithms - Rule based structure identification - Neuro-Fuzzy controls - Simulated annealing.Genetic Algorithms: Evolutionary computation. Survival of the Fittest - Fitness Computations - Cross over – Mutation, Reproduction - Rank method - Rank space method.

Recommended Books:

1. Stuart J.Russel, Norvig: AI: A Modern Approach, Pearson Education, Latest Edition
2. Michael Negnevitsky: Artificial Intelligence: A Guide to Intelligent Systems, 2/E, Addison- Wesley, 2005
3. Yegnanarayana B: Artificial Neural Networks, Prentice Hall of India Private Ltd., New Delhi, 1999.
4. Hagan, M.T., Demuth, Mark Beale : Neural Network Design By Cengage Learning
5. Goldberg, David E. : Genetic algorithms in search, optimization and machine learning, Latest Edition, Addison Wesley

Publishing Research(2-0-0)	**2 credits**

Course Learning Outcomes(CLO):

CLO1: Skill to identify and discuss the role and importance of research in the social sciences.

CLO2: Skill to identify and discuss the issues and concepts salient to the research process.

CLO3: Skill to identify and discuss the concepts and procedures of sampling, data collection, analysis and reporting.

Meaning of Research, Indian Research Story, I want to publish a research paper - How do I Start? Find the right journal for your work What Makes a Great Paper: An Overview - There is no magic formula

Elements of writing Style - The ABC of good writing, The ABC of writing: being accurate, The ABC of writing: being brief, The ABC of writing: being clear, Applying the ABC of writing Elements of writing Style, Titles and Abstracts - - Discussions on the NMC videos , Extend the summary of the understanding of their research field to about 200 words, The DEF of writing a good title, Writing a specific title, Writing a DEF title

Tittles & Abstracts - Why titles and abstracts are important, Things to avoid in titles: complex compound nouns, Things to avoid in titles: acronyms, Things to avoid in titles: question marks, Things to avoid in titles: puns, Choosing keywords for your paper, How to write an abstract: the five question technique, How to write an abstract: the Nature summary paragraph, Things to avoid in abstracts: empty statements, How can this abstract be improved?

Authorship and author's responsibilities - Principles of authorship, Definitions of authorship, Author contributions,Plagiarism and Other Ethical Issues Why researchers behave unethically, Defining plagiarism, Types of self-plagiarism.

Recommended Books

1. Mainly Nature Master Class videos to be referred.

Semester V

Engineering Education (4-0-0)	**4.0 Credits**

Course Learning Outcomes(CLO):

CLO1: The students would be able to apply principles of mathematics, science, and engineering in a variety of contexts

CLO2: They would be skilled to design and conduct experiments, as well as to analyze and interpret data.

CLO3: The students would possess the skills to use the techniques, skills, and tools necessary for science and engineering practice.

Engineering Education – concept, significance in Indian context, scope of Engineering Education and Role of Engineer and Technicians, Educating the engineers of new century - Generic Skills appropriate to engineering practices: speaking, listening, reading, writing, decision making, problem solving, team building, creativity, and adaptability: their concepts, importance and strategies for enhancing these skills), Educational Technology : Concept, Types of Educational Technology- Technology in Education, Technology of Education and Systems Approach to Educational Technology, Planning and Organizing for Instruction in engineering contexts : Steps in Instructional Planning – Understanding learners; task analysis; writing instructional objectives; instructional methods (Problem Based Learning, Case Study and Cooperative Learning); selecting evaluation techniques; Developing lesson plans (Theory and Practical); Development of instructional resources (handouts, instructional sheets, tutorial sheets, exercises, PowerPoint), Implementing Instruction: Motivating students Concept, types and techniques, Ensuring student involvement through Integration of media (internet and computer), Evaluation of learning outcomes and teacher effectiveness: Concept, dimensions, Evaluating learning outcomes (cognitive, psychomotor & affective) , Teacher effectiveness (self, peer and superior evaluation)

Recommended Books:

1. Bhattacharya, SK (2006) Educational Technology. New Delhi: Abhishek Publications 2006
2. Cole PG and Chan LKG (1987) Teaching Principles & Practice New York: Prentice Hall
3. Duffy Judy Lever, McDonald Jean (2010) Teaching and Learning with Technology.
4. Gagne, RM & Briggs LJ (1980) Principles of instructional design. New York: Holt, Rinohart & Winston.Inc.
5. Kulkarni, SS (1986) Introduction to Educational Technology. New Delhi: Oxford & IBH Publishing company

Intellectual Property Rights(2-0-0)	**2.0 Credits**

Course Learning Outcomes(CLO):

CLO1: Understand the Basics and Need of IPRs.

CLO2: Fill the invention disclosure form for patenting of an idea.

CLO3: Conduct the prior art to decide the patentability of the idea.

CLO4: Draft provisional/complete specifications of the patent application that will enhance their skill as an entrepreneurship.

Introduction - Intellectual Property, Intellectual Property Rights, Categories of Intellectual Property, Rights protected under Intellectual Property, IPR as Instruments of Development, History of IPR in India, History of Copyright Law in India, History of Patent Law in India, History of Trademark Law in India Overview of Laws related to Intellectual Property Rights in India. Copyright – Introduction of Copyright, Copyright law in India Classes of works for which copyright protection is available, Ownership of Copyright, Assignment of copyright, Transmission of copyright by testamentary disposition, Relinquish copyright, Term of copyright, Rights of Broadcasting Organization and of Performers, Intellectual Property Rights (IPR) of Computer Software, Procedure of registration under copyright in India. Patent - Introduction to Patent, Meaning of 'Invention' under Patent Law, What is not an 'Invention'? Patent system in India: what can be patented and what cannot be patented?, Hierarchy of officers and jurisdiction of patent offices. Different types of patent applications, Precautions while patenting, Publication and Examination, Granting of patent, term and date of patent, Renewal and restoration, Rights of a Patentee, Compulsory license under Paris convention, Compulsory license under TRIPS, Patent Agent - Eligibility and criteria, Patent Infringement & penalties, E-filing of a patent in India. Trademark-What is Trademark? Features types and functions of a trademark, Trademarks law of India, Who can apply for a trademark, How to file a trademark application for registration, Procedure for series registration and collective marks, Renewal of trademark, Offences and Penalties, Procedure of e-filing. Designs - What is Design, Design law in India, Need for Registration of design, Exclusion from scope of design, Requirement for registration of Design, Who can apply, Procedure for submission of application of registration, Cancellation, Piracy, Administration. Geographical Indications of Goods: What is a Geographical Indication? Laws relating to Geographical Indication of Goods Registration of Geographical Indication, Procedure for Filing application for registration of Geographical Indication, Infringement of Geographical Indication. Semiconductor Integrated Circuits Design: Semiconductor Integrated Circuits Layout-Design (SICLD) Act, 2000Criteria for registration of Chip Layout Design, Duration, Person entitled to protection of Layout-Designs, Steps for registration of a layout-design, Documents to be submitted along with application, Prohibition from registration, Penalties. Biological Diversity Biodiversity Act, 2002, Access to Biological Diversity, Exclusion under Biological Diversity Act, Penalty, National Biodiversity Authority. Protection of Plant Varieties and Farmer Rights Protection of Plant Varieties and Farmers' Right Act, 2001, Duration of protection of a registered plant variety, Registration of Plants, Application for registration, Criteria for registration of new variety, Prerequisites for filing an application form for registration of plant variety, Guidelines for submission of applications for Registration of Plant Varieties, Plant Authority (PPV&FR Authority). Undisclosed information- Introduction to Undisclosed Information. The agreement of trade related aspects of intellectual property rights (TRIPS). World intellectual property organization (WIPO) mission of WIPO, core tasks of WIPO, how WIPO works, WIPO goals. Intellectual property treaties - Paris convention for the protection of industrial property, Berne convention for the protection of literary and artistic works, the patent cooperation treaty (PCT), patent law treaty (PLT). Commercialization of intellectual property rights - commercialization of

intellectual property rights by licensing, valuation of IPR, concept of IP valuation, methods of valuation

Recommended Books and sites:

1. Kompal Bansal and Parikshit Bansal, "Fundamentals of IPR for Engineers", B.S. Publications
2. Cyber Law. Texts & Cases, South-Western's Special Topics Collection.
3. May, C. and Sell, S.K., 2006. Intellectual property rights: A critical history. Boulder: Lynne Rienner Publishers
4. Dutfield, G., 2009. Intellectual property rights and the life science industries: past, present and future. World Scientific.

Appendix A

Course Code Scheme

Sample Course Code						
A	**M**	**L**	**3**	**2**	**0**	**3**

First two letters would indicate the academic Unit offering the course Third letter would indicate the type of Course
First Number = Credits of the course = **Round up (Lecture hours per wk * 1 + Tutorial Hours per wk * 0.5 + Lab hours per wk * 0.5)**
Second Number = Year of Program
Last Two numbers = Sequencing of course

Allotment of first two letters	
AM	Maths
PY	Physics
CH	Chemistry
GE	General Education
CL	Languages
CS	Computer Science
EC	Electronics
EE	Electrical
ME	Mechanical
CE	Civil
CA	Computer Applications
BS	Business Studies
AR	Architecture
ED	Education
PH	Pharmacy
AS	Applied Science
PE	Physical Education

Third letter	
L	Course with only theory component
P	Course with only Lab component
T	Training, Dissertation
S	Self Study, Project, Seminar
W	Workshop course

First numeral	
1	1 credit course
2	1.5 or 2 credit course
3	2.5 or 3 credit course
4	3.5 or 4 credit course
5	4.5 or 5 credit course
6	5.5 or 6 credit course
7	6.5 or 7 credit course
8	7.5 or 8 Credit Course
9	8.5 or 9 or more credit course

Second Numeral (this number indicates the incremental year of study after 12th class)	
0	For courses are after 10th
1	Year 1
2	Year 2
3	Year 3
4	Year 4
5	Year 5
6	Year 6
7	Year 7

Third and Fourth Numerals (Sequencing of Course)	
01	Course Number 1
02	Course Number 2
03	Course Number 3
04	Course Number 4
05	Course Number 5
06	Course Number 6
07	Course Number 7

Appendix B

Calculation of CGPA

The CGPA (calculated on a 10 -point scale) would be used to describe the overall performance of a student (from the semester of admission till the point of reckoning) in all courses for which LETTER GRADES will be awarded. GPA will indicate the performance of student for any particular semester. Formulas for calculation of GPA and CGPA has been provided as below:

$$SGPA_i = \frac{\sum_{j=1}^{k} C_{ij} G_j}{\sum_{j=1}^{k} C_{ij}}$$

$$CGPA = \frac{\sum_{i=1}^{N}\left(GPA_i * \sum_{j=1}^{n} C_{ij}\right)}{\sum_{i=1}^{N}\left(\sum_{j=1}^{n} C_{ij}\right)}$$

Where n = number of subjects in the semester; N = number of semesters; GPA_i = GPA for the ith semester; C_{ij} = number of credits for the jth course in ith semester; and G_j = Grade point corresponding to the grade obtained in the jth course.

Table below shows the grade point for every valid grade that may be awarded to a student pursuing a particular course:

Grade	Grade point	Qualitative Meaning
O	10	Outstanding
A+	9	Excellent
A	8	Very Good
B+	7	Good
B	6	Above Average
C	5	Average
P	4	Pass
F	0	Fail
I		Incomplete

'I' grade would be awarded to those students, who due to some reason or the other have not been able to appear in certain required number of evaluation components conducted for a course. Later 'I' grade would be changed to a relevant grade, once a student has fulfilled the requirement of appearing in certain number of evaluation components for a course.

Example to Understand the Calculation of SGPA

Suppose a student is registered in four courses 'W', 'X', 'Y' and 'Z' in a particular semester as mentioned below in the Column - I of the table. Column - II in the table below depicts the number of credits, which those courses carried. At the end of the semester, student was awarded with the grades as mentioned in Column – III in the table given below. Column – IV indicates the corresponding grade weight. Column – V and Column – VI indicate essentially the Credit value and Grade Points for every course completed by a student in that particular semester.

Courses in which student registered (Column – I)	Credits (Column – II)	Letter Grade Column - III	Grade Value (Column – IV)	Credit Value (Column – V)	Grade Points (Column – VI)
Course W	3	B	6	3 x 6	18
Course X	3	A	8	3 x 8	24
Course Y	3	O	10	3 x 10	30
Course Z	2	O	10	2 x 10	20
Total	11			Total	92

Thus, the total SGPA of the student would be=

SGPA= Total grade pts./Total no. of Credits= 92/11 = 8.36

Suppose the SGPA of the student in two successive terms is 7.0 and 8.0 with respective course credits being 12 and 11, then the

$$CGPA = \frac{7x12 + 8x11}{12 + 11} = \frac{84 + 88}{23} = 7.48$$

Appendix-C

Course Code	Title of the Course	Course Learning Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12
ECL4501 ECP1501	Advanced Digital System Design Advance Digital System Design Lab	**CLO1:** Understand the basics of difference between various systems								M				
		CLO2: Skill to implement simple logical operations required for the designing of systems.								M				
		CLO3: Skill to design and implement various filters.									M			
ECL4630	Semiconductor Material and Devices	**CLO1:** To be able to read and interpret electronic datasheets and diagrams.												L
		CLO2: To be able to measure the electronics & electrical parameters of an amplifier like voltage gain, input & output impedance.			H									
		CLO3: Skill to design, construct and troubleshoot transistor based amplifier complex electronic circuits							M					
ECL4629	Microwave and RF Design	**CLO1:** Students will gain complete knowledge about the significance, types and characteristics of various microwave devices.			H			H						
		CLO2: Skill to analyze mathematically the operation and working of various tubes or sources for the transmission of the microwave frequencies										H		
		CLO3: Students will gain the basic understanding about the principles and working of RADAR.									H		H	H
ECL4607 ECP1607	Mixed Signal Circuit Design Mixed Signal Circuit	**CLO1:** Apply knowledge of mathematics and engineering to design CMOS analog circuits to achieve desired	M		M									

	Design Lab		performance specifications.												
		CLO2:	Skilled to identify, formulates, and solve engineering problems in the area of mixed-signal design.		H										
		CLO3:	Design and implement various types of mixed-signal integrated circuit for real world applications during their employment and entrepreneurship.			H									
		CLO4:	Applications for real world applications.	H											
		CLO5:	Applications for societal problem solving and employability.						M						
ECL4606 ECP1606	Digital Image Processing Digital Image Processing Lab	**CLO1:**	After the completion of the course student will be able to understand the fundamental concepts of a digital image processing system like Image formation, Image sampling and quantization											M	
		CLO2:	Students will develop the skill to analyze the different images in the frequency domain using various transforms	H											
		CLO3:	Students will be able to realize the importance of filters for the images and also they will be able to differentiate between the different types of filters.		H										
		CLO4:	Applications of image processing in recognition											H	
CSL4601 CSP1601	Communication Network and Protocols Communication Network and Protocols Lab	**CLO1:**	Understand the small networks by following the top-down approach from application to physical layer.	L				H							
		CLO2:	Acquire theoretical knowledge about the different network technologies	M											
		CLO3:	Skilled to understand the functioning of different layers in OSI model and TCP/IP .											M	
		CLO4:	Identify various system security and protection issues that enhance employability.	L											
CSL4602 CSP1602	Machine Learning Machine Learning	**CLO1:**	After Completing this course, the students will have skill to be able to								M				

	Lab		analyze the data, identify the problems.												
		CLO2:	The students will able to choose the relevant models and algorithms to turn available data into valuable and useful information.								M				
		CLO3:	The students will be skilled to apply different machine learning problems that will increase their employability.								M				
		CLO4:	The students will be able to evaluate the performance of models.								M				
ECL4601 ECP1601	Internet of Things and Embedded System Internet of Things and Embedded System Lab	**CLO1:**	Understand fundamental concepts and technologies related to embedded system and IoT based devices									M			
		CLO2:	Understand the fundamentals of RTOS and application development techniques.												L
		CLO3:	Skill to write fast-executing embedded code that utilizes the CPU, memory and peripheral resources efficiently			H									
		CLO4:	Understand the various communication and networking protocols used for developing IoT enabled devices during their employment.							M					
ECL 2601	Publishing Research	**CLO1:**	Skill to identify and discuss the role and importance of research in the social sciences.			H			H						
		CLO2:	Skill to identify and discuss the issues and concepts salient to the research process.										H		
		CLO3:	Skill to identify and discuss the concepts and procedures of sampling, data collection, analysis and reporting.									H		H	H
CSL4651	Engineering Education	**CLO1:**	The students would be able to apply principles of mathematics, science, and engineering in a variety of									H		H	H

			contexts												
		CLO2:	They would be skilled to design and conduct experiments, as well as to analyze and interpret data.	M		M									
		CLO3:	The students would possess the skills to use the techniques, skills, and tools necessary for science and engineering practice.		H										
CSL2518	Intellectual Property Rights	**CLO1:**	Understand the Basics and Need of IPRs.	H											
		CLO2:	Fill the invention disclosure form for patenting of an idea.						M						
		CLO3:	Conduct the prior art to decide the patentability of the idea.											M	
		CLO4:	Draft provisional/complete specifications of the patent application that will enhance their skill as an entrepreneurship.								M				
CS 952	Programming in Python	**CLO1:**	Recognize the characteristics of machine learning that make it useful to real-world problems and learn skills.								M				
		CLO2:	Characterize machine learning algorithms as supervised, semi-supervised, and unsupervised.									M			
		CLO3:	Skilled to effectively use machine learning toolboxes.												L
		CLO4:	Implement machine learning solutions to classification, regression, and clustering problems.			H									
		CLO5:	Understand how to perform evaluation of learning algorithms and model selection.							M					
CS 951	Programming in C#	**CLO1:**	Students will gain an in-depth knowledge about overall syntax and semantics of .NET programs			H			H						
		CLO2:	Students will be skilled to use an IDE to compile, load, save, and debug a .NET program										H		
		CLO3:	Students will develop technical thinking and problem solving ability to									H		H	H

			find an appropriate solution for a problem.												
		CLO4:	Students will be able to demonstrate the ability to create test cases to determine that a solution produces expected outputs for given inputs	M		M									
		CLO5:	Incorporation of programming in real time applications that will increase their employability.		H										
CS 953	Programming in R	**CLO1:**	Students will gain an in-depth knowledge about overall syntax and semantics of R programs.			H									
		CLO2:	Students will be skilled to use an IDE to compile, load, save, and debug a Rprogram.	H											
		CLO3:	Students will develop technical thinking and problem solving ability to find an appropriate solution for a problem.					M							
		CLO4:	Students will be able to demonstrate the ability to create test cases to determine that a solution produces expected outputs for given inputs											M	
		CLO5:	Incorporation of programming in real time applications that will increase their employability.	H											
CS 954	Advanced Programming in Java	**CLO1:**	Students will gain an in-depth knowledge about overall syntax and semantics of Java programs		H										
		CLO2:	Students will be skilled to use an IDE to compile, load, save, and debug a Java program											H	
		CLO3:	Students will develop technical thinking and problem solving ability to find an appropriate solution for a problem.	L				H							
		CLO4:	Students will be able to demonstrate the ability to create test cases to determine that a solution produces expected outputs for given inputs	M											
		CLO5:	Incorporation of programming in real time applications that will increase											M	

			their employability.												
ECL4631	Rapid Prototyping using FPGA	**CLO1:**	The students completing this course are expected to understand the structure of various number systems and its application in digital design.	L											
		CLO2:	Students will be able to design the appropriate truth table from a description of a combinational logic function								M				
		CLO3:	Students will be skilled to analyze and design various combinational and sequential circuits like Comparators, Multiplexers, Encoders etc.								M				
		CLO4:	Students will be skilled to design the synchronous circuits like Pulse train generator, Pseudo Random Binary Sequence generator that will increase their employability.									M			
ECL4632	Advanced Wireless Communication System	**CLO1:**	The students would be able to apply the knowledge of mobile communication engineering to solve coverage and call failure problems in cell phones.												L
		CLO2:	They would be skilled to implement the cellular concept and antenna system design consideration aspects in optimizing the cellular architecture as per user needs during their employment.			H									
		CLO3:	The students would possess in-depth knowledge to select and use optimum multiple access technique for interference-free communication.							M					
		CLO4:	The students would possess ability and technical skills necessary to understand digital cellular standards and architecture designs.			H			H						
		CLO5:	The students would have acquired adequate knowledge about major aspects of 3G/4G digital cellular networks.										H		
ECL4616	RF Circuit Design	**CLO1:**	Understanding the design concept of			H									

			various RF/Microwave devices.												
		CLO2:	Knowledge of Microwave Circuit Analysis and Impedance matching.	H											
		CLO3:	Understanding the behavior of non-linear RF/Microwave Devices.						M						
		CLO4:	Ability to design discrete RF/ Microwave Devices that will increase their employability.											M	
ECL4662	Biomedical Signal Processing	**CLO1:**	The student will be skilled to model a biomedical system	L				H							
		CLO2:	The student will be able to understand various methods of acquiring bio signals.	M											
		CLO3:	The student will be able to understand various sources of bio signal distortions and its remedial techniques.											M	
ICP4306	Mobile application Development	**CLO1:**	Model and manage mobile application development using range of methods.	L											
		CLO2:	Student will be able to learn about the different frameworks.								M				
		CLO3:	The student will be able to develop mobile applications that will increase their employability.								M				
CSL4641	Big Data	**CLO1:**	Student will be able to Learn predictive modelling and its applications across domains.									M			
		CLO2:	Student will be able to Learn the concepts and metrics to evaluate and optimise digital marketing efforts.												L
		CLO3:	The student will be able to Understand how to use data analytics to forecast, plan and optimise inventories.			H									
ECL4663	Sensor Technology and MEMS	**CLO1:**	Student will be able to understand the operation of micro devices, micro systems and their applications							M					
		CLO2:	Student will be skilled to design the micro devices, micro systems using the MEMS fabrication process.			H			H						
		CLO3:	The student will be able to Gain the technical knowledge required for										H		

			computer-aided design, fabrication, analysis and characterization of nano-structured materials, micro- and nano-scale devices that will increase their employability.												
ECL4627	System Implementation of Vision	**CLO1:**	Student will be able to identify basic concepts, terminology, theories, models and methods in the field of computer vision								H		H	H
		CLO2:	Student will be able to describe known principles of human visual system,	M		M									
		CLO3:	The student will be able to describe basic methods of computer vision related to multi-scale representation, edge detection and detection of other primitives, stereo, motion and object recognition.		H										
ECL4661	Hardware and Software Co-Design	**CLO1:** **CLO2:** **CLO3:**	Student will be able to analyze and explain the control-flow and data-flow of a software program and a cycle-based hardware description,			H									
			Student will be able to identify performance bottlenecks in a given hardware-software architecture and optimize them by transformations on hardware and software components	H											
			The student will be skilled to use simulation software to co-simulate software programs with cycle-based hardware descriptions.				L								
ECL4615	Smart Antennas	**CLO1:**	Student will be able to analyze the behavior of EM Wave through different medium such as Transmission Lines and Waveguides.										M		
		CLO2:	Skill to solve transmission line impedance mismatching problems in communication and power transmission using stub matching and Smith chart	H											
		CLO3:	The student will be able to understand the basic parameters & properties of Antennas, Antenna Types, and								M				

			Antenna Arrays for Antenna Gain and Directivity Enhancement.												
CSL4653	Pattern Recognition	**CLO1:**	Student will be able to Explain and compare a variety of pattern classification, structural pattern recognition, and pattern classifier combination techniques.								M				
		CLO2:	The student will be skilled to apply pattern recognition techniques to real-world problems such as document analysis and recognition									M			
		CLO3:	The student will be able to Apply performance evaluation methods for pattern recognition, and critique comparisons of techniques made in the research literature												L
CSL4652	Speech Signal Processing	**CLO1:**	To acquire knowledge of audio and speech signals.			H									
		CLO2:	Skill to develop understanding of speech generation and recognition models.							M					
		CLO3:	Skill to relate human physiology and anatomy with signal processing paradigms.			H			H						
CSL4670	Soft Computing	**CLO1:**	To Learn about soft computing techniques and their applications										H		
		CLO2:	Skill to analyze various neural network architectures.									H		H	H
		CLO3:	Understand perceptrons and counter propagation networks..	M		M									